Reconsideration of Opening Design in the Integration of Natural Light into Interior Space

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ABSTRACT

Natural light was the main lighting sources before the invention of artificial lamps. After that, most of the designers started to design windowless buildings, which caused the consumption of a lot of fossil fuel besides its expensiveness. After 1960s, some of the architects started to re-think about natural lighting. They started to consider natural lighting in their design until the contemporary period. During the contemporary period, a design event affects architecture and forced architects and designers to be part of it with the invention of new technologies or materials. Therefore, for instance, it led to the emergence of digital architecture, where parametric design or fluid design arose as a result. This kind of architecture allows architects to design in any form, shape, and size where the priority was the shelter and functional role of opening more than the interior and its effects on the user or space. Therefore, together with the form, changes on opening and fenestration design affected the integration of natural light into interior spaces as well.

In due course, this study discourses the role opening design has on the integration of natural light into the interior space. It gives priority to the effects of opening on the interior space more than the shelter of a building or the functional role of the openings. Accordingly, at first, this study emphasizes the need for reconsideration of openings and investigates different methods and techniques that openings can be designed. Then it evaluates the effects of various opening designs on the integration, natural light into an interior space and its effects on interior design / space besides the user.

Keywords: Natural Lighting, Interior Design, Interior Space, Opening and Fenestration Design, Opening Design Techniques, Interior Design Elements and Principles.

ÖZ

Yapay aydınlatmanın keşfinden once doğal ışık temel aydınlatma kaynağı idi. Yapay aydınlatma ile birlikte tasarımcılar penceresiz binalar tasarlamaya başladırlar. Bu pahalı bir çözüm olmakla birlikte, çok fazla yakıt tüketiminin oluşmasına etken oldu. 1960'tan sonra bazı mimarlar yeniden doğal ışığı temel alan tasarımlar yapmaya başladılar. Günümüz mimarisi yeni bir dönemin başlangıcı oldu ve parametrik tasarım veya akışkan tasarım gibi yeni mimari yaklaşımlar ortaya çıktı. Bu gibi yaklaşımlar mimarların mimarideki sınırları aşmalarına ve farklı biçimlere sahip binalar tasarlamalarına etken oluşturdu. Bu heykelsi tasarımlarda binaların iç mekanlarından daha fazla binaların kabuğu/biçimi ön plana çıkmaya başladı. Değişen bina biçimleri açıklık tasarımlarını ve doğal ışığın iç mekana entegrasyonunun değişimine etken oldu. Açıklıkların işlevsel rolü biricil olarak düşünülürken iç mekana ve kullanıcısına etkisi işlevi kadar tasarım sürecinde yeterince düşünülmedi.

Bu çalışma, bu bağlamda, değişen mimari yaklaşımlarla, değişen teknoloji veya malzemelerin de etken olduğu yeni tasarlanan binalarda, açıklıkların tasarımını irdelemektedir. Ayrıca, değişen bina biçimlerindeki açıklık tasarımları sonucunda doğal ışığın iç mekana entegrasyonu ile mekanın tasarımı ve kullanıcının üzerindeki etkisini de tartışır.

Anahtar Kelimeler: Doğal Aydınlatma, İç Mekan Tasarımı, İç Mekan, Açıklık Tasarımı, Açıklık Tasarım Teknikleri, İç Mekan Tasarımı Elemanları ve İlkeleri.

TO MY HUSBAND,
FOR HIS UNCONDITIONAL LOVE

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First, I would like to thank my supervisor and mentor, Assoc. Prof. Dr. Nil Paşaoğluları Şahin, for her guidance, support and patience throughout my Master study. I do appreciate her efforts and encouragement, numerous discussions and valuable feedback in the last year.

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At the end, I would like to dedicate this thesis to my husband who encouraged me to broaden the horizons of my imagination and supported me through my education. I hope that dedicating this thesis to him, even though it is not much, could return a bit of his love and kindness.

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INTRODUCTION

> "Light and the effects of light are key to the enjoyment and functional success of spaces" (Coles & House, 2007, p.118).

> "The performance of natural light that penetrate through various size and position need to be investigated, in order to make sure that enough amount of daylight is received without creating any undesirable effects to occupied space" (Syed Husin & Hanur Harith, 2012, p. 197).

1.1 Subject Matter and Problem Statement

According to Serra's work called: *Chapter 6-daylighting in Renewable and Sustainable Energy Reviews* architecture means a contraposition of inside and outside. Therefore, to think about its interior design is as important as its architectural form. Architectural form makes sense to people outside and affects the city view. However, interior architecture of a building affects the people's life style and conditions of living. Thus, it is necessary to provide the comfortable environment for them (1998).

"There is no limit to the type or size of building that can fall within the practice of the interior architect and equally no limit to the range of activities which they may design" (Coles & House, 2007, p.14). Additionally, Dodsworth (2009) believes that interior architecture is more than it looks like. As he says, interior architecture means to find a solution to answer a set of problems, a holistic way that people enjoy the spaces that they inhabit. On the other hand, for Poldma (2009), interior forms, spaces

and its design directly depends on lighting sources. Everything needs light to display itself. It could be said that, talking about architecture is talking about light and above all, the natural light (Serra, 1998).

A designer can design a charming space with all details, finest materials in most gorgeous color, but without light, there is a waste of time, effort, and money (Serra, 1998). "Interior environment and their design are profoundly influenced by how designers integrate color and light with form and space" (Poldma, 2009, p.19). Furthermore, (Hua, et. al, 2011) introduces natural light as a significant light source, which has proposed to enhance indoor environmental quality.

During the daytime, it is the natural light, which comes to the surfaces and shows their details from the spectral viewpoint. Surfaces play an important role to bring daylight into space (Serra, 1998). Besides, the characteristic of the light coming into the space can affect all design aspects such as color and value.

According to Coles & House (2007), early openings were just simply holes in the walls, were devoid glazing materials and limited in size. However, nowadays, architects design various types of opening with delimitation in size, shape, and its entire characteristic. For instance, when the consideration is the day lighting of interiors, their size is extremely variable. Currently, they are usually higher than they are wide or furthermore, the colored glasses are being used for opening, whereas they could be seen in many shapes or size which will affect day lighting design (Ching, 2007).

Coles and House (2007) suggest that light and its effect are the keys to the 'enjoyment and functional success of space'. On the other hand, Serra (1998, p. 115) believes that despite transporting, light has color, and "it is for this reason that great architecture has always been associated with natural lighting, generating it with and within itself". As she mentions, light is general, but natural light is particular rather than the artificial light.

Natural light can affect human being when perceived by the sense of sight. Despite of it, natural light is more economical as a tool for design and more effective on human perception and body. Coles & House (2007) quote from Renzo Piano that: "natural light can make a room alive, when we feel turning earth, and moving sunlight it is effective to individual vision and their sense".

The Sun and sky, are basic determinants and main sources of natural light (Zemmoure& Schiller, 2004). Similarly, daylight could be introduced as a technique, which brings natural light into space (Syed Husin&HanurHarith, 2012). Coles & House (2007), classify natural light into two groups: sunlight and daylight. Sunlight is the light that comes from visible sun and has both physiological and psychological effects on the human being. Daylight has defined as the light that has produced whenever the sun is above the horizon. "Light propagates space at a speed that for architectural purposes can be regarded as instance" (Serra, 1998, p. 120).

It should be mentioned that from the beginning of architecture, natural light was the main light sources during the daytime until the discovery of artificial light. Then architects considered artificial lighting until the period of modernism, which cost a huge amount of fossil foils and was expensive at the same time. Therefore, designers

start to rethink interior day lighting as an inseparable part of the building design process during the modernism period.

Problem Statement

Natural lighting gives inhabitants pleasing and natural environment within the interior spaces. The functional role of natural lighting in the space is more than just the amount of light, it affects texture, color or forms and effects design of the space. Function of openings and their effect on interior space besides the user is a significant issue. Nowadays, with the effect of new technology, new materials, and new design approaches, buildings design have changed and together with that, the opening designs also have changed tremendously. The role of light is ignored in contemporary architecture where today's representative buildings totally neglect the important part natural light could play in their interior. Thus, there is a need for re-consideration of opening design in order to understand the integration of natural light into interior spaces.

1.2 Aim and Research Questions + Limitation

Aim

The main aim of this research is to investigate design approaches of opening design to provide / overview of contemporary approaches and possibilities to design openings in the integration of natural light into interior space.

Besides, the subsidiary aim of this study is to discuss the effects of designed natural light integrated, both on the interior space and on the human being.

Research Question

This thesis mainly seeks to quest: What are the new approaches to re-consider opening design?

Besides,

How designed openings effect natural lighting and interior design of the space?

How designed natural lighting effects people / inhabitant in the space?

Limitation

- This study limited to examining openings' design mainly in terms of their size, shape, location, organization or position besides their composition (design elements and principles) whereas treatments of openings (shutters, glazing, glass etc.) are not considered within this investigation.
- Selections of the examples were limited among architectural websites such as Arch Daily and Dezeen which are the most commonly used websites by designers.
- Pile's works called *Interior Design* (1995), A *History of Interior Architecture* (2009), and, *A History of Interior Design* (2014) are the main sources in the theoretical chapter which discusses interior's design evolution during centuries.
- Ching's approach is taken mainly as the basis of the study since he has many different studies on different aspects of design and architecture; starting from the general elements of the architecture, openings and focussing on the interior space as well together with the interior design issue.

1.3 Research Methodology

This is a qualitative research, which based on the interpretation of the relationship between three main concepts of the study, which are the relationship between fundamentals of interior design, natural light and opening design. Accordingly, three main concepts of the study were discussed through a literature survey with an interpretative approach in order to understand the relationship between natural light, opening design and interior space.

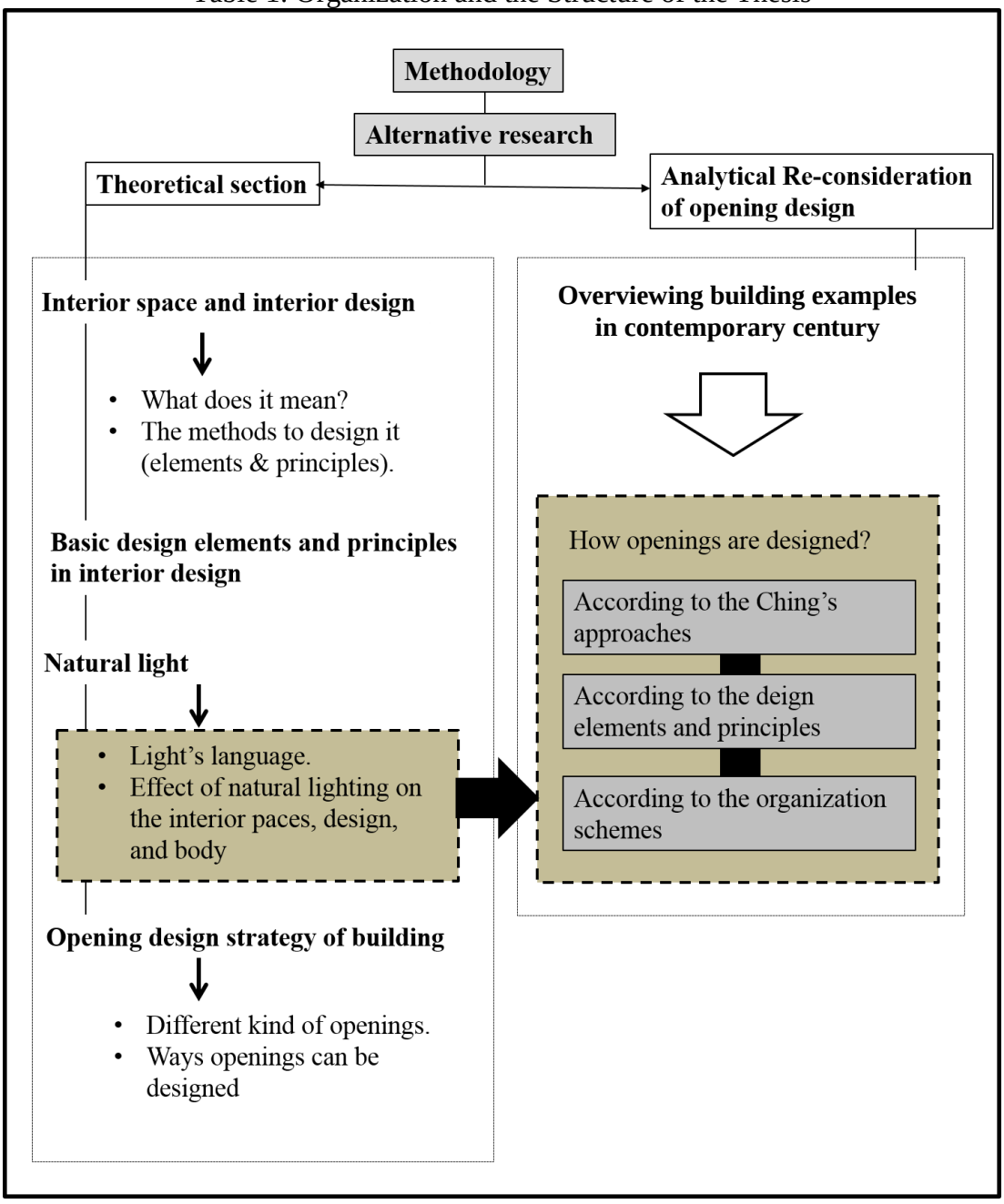
The first section *(The Fundamentals Of Interior Design)* starts by introducing interior design / space and its evolution throughout the history; discusses the various dimensions of interior design and finally, it explains the interior design issues regarding methods and techniques, elements and principles of design.

The second part of the theoretical overview *(Natural light)* refers firstly to the history and culture of natural light during different periods; how it started and evolved and then it considers the language of light as its meaning and how does it works. Afterwards, the effects of natural light which considers its effects both on the building/ interior and on the human body constitute the main subsections under the second part of theoretical overview. It actually refers to the effect of light on the perception of the interior space and human body visually, and functionally.

Opening / Natural Light Design Strategy of Building is the last section of the theoretical overview where openings and fenestrations considered mainly. This section starts by explaining the ways openings being used during the centuries; how they were designed and used in the past and how are they are being used now.

An overview of examples according to their opening design starts in Chapter 3. In this section, different approaches to design opening are investigated firstly according to the Ching approaches; second, how design elements and principles affect the design of the opening were investigated and third, there is an investigation of openings design by considering the organization of design elements in line with various organization schemes. Furthermore, the effect of opening design on the integration of natural light into an interior space and its effects both on space and user are also evaluated. And finally, this study concludes with a provision of an analytical re-consideration of opening design by the discourse on the relationship between opening design and interior space with a special focus put on natural light and its effects on interior space and user (table 1).

Table 1: Organization and the Structure of the Thesis



Chapter 2

THEORETICAL OVERVIEW

> "Interior design is a complex subject involving many related considerations. These include building structure, functional planning, concern with spatial form in three dimensions, the relationship of one space to another, the placement of solid objects (furniture and accessories) within large space, and effect of color pattern, texture and light" (Pile, 1995, p. 43).

2.1 Understanding Interior Design

The birth of interior design was at the same time with architecture that goes back to the earliest civilizations. Interior design aspects were changed and improved as the years passed. How interior design was emerged, what kind of new things was added to it, and how the concept of interior design evolved are the parameters that will be explained in the following sections. After that, the definition of the concept of design in interior spaces besides the introduction of design elements and principles according to interior spaces; with the discourse on the relationship between design basics and light will also be carried out.

2.1.1 Evolution of Interior Design

The beginning of architecture was from Ancient Mesopotamia that was started in Egyptian and Greek Architectures where architecture faced various styles in different centuries until postmodernist after 1972 and continues till present. There is a huge space between the earliest architecture and late architecture (Craven, n.d). Nowadays, architects consider many aspects of design approaches; due to this thread, Serra (1998, p. 130) believe that "Architecture is basically a contraposition of

indoors and outdoors, sheltered space and exposed environment, confidence and vulnerability, privacy and society".

By agreement with Serra (1998), Pile (2009, p.10) continues by talking about the importance of consideration to interior design of built environments. As he says, in the recent centuries, most of the people are spending their time in the indoor environments, they work, sleep, study, eat, bath, and also spend their free time in the indoors "in the modern world, human life experience is largely played out in interior spaces". The Book 'A History of Interior Design' written by Pile (2009) talks about the prehistory of interior spaces which came from the earliest cave and human shelters, but according to that study, the earliest attention to interior spaces was not because of ornamentation, but rather to the 'mythical power over hunted animals'.

Besides this, in another study 'Interior design' written by the same author, Pile explains the history of interior design: Historically, in ancient period, most of interior spaces were dependent on their structure such as earliest "huts, tents, igloos, tepees, and yurts" (1995). By the development of civilization, people found many appropriate ways to create elaborate structure to have their own indoor spaces such as a Gothic cathedral. Its indoor spaces were a part of the structure, glasses with additions carved wood plus many other design elements was a creating of new consistent design in the space (Pile, 1995, p. 11).

Throughout the centuries, ornamentation and decoration of interior spaces become prevalent; it started by mat weaving in various shapes, and continues by lithographing the low or other shapes or portraits, during this time, mass of huge statues was created in palaces (Pile, 2009). Then, in the 'Early Christian, Byzantine

and Romanesque', design of interiors mostly assigned to Basilicas and churches by an exquisite painting of Jesus, his followers, religious laws and the stories of the Jesus (Pile, 2009). With the advent of Islam the portraits of churches were replaced with names of God, Islam's first followers and flowered design in Mosques. Then interior spaces were a witness of exquisite works of tiles, plasters and brickwork (Pile, 2009).

The later middle ages, was the time for various types of arches, standing glass, buttresses, and gargoyles; by the rise of humanism, Italy, France and Spain were the places for greeting and attracting the interior environment designing during the Renaissance, Baroque and Rococo periods. During these periods human scales were considered, and they were periods of luxury-oriented; abundant use of golden colors, painting portrait on walls and ceilings, using lots of two or three dimensional statues and also using expensive furniture belong these times, so it could be said that these periods were an abundance of interior design focusing (Pile, 2009). The invention of electricity brought a new life to interior design 'at the end of the 19th century until the middle of the 20th century'.

Pile (2009) talks about 'the rise of interior decoration' during 19th and 20th centuries, by his statements as:

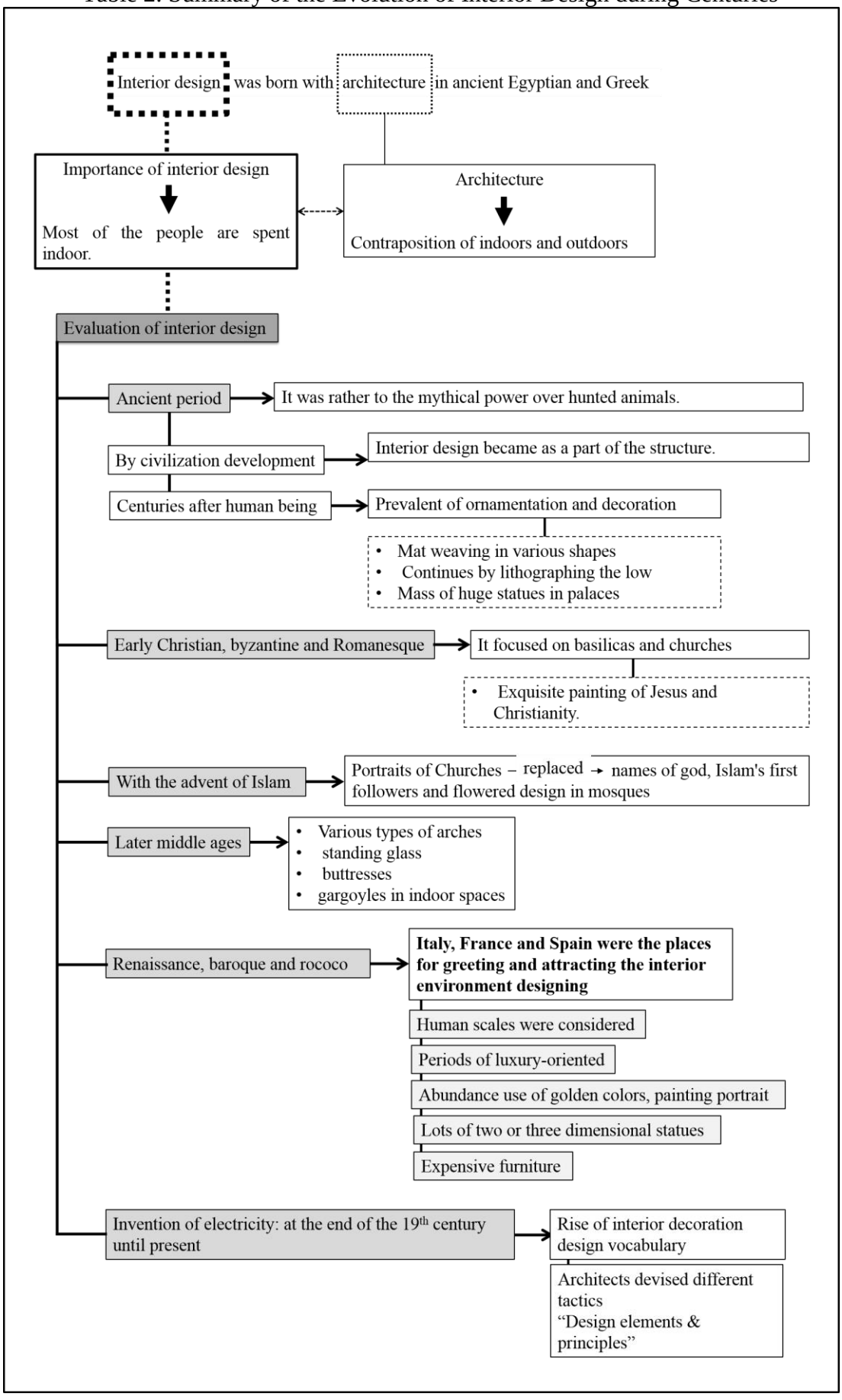
> "Eclectic architecture created for interior design specialists who had the knowledge and skill to produce rooms in styles appropriate to the building that housed them. The profession of interior decoration developed to fill this need. The typical decorator was trained to know period styles, to be skillful in assembling the many elements that go into an interior, and, often, to be an expert in acquisition of antiques, art works, and whatever else might be required to complete a project. Many decorators were also dealers or agents who acquired and resold to their clients' furniture, rugs, and decorative accessories. The

> ability to charm, cajole, and adjust to the whims of wealthy clients were essential skills" (p. 314).

Twenty century is known as the emergence of modernism. Pile & Gura (2014, p. 329) mention the emergence of design vocabulary as the most significant part of design development in the 20th century "the most important development in early twentieth-century design was the emergence of a design vocabulary appropriate to the modern world of advance technology and the new patterns of life that is brought about". The name that is given to all new forms of arts is Modernism. Even it is painting, sculpture, music, architecture, and literature. Then, as the time passed, the architects devised different tactics and principles of design elements that are still continuing until now (Pile, 2009).

In addition, Ludwig Mies van der Rohe, European Walter Gropius, American Frank Lloyd Wright, and Le Corbusier are mentioned by Pile & Gura (2014, p. 329) as four architects which were pioneers of modernism in design. They all were the architects; however, they also were active to design interior spaces, objects. After that, recently many other architects and designers brought different approaches to the interior design issue as much as the architectural form of the buildings such as Karim Rashid, Zaha Hadid, Norman Foster and many others.

Table 2: Summary of the Evolution of Interior Design during Centuries



2.1.2 The Design Dimension in Interior Spaces

Before mentioning interior design, Pile (1995, p. 33) explains the definition of the design; according to him: "there are many definitions of the word 'design', what most of the people think about it is as a 'meaning pattern or decoration'. Some other people define it as a fashion or stage design. According to engineering, design may define as 'sizing structural members'. And in fine art, design means the art or spatial organization of design elements in a space such as line, form, texture, and color".

In terms of 'interior design[1], industrial design and architecture' design is described as "all of the decisions that determine how a particular object, space, or building will be. It can also be described as determination of form, with form understood to mean every aspect of every quality, including size, shape, material, structure, texture and color" (Pile, 1995, p. 33). So, interior design can be defined as some subjects which are combined together to make a relation with the spaces around. "Interior design is a complex subject involving many related considerations. These include building structure, functional planning, concern with spatial form in three dimensions, the relationship of one space to another, the placement of solid objects (Furniture and accessories) within larger spaces, and effects of color, pattern, texture, and light" (Pile, 1995, p. 43).

On the other hand, Coles, & House (2007, p. 14-15) introduce interior architecture as factor that all buildings can fall within practice without any limit on their type or size. Then, Kahn (cited on Gill, 2006, p. 21) mentions the architecture and believes that it begins with a room. He also mentions architecture as a place of mind, "you in

[1] Both the terms interior design and interior architecture is used fairly in line with the way they are used in the sources.

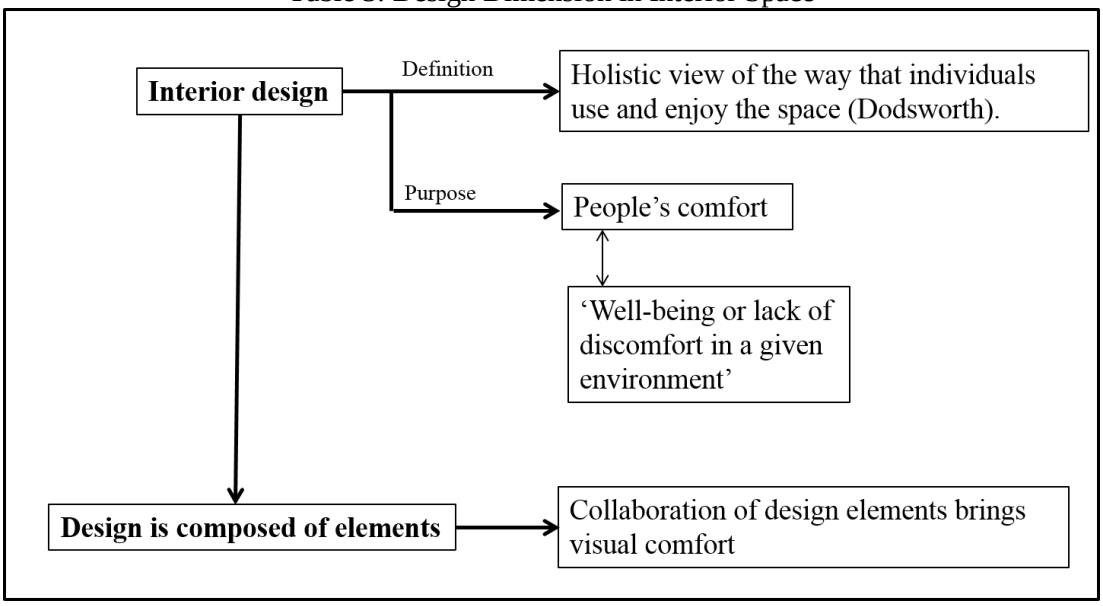
a room with its dimensions, its structure, its light respond to its character, spiritual aura, recognizing that whatever the human proposes and makes becomes a life". Kahn (cited on Gill, 2006, p. 21) continues that the room's structure should be evident in it. But interior design is much more than it looks like as such Dodsworth (2009) mentions it as a 'holistic view of the way that individuals use and enjoy the space that they inhabit'. Dodsworth (2009) also believes that interior design means to find or create an answer to sets of design problems that can unify the experience of the space. On the other hand, Turrell (cited on Vaughn, 2008, p. 25) says people always make forms instead of making space, and then they add design elements in it. So it is shapes of various forms that explain the geometry of the space (Gill, 2006, p. 28).

Serra (1998, p. 127) insights people's comfort as the main major in the field of interior design; she defines comfort as 'well-being or lack of discomfort in a given environment'. People experience spaces through their perceptual system; they explore their environment by their movement of an object to another (Gill, 2006, p. 29). "The union of materiality and hue work together to develop impression on the physical space" (Lawson, 2003, p. 18). As Beever (2006, p. 14) mentions, the design is composed of elements such as color, form, shape, texture, and light, and with the help of these elements it communicates the message to the occupants. "By this interaction of contrasting elements, a complex perception of material and space is generated" (Lawson, 2003, p. 21).

Design can be 'dissected into basic components' and design elements are known as these components (Beever, 2006, p. 10). In interior design, each element has its own identity which is distinguishable from the other elements (Beever, 2006, p. 11). As

Beever (2006, p. 10) Quotes Klammer& Schulz (1992), people experience is divided into object and action as two basic categories; “as a result, design elements are selected based on their intended use and function and their particular contribution” (Beever, 2006, p. 11).

Table 3: Design Dimension in Interior Space



2.1.3 Basic Design Elements and Principles in Interior Design

Quality of designed space is related to the way designer combine and use design elements and through the use of the principles they are organized with (Pile, 1995). Thus, understanding basic design elements and principles is necessary as the first step in the design process. “The terms basic design indicates a body of ideas about design that is as general and universal in application as to transcend the special and detailed concerns of design projects. Basic design deals with theories and principles that refer to all aspects of all design” (Pile, 1995, p. 43). Besides this, according to Ching (cited in Beever, 2006, p. 10), selection of design elements and their organization is needed to satisfy the ‘functional and aesthetic needs’. Accordingly, all design elements should work together with design principles.

2.1.3.1 Interior Design Elements

There are many kinds of design elements which are categorized with different designers in various works. For example, design elements in a two-dimensional painting are different from design elements in a three-dimensional statue and they both are also different from interior design elements within an architectural perspective. For instance, Ching (2007, p. 1) mentions point, line, and plane as the primary design elements of all matters. He believes that point is the beginning of all pictorial forms. Each indicated position in the space is called a point. The point becomes a line by its length, direction and position. Line is the first 'one dimensional element'; it starts and ends with two points. Then, lines can make a plane by their length, shape, surface, orientation and position; and the movement of planes in different directions will make a form (Ching, 2007, p. 1).

On the other hand, Wong (1972, p. 7) introduces four main groups for the design elements. These are: (1) conceptual elements, (2) visual elements, (3) relational elements and (4) practical elements. He also believes that all design elements should fall within one of these categorizations, and work together that they will have no meaning if the designer uses them individually.

(1) *Conceptual design elements:* The existence of conceptual elements are not actually visible, but 'they seem to be present. For instance, while individuals look at a formed object, they almost know the points at the end of the angles, or they understand that form came to life by combining planes, but they cannot see them because those points or planes are not there, if they were there, they would no longer be conceptual (Wong, 1972, p. 7).

The next picture shows an example of using the conceptual element in interior design of a space. In this example, there are two planes which are connected to each other by a line, and there is a circular shape in the middle of one of the planes. However, with a whole view, there is just a curved 3-dimensional form in the space [Figure 1].

Figure 1: Conceptual elements in interior design of a space (URL 1).

(2) *Visual design elements:* If each conceptual element has its own color, texture and material, they become visible and can be introduced as a visual element. If it happens, and they replace to visible elements, their role will be important because they are all of what people can see of the design (Wong, 1972, p. 7).

The next example is demonstrating visual element in interior design of one of the Karim Rashid's works. In this example, there are two visual elements that have their own special color. Here, there is an egg form in red color with a hole in the middle, the empty place is colored in black. The black hole looks like a planar element in the form, for the placement of the goods [Figure 2].

Figure 2: Visual element in interior design (URL 2)

(3) *Relational design elements:* Relational elements govern the interrelationship between the shapes in the design. This relation may be by element's direction or their position in the space (Wong, 1972, p. 7). The next example is one of the Zaha Hadid works in Palazzo della Ragione. This picture is a proper example of using a relational element in interior design. In her work, she has used many cube shaped elements on the floor, according to relational design element point of view, the size (high), and shape of all elements are related to each other [Figure 3].

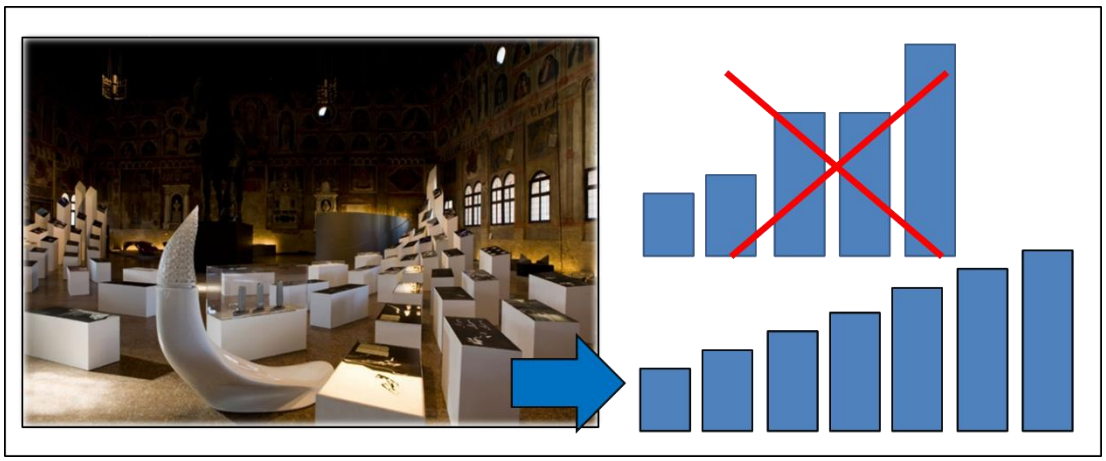


Figure 3: Relational element organization in interior design of the Palazzo della Ragione – Zaha Hadid (URL 3)

(4) *Practical design elements:* Practical elements are representation, meaning and the function of it. For example, representing means how that element exists naturally or artificially. What viewers understand while watching it or what is the element's message or its meaning. Moreover, served the purpose of a design element is called is its function (Wong, 1972, p. 7). Next example demonstrates a good practical design element in architecture. Here, many arched elements are repeated in the same size and shape to direct users to a certain point [Figure 4].

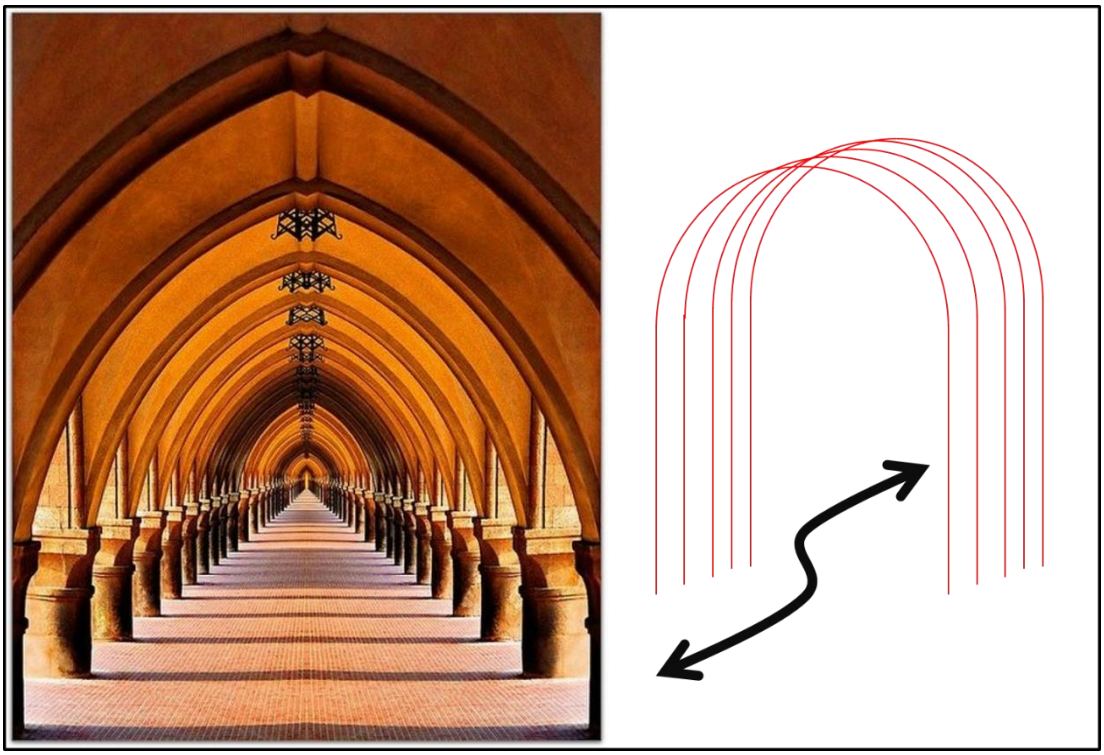


Figure 4: Practical element in interior design (URL 4)

According to the interior design point of view, Rao (2012), and Zelanski & Fisher (1996) believe that the interior design process is based on interior design elements and interior design principles. Zelanski & Fisher (1996) introduce line, shape/form, space, texture, value and color as main interior design elements. On the other hand Rao (2012) adds material, pattern and light to their approaches. In addition, Lauer &

Pentak (2011) believe that illusion of space and motion are other design elements. The basic design elements and principles under this section mostly were defined based on the researchers' approaches that are already mentioned.

Grimley & Love (2007) classify interior design elements into two groups, fixed elements and movable elements. According to those mentioned researchers, walls, doors, windows, moldings, cabinetry, and light fixtures, all are fixed elements. On the other hand, all furniture and art works can be considered as moveable interior design elements. However the focus of this study will be under the "fixed" classification based on opening and fenestration design. "The elements of interior design are the separate parts or components that make up a space. The term comes from the long-used phrase elements of architecture, referring to the basic building components – walls, floors, ceiling, columns, doors, windows, and similar items" (Pile, 1995, p. 203).

The elements under this section are categorized according to Zelanski & Fisher (1996), Lauer &Pentak (2011), Pile (1995), and Rao (2012) approaches which include: *line*, *shape* and *form*, *material*, *pattern* & *texture*, *color*, *value*, and *light*. Each of these elements is displayed and supported with examples of interior spaces among known famous interior architects' works.

1) *Line*: Line is introduced as the main design element; by combining lines many different shapes will be created (Rao, 2012). The motion of a point (Lauer & Pentak, 2011) creates a line as only one dimensional design element. As Lauer & Pentak (2011, p. 128) points out, "in theory, line consist only of the dimension of its length, but, in terms of art and design, we know line can have varying width as well".

From the interior design perspective, the concept of line can be defined in various models; it may be caused by specific lighting, using linear form, and painting and also through special furniture's design. In addition, as Pile (1995) points out: "when a point moves through space or when two points are connected, the line is generated. Line, which may be straight or curved, has length but not breadth. We seem to see lines where things have edges, where one plane meets another, or where there is a change of color or surface in a plane" (p. 47). Then he categorizes line, as he says a straight line can fall into several positions vertically, horizontally, diagonally, and curvedly [Figure 5].

Figure 5: Linear element in interior design (Hjørring Central Library, designed by Rosan Bosch) (URL 5)

2) *Shape and form*: According to Rao (2012, p. 3) form is mentioned as each shape or every mass that are strongly related to the lines. On the other hand, Lauer &Pentak (2011, p. 152) states that "a shape is a visually perceived area created either by an enclosing line or by color or value changes defining the outer edge". In addition, Ching (2007) mentions the form as an 'inclusive term' that is categorized by their shape. He believes that all objects have their own form and shape. In terms of interior design, shape or form can be used as various types, if they are geometrically shapes or not; the important thing is that all physical objects in interior space are defined as

forms and shapes (Lauer &Pentak, 2011). According to Ching's (2007) definition, the shapes are more two dimensional planar elements and forms are more three-dimensional elements [Figure 6].

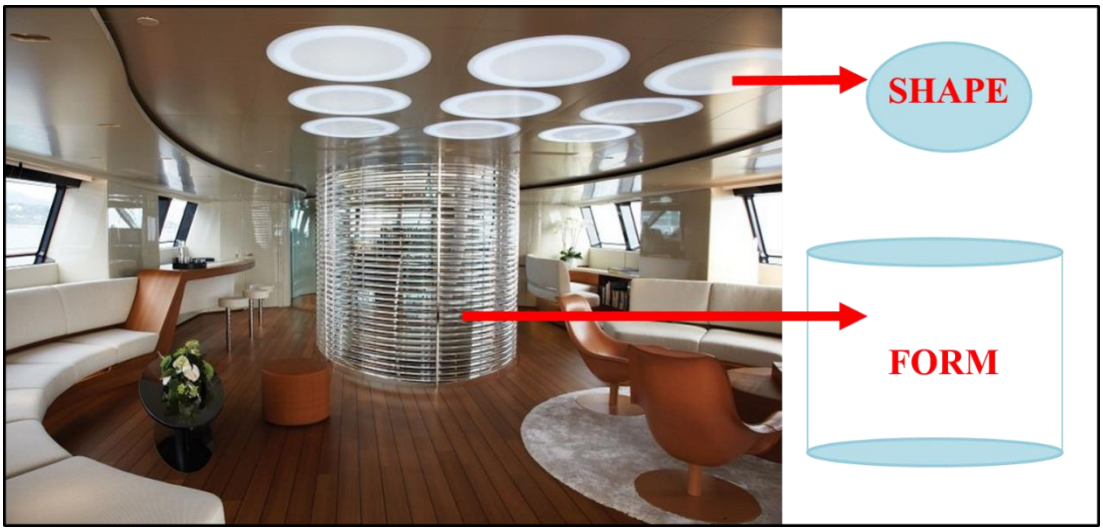


Figure 6: Shape and form in interior design – Lord Norman Foster (URL 6)

3) *Material*: "Every interior exist within a structure made up of materials organized in a way that provides an enclosure envelope and a supporting system of elements having an architectural or engineering basis" (Pile, 1995, p.203). Whatever is used in a building is a kind of material. Such as: stone, cement, timber, iron, wood, glass and everything which used to make an object (Rao, 2012).

Choosing material to design an interior space is one of the important parts of the design process. Dodsworth (2009, p. 106) believes that in terms of interior design, the aesthetic purposes of using or choosing materials are as important as particular purposes. Finishing material and furniture's material play an important role to the elegance of the space and they affect viewer's perception, so they also affect designer's work [Figure 7].

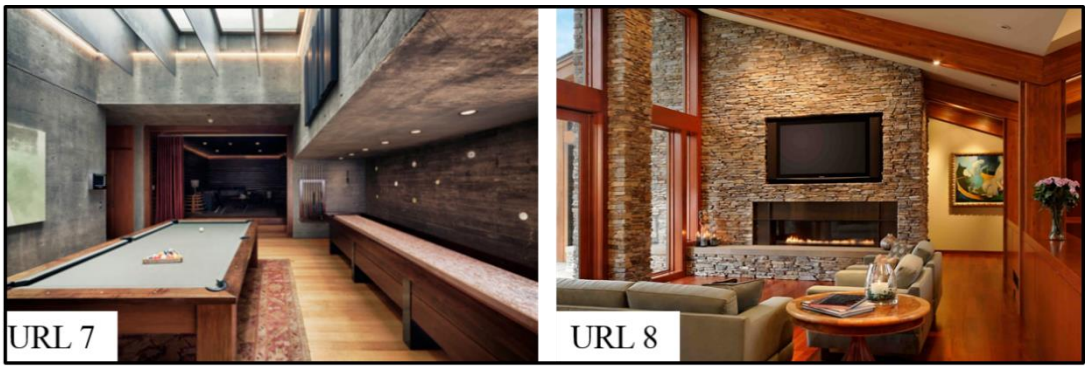


Figure 7: Use of various materials to design interiors

4) *Pattern and Texture*: The character of any surfaces of any objects is its texture. "Pattern is a kind of surface enrichment" (Rao, 2012, p. 4). Every visible object has its special pattern or texture, it may be smooth or rough, but it exists everywhere on all surfaces. Texture is a definition of surface's quality that brings sense to the place (Dodsworth, 2009) [figure 8].

Figure 8: Left picture: Pattern created in interior design (Poncho no. 8- an Italian restaurant) Right picture: interior design based on use of texture (OWEN Design by Tacklebox Architecture)

5) *Color*: Yellow, red and blue are known as primary color categorization, and then by mixing these three colors in different ways, thousands of new colors will be made (Rao, 2012). Colors have different sense, as Grimley & Love (2007, p. 136) states:

"color remains one of the most challenging and contentious aspect of interior design". Each color has its sense which affects the viewer's perception. Holtzschue (2011) says that color is the first visual element, and it is seen by the eyes but is 'takes place in the mind'. For example, blue seem cold, on the other hand red looks warmer, so in terms of interior design it should be considered that the color is used in the space to affect occupants' perception (Holtzschue, 2011) [Figure 9]. On the other hand, the effect of color also is related directly to the light, "the effect of color results from some special properties of light" (Pile, 1995, p. 261).

Figure 9: Color and interior design (Modern College Interior Design by Clive Wilkinson Architects)

6) *Value*: Lauer & Pentak (2011), explain the value as lightness or darkness of a space or objects' color; if only one color is used in the design and designer played with its darkness or lightness, then the value comes to life [Figure 10].

Figure 10: Value as one of the design elements in interior design (Silk Road restaurant- Designed by Karim Rashid)

7) *Light*: "Human vision depends on the perception of light" (Pile, 1995, p. 261). As Rao (2012) states, in architecture, light is defined as a kind of art and utilitarian element which directly affects its environment; it may not be introduced as a design element but it is an artistic element which gives mood to the space. In addition, Holtzschue (2011) mentions the effects of light and believes that light directly, affects all elements, without proper lighting, none of the elements can be seen so it also affects the viewer's perception too [Figure 11].

Figure 11: Interior lighting design and its affect to design elements

2.1.3.2 Interior Design Principles

Besides design elements and their significant role in the design process, considering the design principles also are important. Rao (2012) believes that in order to have a successful design, all elements should work with design principles. According to the principles of design, Rao (2012), Zelanski & Fisher (1996), and Lauer & Pentak (2011) all are agreed with classifying interior design principles in 7 groups: balance, emphasis & focal point, rhythm, repetition, scale and proportion, unity or harmony, and variety.

1) *Balance*: "Balance is equalization of attraction on both sides of the center" (Rao, 2012, p. 4). Balance means making visual comfort for the viewer's eyes and it happens when the elements of designed object are in a harmony, according to Zelanski & Fisher (1996, p. 36- 53) balance consist vertical balance and horizontal balance.

   The easiest way of making, balance, is designing both sides such as in a mirror. It means whatever is used on the left side it should repeat on the right side too, or how the designer has designed top of the object, he should repeat it on the bottom of the object too, this kind of design is based on symmetrical or formal balance (Pile, 1995) [Figure 8]. On the other hand Ching (2007, p. 411) mentions about the asymmetrical or informal balance. As he says, an informal balance is "a state of equilibrium between contrasting, opposing, or interacting elements. Also, the pleasing or harmonious arrangement or proportion of parts or elements in a design or composition" [Figure 12].

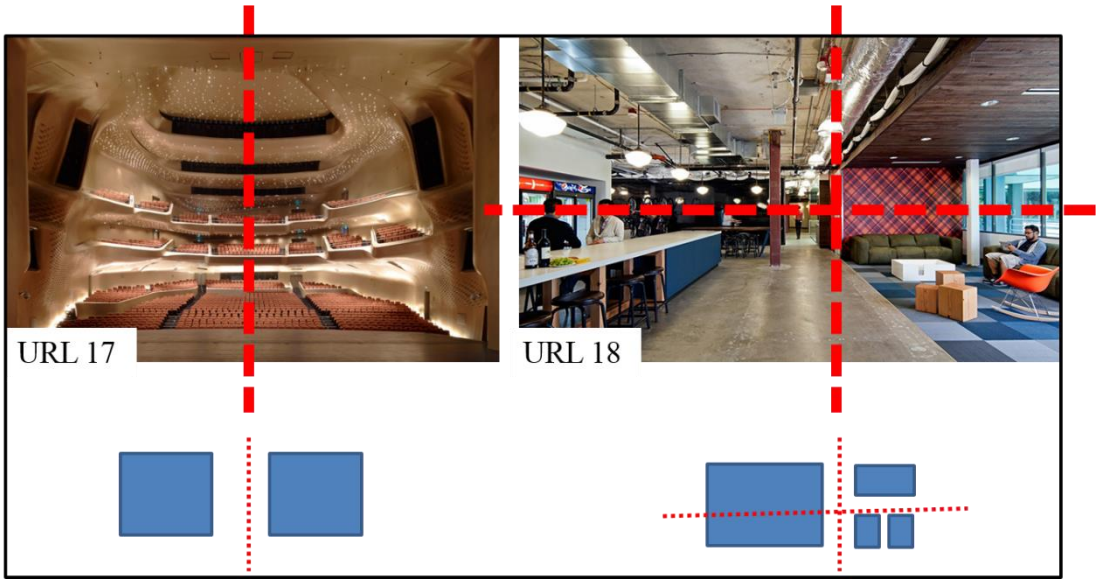


Figure 12: Balance as one of the design principles in interior design (Left side: Formal balance, Novel Opera de Guangzhou- designed by ZahaHadid Right side: Informal balance, Microsoft's new office, designed by Studio O+A)

2) *Emphasis and Focal Point:* Lauer & Pentak (2011) describe it as attracting attention. "Emphasis helps to center the interest in the most important thing or spot in any arrangement" (Rao, 2012, p. 5). According to Zelanski & Fisher (1996), emphasis happens when designer design a focal point or a special object in the space to force viewer's attention to it. There are different ways to create a focal point in a space. All objects and elements may be designed as a focal point. It may be happened by designing a special form; emphasis also can be created according to the color or texture. Sometimes lighting an object in a special way will be a focal point. Thus, the way designer focuses on something is the focal point of the space. Similarly, Pile (1995) believes that emphasis means trying to show something especially in the space and "this is achieved through balancing size, value, color and selection of material" (p. 57).

Next example demonstrates how focal point is created in a space. The left picture is *Moroccan Bank's Regional Offices*. Here designer brings down a linear form from

the ceiling to make sitting place. Thus, this sitting area creates a focal point in the space. On the other hand, the right picture also displays focal point in Reichstag Glass Dom Roof. Here, it is the museum architecture which makes a focal point in the space [Figure 13].

Figure 13: Focal point in interior space (Left: MOROCCAN BANK'S REGIONAL OFFICES - Designed by FOSTER + PARTNERS, right: Reichstag Glass Dom Roof – by Norman Foster)

3) *Rhythm*: The eye movements of something called rhythm. Pile (1995) believes that mind enjoys the rhythm. He introduces rhythm as a significant design element 'in both historic and modern design'. The ways lines, shapes, color or forms are repeating will develop the rhythm (Rao, 2012). Additionally, Pile (1995) mentions rhythm as a concept which borrows from the music and states that: "rhythm relates visual elements together in a regular pattern. It can be achieved by repetition, whether simple, as in a rhythm such as 1 1 1 1, or more complex, as in *1* 111 *1* 111 *1*" (p.56).

With an agreement, Zelanski & Fisher (1996, p. 36- 53) also explain rhythm as a design principle which includes the movement of a viewer's eye through the repeated object. It may happen while a color is changed during object's repetition or may

happen while the size of the objects are changed, so the rhythm is named to the changes that occur in an object during repetition. Direction of repeated objects is another way to create rhythm [Figure14].

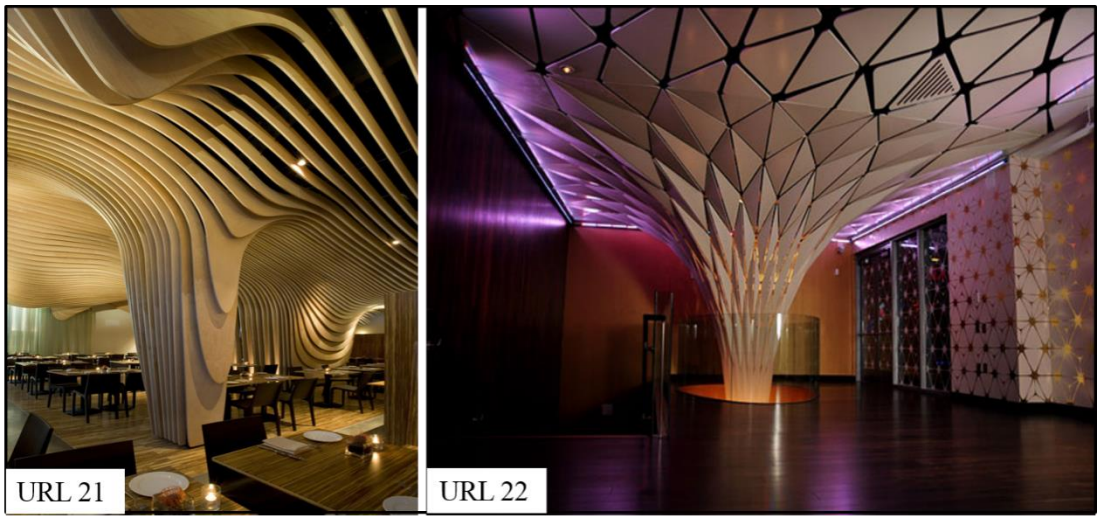


Figure 14: Rhythmic elements in interior design

4) *Repetition:* "If we use the same form more than once in a design, we use it in repetition" (Wong, 1972, p. 15) [Figure 11]. Wong (1972, p. 15) introduces eight ways that an item may repeats, (1) repetition of shape: as shape has already been introduced as one of the main factors, so its repetition is important too, it may be happened in shape sizes or their colors. (2) Repetition of size: it just will happen when the shapes are very similar or repetitive. (3) Repetition of color: it happens when the color is same in all objects, but their shape or size may be different. (4) Repetition of texture: it is like color repetition, the shape and size may be different but their texture is same. (5) Repetition of direction: "this is possible only when the forms show a definite sense of direction without the slightest ambiguity". (6) Repetition of position: "this has to do with how forms are arranged in connection with the structure". (7) Repetition of space: it means that all forms occupied the

space in the same manner or way; in other word all forms are negative or positive. (8) Repetition of gravity: “gravity is too abstract an element to be used repetitively” (Wong, 1972, p. 15).

Figure 15: Repetition of same size of elements in interior design (The Cave Restaurant Design by Koichi Takada Architects) (URL 23)

5) *Scale and proportion:* It is a complete relationship between each object with another and to the whole designed area (Pile 1995, p. 53). “Proportion is the consideration of weight, shape and division of an object. It demands that all space divisions should be pleasingly related to each other” (Rao, 2012, p. 5). In similarity, Lauer & Pentak (2011) states that scale and proportion are directly related to size. Ching (2007) believes that in terms of design, scale is referred to human dimension; it means that all elements should be designed according to human dimension. On the other hand, scale as one of the design principles also can be defined as interior element’s arrangement according to their size [Figure 16].

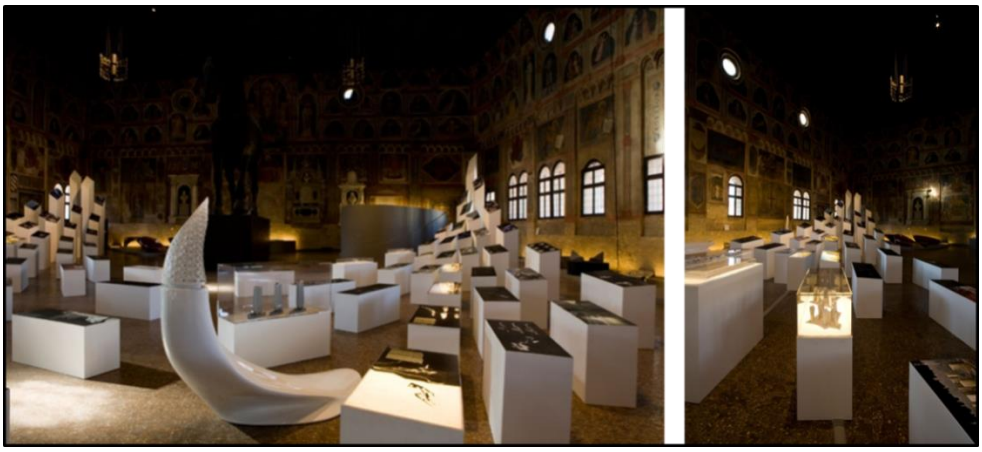


Figure 16: Scale of elements in terms of design (Palazzo DelDesignedone, Padua, Italy Desined by ZahaHadid) (URL 24)

6) *Unity or harmony:* It happens when everything, each element and all objects are designed or organized in conformity (Rao, 2012). In addition, Ching (2009, p. 418) mentions unity as "the state or quality of being combined into one, as the ordering of elements in an artistic work that constitutes a harmonious whole or promotes a singleness of effect". He also mentions both proximity and similarity as supplementary components of unity and harmony.

Next example displays harmony in interior design of two spaces. The left picture is a part of a restaurant, here there is a long dining table which is matched and fits with its location. Thus, the lighting design above it is also matched with the shape of the dining table. This lighting is as long as the table is. On the other hand, the colors of all objects in this space are in harmony with each other. On the right side, the picture shows a room of the Burj Al Arab hotel. Here designer made harmony in the space according to colors with the special Arabic design. They all are traditional forms and colors which are used in the interior design of a modern hotel [Figure 17].

Figure 17: Harmony in design
Left Picture: Unity is happened by using a same form in 3- D and 2-D as lighting design and the table.
Right Picture: There is a harmony of shapes and forms in the design of the space which is matched with Arab traditional shapes.
Additionally, in both pictures there is a harmony of the used colors.

7) *Variety*: Variety is mentioned as another design principle which is happened when designers use an item more than two times by varying them, so to vary an element and using it several times is called variety and is introduced as one of the design principles (Zelanski & Fisher, 1996). The next example is one of Karim Rashid's interior designs. Here he used curve shapes in his design and used them in different ways. Sometimes, as a spherical shape and sometimes just curved two dimensional lines on the ground or on the ceiling. Furniture, colors, paintings, shapes and all things here are designed considering curvy shapes which called variety in interior design [Figure 18].

Figure 18: Variety in design- Karim Rashid's interior design –Lotte Amoje Food capital

All design elements should work together, and also they should be organized according to the design principles. While elements are designed based on principles, they will create other elements. For example, a rhythmic design of forms also creates texture, and this called collaborating elements and principles which bring aesthetic to design. On the other hand, light is being discussed as the most important artistic element that is caused to save the elegance of the space. Without light, none of the elements and the way they are organized can be seen. In the following summary of the section is given and is continued with the significance of natural light in the further section.

Table 4: Design Elements and Principles

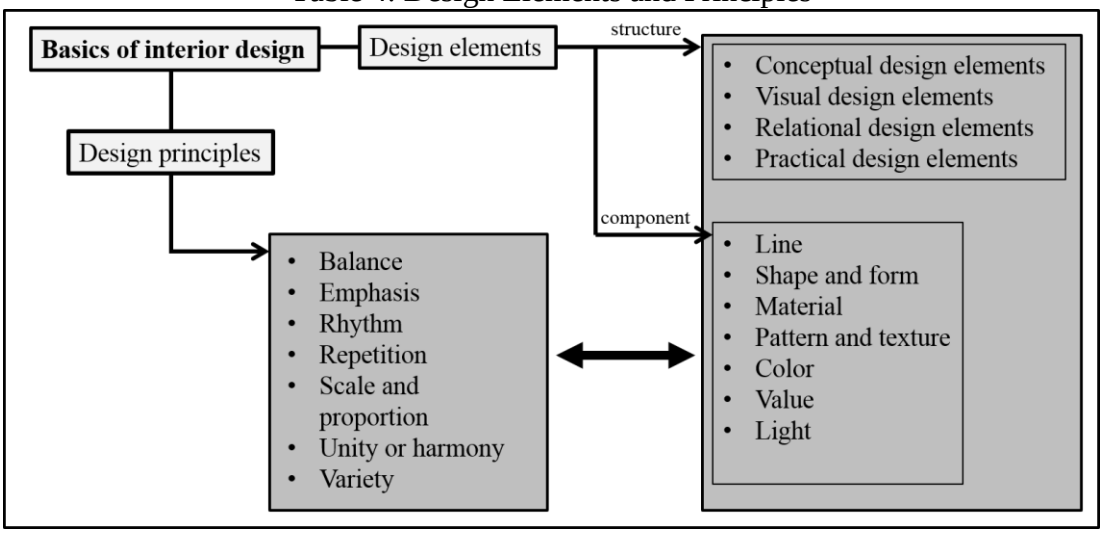


Table 5: Summary of the Sections-2.1 (Interior Design) / 2.2 (Design Elements And Principles)

➢ Evolution of interior design

- considering to mythical power over hunted animals.
- Focusing on the structure such as huts, tents, igloos, tepees, and yurts.
- Focusing on Basilicas and churches → exquisite painting of Jesus, his followers, religious laws and the stories of the Jesus
- with the advent of Islam → focus turned to the Islamic mosques with the names of God, Islam's first followers and flowered design. in this time
- Later middle ages → various types of arches, standing glass, buttresses, and gargoyles in indoor spaces
- Renaissance, Baroque and Rococo → periods of luxury-oriented, abundance use of golden colors, painting portrait , lots of two or three dimensional statues , expensive furniture
- Invention of electricity → at the end of the 19th century until present : rise of interior decoration/ design vocabulary, architects devised different tactics "DESIGN ELEMENTS & PRINCIPLES"

➢ Design and interior space

definition of the word design:

- In common: meaning pattern or decoration, fashion or stage design According to engineering: sizing structural members
- According to engineering: sizing structural members
- In fine art: design means the artistic or spatial organization of design elements in a space such as line, form, texture, and color.
- In terms of interior design: design is a composed of elements such as color, form, shape, texture, and light, and by the help of these elements it communicate the message to the occupants.

The major file of interior design : People comfort, well-being or lack of discomfort in a given environment.

Design can be 'dissected into basic components' , design elements are known as this components. each element has its own identity which is distinguishable from the other elements

➢ Basic design elements and principles in interior design

- Quality of the space is depended on the ways designer combine and use design elements and through the use of principles they are organized
- All design elements should work together with design principles
- Design elements are different meaning in various condition. For example: a 2-dimentional painting, a 3-dimentional statue, and a architectural design or interior design may have different design element from each other.
- Ching mentions point, line, and plane as the primary design elements of all matters.

Design element

structure

- ***Conceptual design elements:*** to see the point, light, and plane which are not actually exist
- ***Visual design elements:*** when conceptual elements got their own color, texture, material, and light to be visible
- ***Relational design elements:*** the relation between shapes in design
- ***Practical design elements:*** special function and meaning of elements in design

component

- ***Line:*** distance between to point, line shows movement and can be exist easy. By a special lighting or specific painting
- ***Shape and form:*** 2-dimentional mass between lines.
- ***Material:*** what ever is used to built something.
- ***Pattern and texture:*** the character of any surface .
- ***Color: each*** visible object have its color
- ***Value:*** lightness and darkness of colors
- **Light: is defined a kind of art and utilitarian element which directly effects all elements .**

Design principles

- ***Balance:*** equalization of attraction on both sides of the center
- ***Emphasis:*** attracting attention in space
- ***Rhythm:*** the eye movements on something called rhythm.
- ***Repetition:*** use the same element more than once in a design
- ***Scale and proportion:*** consideration' of weight, shape and division of an object
- ***Unity or harmony:*** it happens when everything, each element and all objects are designed or organized in conformity
- ***Variety:*** when designers use an item more than two times by varying them

2.2 Significance of Natural Light

The study under this section is based on the importance of natural lighting in the life and in interior space. At first, meaning of light and natural light will be given. Then, the study will continue with the history of using natural light from the medieval century until now; importance of natural light in the building besides the discussion of the effect of natural light both into space and on the body that is explaining the advantages and disadvantages of natural lighting on both interior space/design and human life.

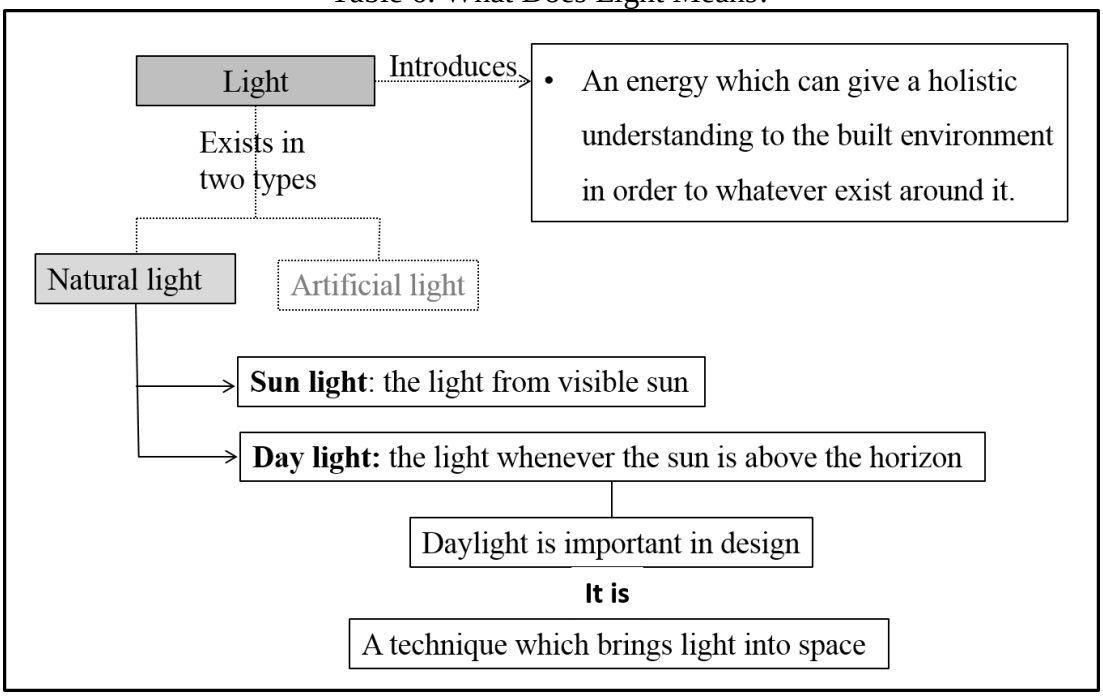
2.2.1 Meaning of Light

Light is introduced as an energy which can give a holistic understanding to the built environment in order to see colors, forms, materials and whatever exist around (Lawson, 2003, p. 32). Vaughn, (2008, p. 30) discuses that there are two types of sources in terms of light: natural and artificial light. However "Kahn relates light directly to the sun". Similarly, Zemmouri & Schiller, (2004, p. 49) also believe that "sun and sky are basic determinants and main sources of natural light".

Natural light includes sunlight and daylight. Sunlight is explained as the light from the visible sun, and daylight as the light whenever the sun is above the horizon if it is visible or invisible (Coles, & House, 2007, p. 120-121). Generally, natural light can be introduced as a technique which brings light into space (Syed Husin, &HanurHarith, 2012). Therefore, natural light and especially daylight is important in design, because design of forms and spaces are dependent on it[2] (Poldma, 2009).

[2] In different sources both day light and natural light isused with the same meaning and in this study both of the terms 'natural light and day light' will be used thoroghly in line with the original sources as they mentioned.

Table 6: What Does Light Means?



2.2.2 History and Culture of Natural Light in Buildings

Pile (1995) believes that light is the main thing that human perception is demented on it. "Without light the human race could not exist" (Barker, 1997, p. 4). Humans have considered the sky since medieval times; the Ancient civilizations used the sky as a tool to be alive (Vaughn, 2008, p. 3). The sun, moon and the stars were the only sources to light the environment; they oriented earliest societies to match themselves with time (Vaughn, 2008, p. 3). The sun as the most important lighting source was used to penetrate through the darkness of caves (Gill, 2006, p. 6). Penetrating sun ray to deep of the caves 'where the main aim of using natural lights' specifically sunlight; through history, there were several ways to penetrate sunlight into space, openings and fenestrations are the main alternative to bring it into space (Coles, & House p. 122-123). As Robbins (1986) believes, "Day lighting has been a part of built from throughout architectural history" (p.ix), however, in the earliest architecture, there were no specific kind of openings, they were just as a simple

whole on the walls with no glazing material and also limited in size because they had to keep the air (Coles, & House p. 122-123).

There has been daylight since beginning of the time in the world and use of it dates to the caves and ancient human shelters until 1900 (Philips, 2004, p. xix). Pile (1995) mentions, until modernism period daylight was the primary lighting sources. As he puts out: “Until modern times, daylight was the primary source of light everywhere; the design of buildings had to take into account the lighting of the interior through windows and such alternatives as skylights” (p. 293). Open fires, candles and many types of lamps were as an auxiliary light before modernism, which were difficult to control and had a limit to the amount of light. Then in 1879, artificial lamp innovated by Tomas Edison and designers turned into electric lighting, which was more qualitative and easy to control (Pile1995).

Vaughn (2008, p. 12) believes that artificial light made after 100 years pass following the invention of the electricity. In addition, Robbins (1986) puts out that “in fact, only during the past thirty five to forty years has day lighting not been considered the primary interior illuminating source during daytime in almost all buildings” (p.ix). Accordingly, the discovery of artificial light made natural light compete with various types of artificial types. It has been shown in some buildings that were designed and build with no fenestration as windows (Philips, 2004, p. xix). Pile (1995) also mentions that there were some large stores, offices, and homes which used artificial lighting as primary light sources. For example, in 1946, Swedish factory owners built a windowless factory to create a cleaner environment which was not found very successful due to its ventilation and illumination all was through electricity. On the other hand, the employers also need to break out wall

panels to get contact with the outside world (Kilbourne Group Blog, 2012) [Figure 19].

Figure 19: Windowless factory that was built in 1946

The illuminating depth of the buildings was the main advantage of using artificial light, which was not healthy. On the other hand, increasing fossil fuels and its finite life made people think of natural light which was familiar with human spirit and healthier for the body (Philips, 2004, p. xix).

During the expressionism period (before and after the First World War), architects started to search about light and its design as a central theme (Gill, 2006, p. 16). Shifting the use of natural light to artificial lighting design was the result of the abundance of electric power, especially after the war; during the postwar period, most of the architects misused the flexibility that artificial light offered, they looked at it as an important advantage but unfortunately they missed how to make a space sensitive (Vaughn, 2008, p. 12). Lots of windowless buildings were the result of increasing use of electric power in the 1960s. As Robbins (1986) continues: “since 1973, interest in day lighting has increased as a result of the oil embargo and the understanding that electric light represent a major energy end use in many kinds of

commercial, institutional, and industrial buildings" (p. ix). Therefore, architects started to think about the importance of using natural light to light the indoor environment (Gill, 2006, p. 8). Accordingly, natural lighting becomes an art which studied technically (Pile, 1995).

Barker (1997, p. 18), introduces Gian Lorenzo Bernini, that was an Italian artist and as one of the first architects who was considered to use natural light into the space. "One of the first architects to orchestrate natural light was Gian Lorenzo Bernini (1598-1680) who brought to the seventeenth century a passion for spatial dynamics which would seldom be rivalled…his techniques was a massing of surface and void, which relied on sunlight to express the sensation of textural boundaries afloat within vast interiors" (Barker, 1997, p.18). See Figure [20] for of Gian Lorenzo Bernini's work.

Figure 20: Gian Lorenzo Bernini's work (St. Peter's Basilica- Italy- 1626) (URL 31)

Gian Lorenzo Bernini was not the only architect, Barker (1997, p. 4) also points out Frank Lloyd Wright, Walter Gropius, and Antonio Gaudi as some architects that focus on various solutions to light indoor environment naturally. However, Barker (1997, p. 18) also mentions that "Schindler, Frank Lloyd Wright, Le Corbusier and Eero Saarinen have explored the inherent beauty of natural light". Le Corbusier was

one of the architects that highly preferred to use natural light in his designs during 1945-1965 (as Curtis, 1996 said in Gill, 2006, p. 2) [Figure 21, Schindler, Frank Lloyd Wright, Le Corbusier and Eero Saarinen's works].

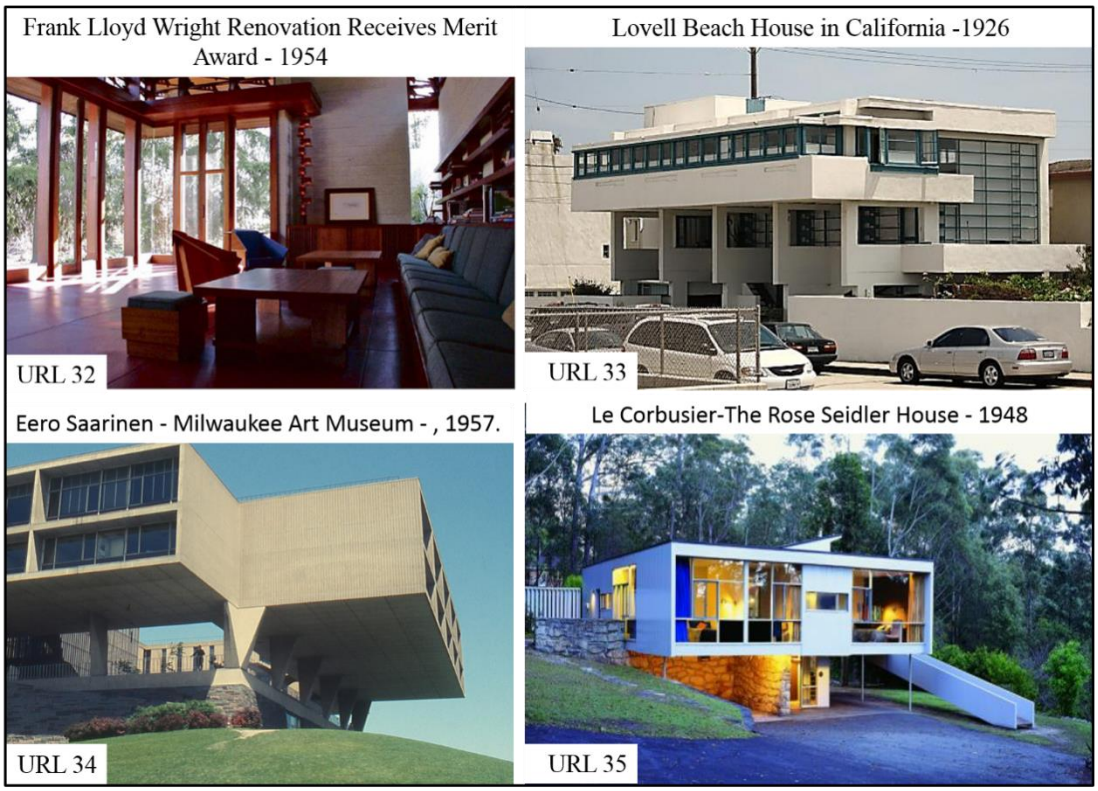


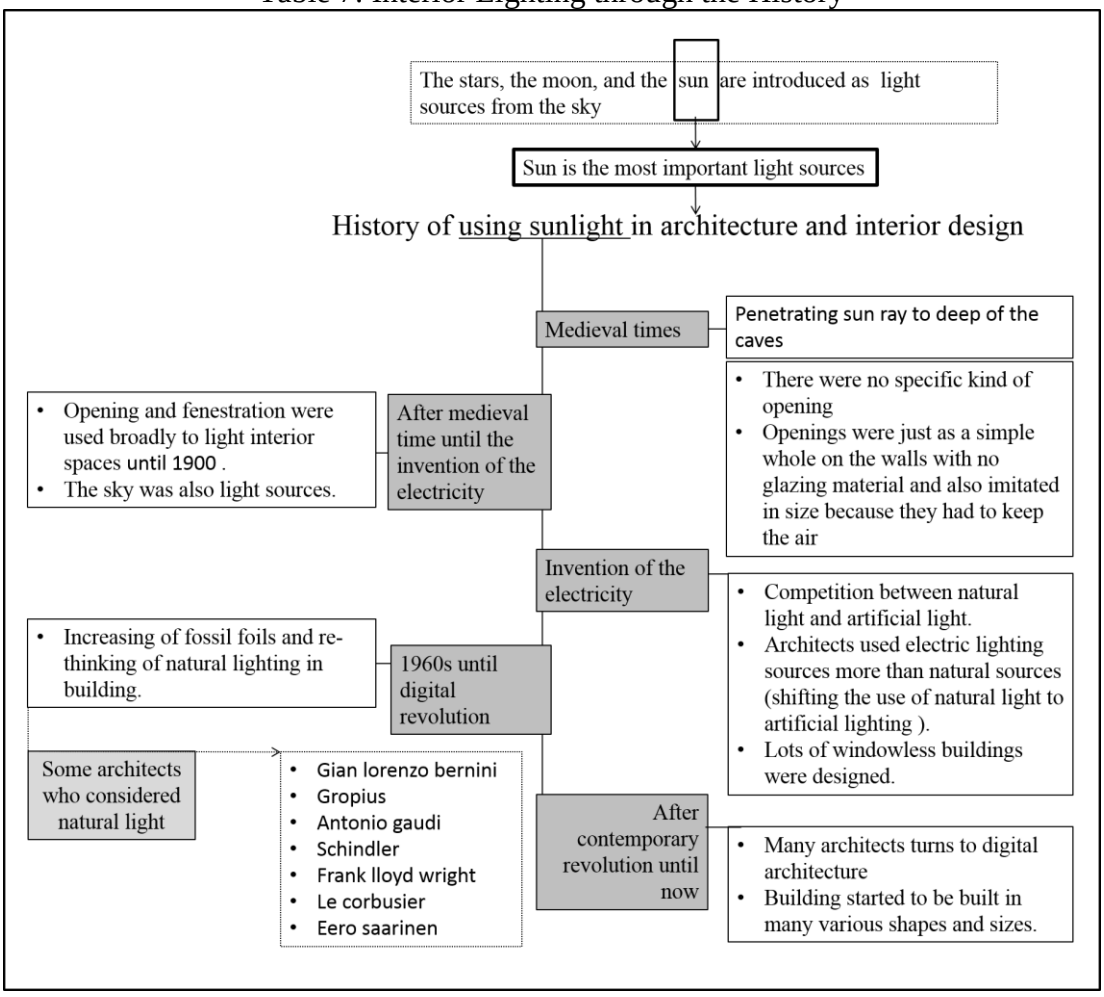
Figure 21: Examples of architects' work - considering to daylight

In the middle of the 20th century, the invention of various types of electric lights affects the essential role that daylight was playing in the buildings; especially in commercial indoor spaces. It mostly was used to light residential or office interior environment; but, over the last 30 years, architects started to rethink of natural light and the advantages of using it in interior space design. Accordingly, the occupant will be able to see outside through an opening, considering psychological aspects of human well-being, and also energy saving (Philips, 2004, p. xv).

According to Vaughn (2008, p. 3), most of architects and designers do not pay attention to the sky and its aspect of natural light, especially daylight and sunlight, which were important aspects of earliest civilization and ancient culture (Vaughn, 2008, p. 3). Similarly, Serra (1998) accentuates, the role of light is ignored in contemporary architecture, as she mentions it in such a way, throughout her words: "Yet when we attempt to analyze the role of light in contemporary architecture, we find a huge vacuum. Today's representative buildings almost totally neglect the important part natural light could play in their interiors" (p. 115).

It was amount of natural light, which was important and considered after modernism until the 1960s. Then, after 1970s, during the contemporary period, contemporary designers such as Zaha Hadid, Frank Gehry, Greg Lynn, Reiser Umemoto and many other architecture groups preferred parametric design approach via digital tools. The opening design and the way they bring natural light into space was changed during contemporary architecture according to this architectural evolution.

Table 7: Interior Lighting through the History



2.2.3 Importance and Effects of Natural Light into Space

Robbins (1986) points out that: "day lighting is both an art and a science; that is, daylight is both a design element and an environmental system, it can enhance aesthetic and qualitative aspects of a building" (p. 3). In addition, Beever (2006, p. 12) introduces light as a significant design element which can 'present itself as an ideal element'. According to Kahn (cited on HikadeStribling, 2009, p. 4) "The most wonderful aspects of the indoors are the mood that light gives to space". As he believes, it is natural light which makes a room alive, where Kahn introduces light as a 'giver of all presence'. As he mentions, in architecture, a space can never reach its place without light. A good day-lighting strategy creates visual stimulation and

productive environment for both the buildings and its occupants (Zemmouri, & Schiller, 2004). So it is essential for each particular space to have its own light.

According to design point of view, the importance of mentioning light as a significant element relies on Rao (2012) which puts out light as an artistic element that states the existence of all design elements and all design principles depends on it. But in terms of natural light, Robbins (1986) counts the importance of natural lighting, which makes it more significant than just thinking of light, if it is natural or not. As he says there are many reasons for considering natural lighting in all types of building interior design, even it is commercial or residential. For instance; quality of natural light, energy conservation, view and contact with the outside world, day lighting apertures as fire exits could be given as some of the reasons. 'Energy consumption and peak cost saving resulting from the use of daylight, no cost chance in construct, opportunity to develop integrate and mechanical systems, psychological and physiological benefits not obtainable with electric lighting or windowless buildings. The genuine desire to have natural light and sunlight in a room and space', and the importance of daylight as a design element are the importance of choosing natural lighting in interior design (Robbins, 1986, p. 3-4).

Similarly, Lam (1983 sited in Robbins, 1986) talks about the quality of natural light, as he believes, quality of natural light can be mentioned as the most important aspect; as he says, the quality of natural lighting is good for vision and visual environment; these two mentioned aspects affect individual ability to see objects properly.

On the other hand, Bean states that: "if you want people to look at something in particular you light it brightly; for when someone walks into a room their attention is

usually drawn first to the brightest object in that room" (2004, P.9). Whereas "Louis I. Kahn dubbed light 'as the giver of all presences' while a very simple statement has immeasurable depth and illustrates just how important light is to architecture" (HikadeStribling, 2009, p. 3).

Tadao Ando is one of the architects that considers the identity of light and believes that "light display its brilliance only against a backdrop of darkness" (Lawson, 2003, p.36). His attention to light is reflected in his works. 'The church of light' is one of his signature works that is built in 1989 in Osaka; "this chapel derives its orientation from the direction of the sun, and from the position of an adjacent existing church building" (Furuyama, 1995, p. 140). Ando display natural light brilliantly in this church [Figure 22].

Figure 22: Church of the light-Tadao Ando (URL 36)

There are two ways of lighting spaces. First is directly from main sources, and the second is indirectly by their reflection to the space (Lindh, 2012, p. 53). While Hue. et.al, (2012, p. 54) mentions daylight as a source of natural light which reduces energy use in buildings, in addition, Poldma, (2009) talks about increasing of indoor

environmental quality, and believes that indoor design, or indoor quality directly depends on how light comes into spaces, and their design. Light and its design is very important for life, “we were born of light; the seasons are felt through light. We only know the world as it is evoked by light…” (Kahn mentioned on Lawson, 2003, p. 24). According to the interior design perspective, light can be defined as the important parameter of the design, where perception of each element or object is depended on it. “Light is an abstract compositional element, creating hierarchy, rhythm, repetition, movement, order, and contrast” (Theodorson, 2002, p. 75).

Theodorson mentions light as an overlooked or additive design element (Beever, 2006, p. 2). But it is important for a designer to know the ways of designing light properly. Thus, it will be so effective which gives the inhabitants pleasing and natural environment (Kotick sited Edwardes, &Torcellini, 2002, p. 32). Using natural light also makes a connection between residents and outside environment, it alerts them of the natural world, the movement of clouds, weather, time, and season (HikadeStribling, 2009, p. 3).

Similarly, Coles & House, (2007, p. 120-121) talk about an inflatable aspect of natural light: “you feel the day going and the clouds moving.” On the other hand, Renzo Piano (as sited in Coles, & House, 2007, p. 120-121) believes that natural light makes a room alive, while daylight is passing, people will turn on it. It could be said that the variability of daylight is the most obvious thing about it “it varies with the season of the year, the time of day, and the weather” (Phillips, 2004, p. xix). Beever, (2006, p. 2) Mentions that intangibility and fluidity of light make it difficult to define or insolate. Furthermore, as Meier, (1997) in Beever, (2006, P.2) states, “you can’t work with light as though is real or solid material. It is a transitory

element…", so by knowing what to want, and determining what is needed in lighting design, it can direct designers in a correct way to get the best result (Vaughn, 2008, p. 9).

"Light can be used to emphasize form depending upon the clarity with which we can distinguish one form from another" (Gill, 2006, p. 28). Lighting is an important subject that has all physiological, psychophysical, and aesthetical aspects in the designed environment (Bean, 2004, p, vii). As Phillips, (2004, p. xv) Reports using daylight in the building have positive effects on both people and their indoor environment. To design interior lighting, psychological and biological aspects of light should be considered to create a well purposeful lighting (Vaughn, 2008, p. 10). KaoraMende is an architectural lighting designer; he believes that the purpose of lighting design is to demonstrate the flow of time, as he says designing light should "create a clear scenario linking scene" (Vaughn, 2008, p. 10-11).

As Serra, (1998, p. 129) mentions:

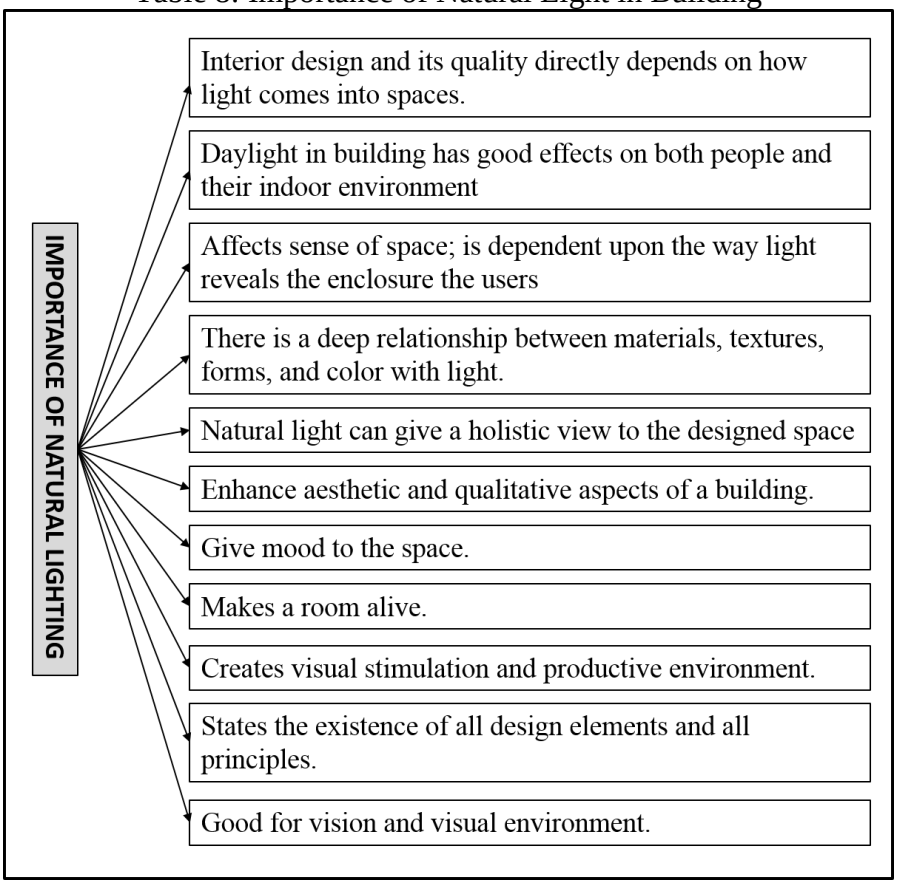
> "The analysis of light on both physiological and psychological levels provides us with the theoretical base for understanding how natural light interacts with architecture, and it is this knowledge that must be used to plan the functioning of light in buildings as a basic part of the project; it should never be postponed as a technique applicable to a previously defined project".

Implementing properly is the only way that can realize the benefits of daylight (Edwards, &Torcellini, 2002, p. 16). Vaughn, (2008, p. 19) defines phototherapy 'exposure of light, time related to natural light, and color of light' as three therapies which are associated with using daylight. So the definition of architecture depends on the major role light plays into space, it can be said that "our sense of space is

dependent upon the way light reveals the enclosure to us" Millet, (1996) sited in Gill, (2006, p. 44). There are three important factors that are directly related to the natural light and its effect to space's perception: '(a) intensity, (b) directional characteristics, and (c) color' (Millet, 1996 sited in Gill, 2006, p. 24-25).

Sun's movement in the sky is its directional character which causes the depth of shadows and makes the contrast between surfaces, it helps designer to design a meaningful relationship with the sun as a source at all times (Gill, 2006, p. 25). Beside shadow or contrast, reflection, color, and intensity are other characteristics of natural light that affect all aspects of design (Serra, 1998, p. 118). As Le-Corbusier (sited in Lawson, 2003) states, there is a relationship between materials, textures, forms, and color with light. Understanding the ways how light can combined with form, texture, and color designers must be let to create an effective, comfortable, and comfortable environment for inhabitance (Vaughn, 2008, p. 10).

Table 8: Importance of Natural Light in Building



"We experience interior through vision", and it depends on the way light enters into space. It is light that makes the space alive through circulation and vision (Barker, 1997, p. 18). As it is well known, natural light is changeable according to the time, so its language and its effect in a sunny June is different from a cloudy January (Barker, 1997, p. 120). So it is very important to know how it is going to be used, for which purpose and for whom (Home How-To institute, 1996, p. 48).

Light can be one of the most important design elements in architecture and interior design, "light is thought to be the soul and spirit of the designed space" (Theodorson, 2002, p. 75). It stimulates an environment and creates a space (Vaughn, 2008, p. 31). Light affects the perception of the space; Gadamer (cited in Lindh, 2012, p. 71) "talks about the light of words making everything visual, evident and obvious."

Unlike other design elements or building materials, light and especially natural light is always changing and it enables the other building's element to change with it simultaneously (Lawson, 2003, p. 6). Light as an architectural design element can create a visual perception dealing with time (Vaughn, 2008, p. 11). "When natural light is allowed to fenestrate a space, the perception that space will simultaneously change with relation to the time of day and season" (Vaughn, 2008, p. 11).

As Louis Kahn mentions "the sun never knew how great it was until it hit the side of a building" (cited on Lawson, 2003, p. 35). The perception of interior environment is activated by the light of the sun (Lawson, 2003, p. 28). It can be said that "Allowing the season of light to enter a space enables the interior atmosphere to change simultaneously with the exterior" (Vaughn, 2008, p.iii). According to Vaughn (2008, p. 41), in order to create a dynamic environment, it is important to manipulate and control the interaction of natural light. Lindh (2012, p. 17) believes that light enables people to see and experience their environment; so a good relation between the surfaces, dimensionality and depth of the surfaces affect the perception of space.

Light as a significant design element plays the most important role in the perception of the space (Lindh, 2012, p. 57). Lindh (2012, p. 57) explains the concept of perception as a word that describes how people see or understand the size, shape, depth, and distance of space, "it also addresses experiences such as the level of light and the level of color as perceived quality" (Lindh, 2012, p. 57). As Beever (2006, p.V) states, to the act of composing indoor spaces, interacting between light and space can be significant. "Within the discipline of interior design, light is often appreciated only for its functional value as opposed to being understood as a compositional tool to be explored and manipulated in the design process" (Beever,

2006, p.V). In a similar way, Vaughn (2008, p. III) describes light as an element that has the inherent ability to increase spiritual experiences of space.

As Kahn realized, form and space have no meaning without light (cited on Vaughn, 2008, p. 31). For instance, according to Kahn "light is the best of every architectural effect" (Gill, 2006, p. 20). Furthermore, Gill (2006) introduces light as an element that plays on the perception or the space subjectivity; as Gill (2006) says: light can filter, guide, extension, and illuminate. According to Lawson (2003, p. 24), "an architecture must have the religion of light. A sense of light as the giver of all presences", Lawson (2003, p. 24) believes that all rooms and spaces should be in daylight, because it gives the mood of the day and brings the season into space. As Lawson (2003, p. 41) says "when a light enters a room, it is your light and nobody else's. It belongs to that room." In a similar way, Serra also (1998, p. 115) describes a great architecture as an architecture that is always associated with daylight.

There are many different approaches through which architects design natural light (Serra, 1998, 132). As Vaughn (2008, p. 14) mentions, buildings with a simple lighting system that incorporate daylight usually perform much better than the buildings which apply elaborate lighting system. Various methods introduce light into architectural forms and spaces, but bringing natural light into space depends on orientation and the location of the sun (Lawson, 2003, p. 22). Edwards, &Torcellini (2002, p. 31) state that consideration of quality and quantity of light during the design process are the important parts of the design.

Having more surface presents more natural light into spaces (Vaughn, 2008, p. 14). As Lindh (2012, p. 19) says: large surfaces have economic implications; "we cannot

afford to illuminate everything. Instead of uniform general lighting, we have a pattern of light spots seen against a dark background. Lit indoor spaces or outdoors spaces in day lighting allow for an immediate and clear overview over a space" (Lindh, 2012, p. 19). With all positive aspects of using natural light into the space, Vaughn (2008, p. 9) believes that "incorrect directional light on textured material can cause a washout effect."

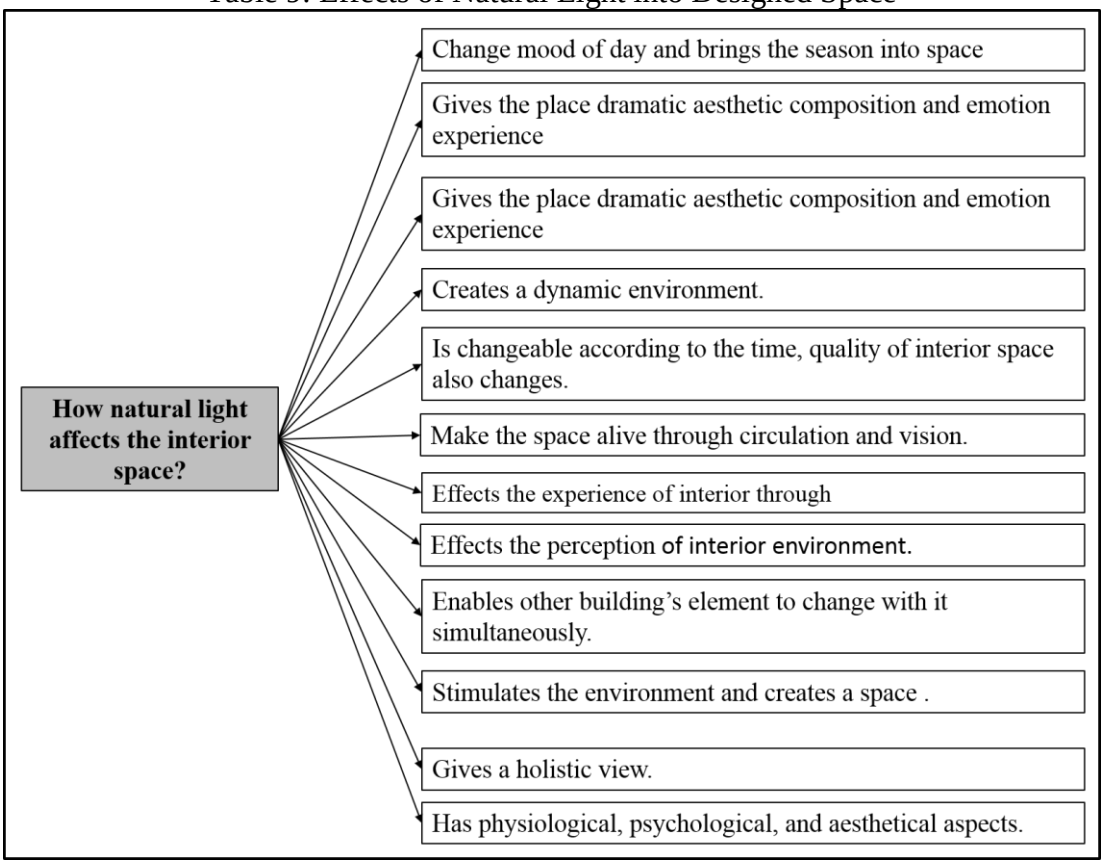
According to Vaughn (2008, p. 16), by designing a good natural lighting system, designers can give the place dramatic aesthetic composition and emotional experience, it can connect the occupants to their environment. To continue, Vaughn (2008, p. 016) also states that designers should understand the light's flux and flow, they should know how to distribute it and how to select materials, because all these are as important part of a successful day lighting design. On the other hand, Lawson (2003, p. 6) mentions that, it is essential to understand about the function of the space for adequate light and the amount of light to have visual senses and enchanting the mind. In order to have a good lighting designed space "the relationship between light and interior space is a mutually dependent on each other. Light renders space; without light, form, color, texture, and scale are unrecognizable. In return, space captures light – receiving it, shaping it, bending it, hiding it and modeling it" (Beever, 2006, p. 1). Moreover, the most important factor is distribution of light (Lindh, 2012, p. 17).

Light and spatially natural light affects the building a lot, for example, direct light makes the space confining at a lower level (Phillips, 2004, p. 42). "The reflectivity of the surfaces and its color can modify the resulting rays of light" (Lawson, 2003, p. 15). Lawson (2003, p. 21) says that understanding the space and the reality of it is

not just through present light, it also happens to its counterpart of shadows; Lawson (2003, p. 21) believes that to understand the full environment, the quality of light and its shadow can be important. “Ranging from the penumbra, total eclipse of light in pure shadow, to the umbra, the partial of light, the physics of light and shadow lend dynamic to the perception of the space” (Lawson, 2003, p.21).

Having the contrast in levels of lighting is a potential for visual rhythm, it plays with light and shadow on surface material, Lawson (2003, p. 21) calls it ‘loud speaker of our perceived reality’. In a similar way, Millet (cited in Gill, 2006, p. 26) talks about contrast as an essential parameter that gives variety in the space; as he says, differentiation between brightness and darkness helps the occupants to understand the overall depth of their environment (Millet cited in Gill, 2006, p. 26). Everything belongs light and light belong everything, and each place has its own light, Lawson (2003, p. 20) believes that an understanding of the space just can be happened by this relationship ‘light and other things’.

Table 9: Effects of Natural Light into Designed Space



2.2.4 Effects of Natural Light on Human Being

Benti Zainordin, et al (2012, p. 55) talk about natural light as a preferred light source for lighting indoor environments, and also this is very good for human beings. Besides, they (2012, p. 55) point out that people like to have daylight in their offices, shops, and schools; as he says, for instance, students will learn much better in daylight environment, shops sell more, and staffs work harder.

According to Barker "People dislike working in spaces without windows. The anxiety of daylight deprived office workers is a reaction to being starved not only by daylight, but also of a view and a sense of space (Barker, 1997, p. 22). Meanwhile, he mentions that in the commercial space and in their design natural light preferred as an attracting source to direct people to goods. As he says in malls or big shopping

centers voids will be effective for customers mind; “Due to the vast scale of some malls, many people experience a sense of alienation; sympathetic lighting of inner circulation voids can help counteract the sensation of spatial exposure” (Barker, 1997, p. 31). Barker continues that natural light will also guide costumer to exit door or may show the directions to the products. “All retail lighting is an attempt to lead the customer to the product… In commercial spaces “lighting must provide guidance, simulation and a positive sense of direction” (Barker, 1997, p. 31& p. 35).

“The use of day lighting decreases utility costs and improves the wellbeing of building occupants. The effect of natural light, on building occupants should be an important consideration for building design… daylight can provide satisfaction for both building occupant and owners” (Edwards, &Torcellini 2002, p. 38). Phillips (2004, p. xix) point out that working in day lighting spaces is healthier than working in the artificial lighting environment. By using the proper day lighting system, natural light proves to be a beneficial and healthy aspect of building and its resident (Edwards, &Torcellini 2002, p. 38).

Serra (1998, p. 128) talks about the relationship between natural lighting and human beings:

> “Light is general and natural light in particular acts upon human beings when perceived by our sense of sight, and this action can be considered to have two main consequences. The first and the most general of these is our perception of the world which is conducted by means of sight and provides our brain with information about our surroundings. This perception is also important aesthetically and is very important in architecture for both reasons. The second consequence is more specific and consist of the discomfort, light can cause our sense of sight, particularly the distribution of luminance is the field of vision, which affects the user comfort and is therefore also decisive in the design of space”.

Light affects the body strongly and there are no other sensations as strong as it, understands its power is very important (Vaughn, 2008, p.8). Natural light roots people to their environment, the time, and their experience (Theodorson, 2002, p. 75). Additionally, Pile (1995, p. 293) mentions lighting, as the most significant aspect which make an interior design successful. He states that: "Good lighting supports convenience, comfort, and favorable emotional reaction" (p. 293). Pile also classifies a proper lighting under four reasons: 'set a desired mood or atmosphere, direct or contrasted attention, control shading and shadow to aid the viewer in seeing form and texture, and emphasize or modify spatial perception'.

On the other hand, abundance or lack of daylight directly affects the human experience and the mood of the space (Vaughn, 2008, p. 17-18). Having daylight in indoor spaces biologically connects occupants to outside environment; this is the most important aspect that offers by natural lighting (Vaughn, 2008, p. 14). "The lighting design of a building should be more than a functional necessity; it should connect with the human spirit" (Vaughn, 2008, p. 12).

"In the absence of light, the perception of the environment is generated through mental interpolation, not visual impact" (Lawson, 2003, p. 35). A well indoor lighting design should capture the emotional responses immediately (Vaughn, 2008, p. 9). In terms of lighting design, several factors may have a significant role for occupant's understanding, such as direction of light, the level of light, its relationship with other areas, and proportion of the illuminated environment (Lindh, 2012, p. 17). In addition, Vaughn (2008, p. iii) explains light as an important design element that can create a 'conscious visual perception' which is responsible for the time; Vaughn (2008, p. iii) believes that it is perception of light that makes a place alive.

Without day lighting in space, the body will disconnect to the outside environment and it starts the problematic health condition (Vaughn, 2008, p. 17). “As our eyes change from darkness into light, we begin to perceive contrast and recognize forms. These forms and colors determine depth and visual perception of the space around us” (Vaughn, 2008, p. 8). The color of natural light changes through the seasons and days, from morning to noon and evening; Gill (2006, p. 27) talks about it as a compensate changing by human’s expectation in the way they ‘perceive the same space at different times of a day’. As Phillips (cited in Gill, 2006, p. 28) mentions, the experience of natural light changes from morning to evening, he states this change as a part of people’s experience. Gill (2006, p.29-30) believes that as people walk through a space, their visual perceptional system aware them about their environment; as Gill (2006, p.29-30) says, the illuminate of light inform people about the space.

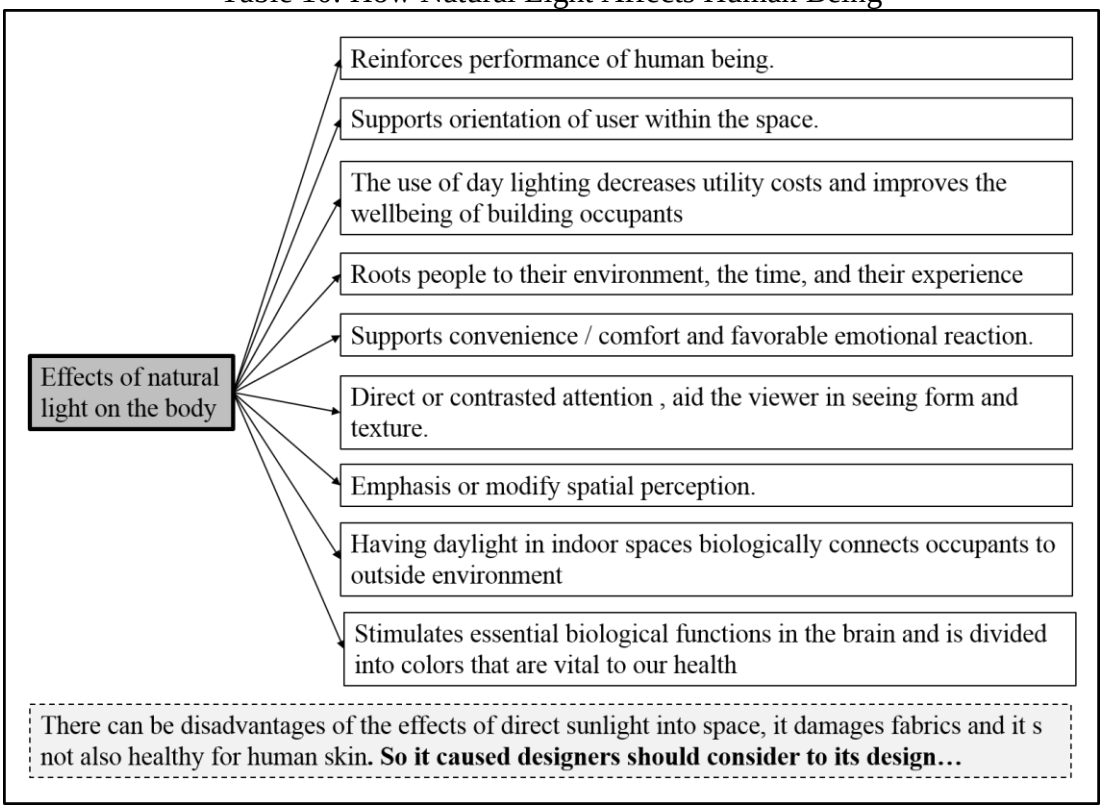
All through this time, daylight has been mentioned as a main source to illuminate the indoor environment (Gill, 2066, p. 6-7). As introduced before, there are several ways ‘to evolving and dynamic interaction between light, surface, and occupant’ (Lawson, 2003, p.27). Despite of body’s comfort in natural lighting, the quality of received light may be very important (Edwards & Torcellini, 2002, p.18). There can be disadvantages of the effects of direct sunlight into space (Phillips, 2004, p. 12).

The way designers bring light into space affects its occupants; there are lots of previous research about the effects of brightness or darkness of the spaces. For example, in Lindh’s (2012, p. 41) study, he says that in people mind brighter objects look closer. Besides, “Ashley had already found that brightness influenced distance

judgment" (Ashley, 1898). Coules, found that a brighter object farther away is equivalent to a dimmer object that is nearer" (as cited in Lindh, 2012, p.41).

Gill (2006, p. 59) mentions clear evidence, as he says: people usually choose the brighter way to pass through. In same way, Vaughn (2008, p. iii) describes light as a sensation aroused that stimulates people's visual organs. Therefore, as people prefer brighter places, Serra (1998) explains the aim of using daylight, as she says it 'is to ascertain the amount of light in interior environments, together with its distribution'.

Table 10: How Natural Light Affects Human Being



2.3 Natural Light Design Strategy of Building

In terms of natural lighting, openings are introduced as the only way for integrating natural light into the space. Therefore, this section of the research is about opening and fenestration which is directly related to the architecture and interior design. The effects of opening into space, the ways they were designed, and their organization will be discussed in this section. To achieve this, firstly, evolution of openings through history is mentioned. Then, definition of opening in the building and type of opening explains in general.

2.3.1 History and Background of Openings and Fenestrations

The lives of the inhabitants has been informed by daylight from the earliest caves, at first it was done by differentiations between nights and days, but Barker (1997, p. 8) mentions the colorful windows of churches in the Byzantine period as the beginning of opening design in the history of architecture. Nowadays, by more complication dwelling it is the job of various openings and fenestrations to let the light in (Phillips, 2004, p. 3). Accordingly, the history of windows can be defined as the history of architecture (Phillips, 2004, p. 3).

Phillips (2004, p. 3) introduces the history of opening as the history of architecture, as he mentions “the window was the vehicle for the introduction of daylight, and ultimately to the wondrous interiors of the mediaeval cathedral, the Baroque churches or the many private buildings of the eighteen century.” It was before the introduction of glass that the early windows were developed, so they were left open or sometimes closure to minimize the heat loss of night-time, for this purpose, they have some thin marble slabs, or mica and sometimes oiled papers (Phillips, 2004, p. 19). During the medieval century, installing wooden shutters on the interiors were

also common, they helped to control the light and the air was coming into space (Phillips, 2004, p. 19).

The introduction of glass was with the small panes in Roman architecture and it was the beginning of the windows as it is known today (Phillips, 2004, p. 19). Phillips (2004, p. 3) introduces the discovery of glass 'as early as 3000BC in Egypt' they used the small panes of glass setting into the bronze frames to fill the empty space of early windows. This kind of filling openings was left until the 17th century, then it became to the largest panes to be made possible largest windows in England (Phillips, 2004, p. 3). As Gill (2006, p. 8) states "the modern movement in the 1930s saw the use of full wall glass and wraparound windows at the corners. This was one of the earliest attempts aimed at expressing the freedom in the relation between the exterior and the interior."

The penetration of daylight from side windows depends on the height of the ceiling, as the heights of the early buildings were low, so it was made limitation to penetrate the amount of daylight (Phillips, 2004, p. 20-21). During the 17th and 18th century, with the design of important buildings, the ceiling heights were raised and designers could reach more daylight into spaces. As buildings became grander, large openings could not reach adequate daylight, so the concept of roof lighting was developed to integrate the natural light far ever the side windows (Phillips, 2004, p. 20-21). "The early roof light was perceived either as domes" (Phillips, 2004, p. 23). On the 20^{th,} industrial building's roof light was also used which is called Atrium. The modern atriums were covered by glazed skylight to reduce amount of cached daylight, it sometimes works as a natural ventilation system as well. As it is stated by Phillips, in

the early 20th century, the innovation of daylight is continued by 'fully glazed façade and the large-scale atrium' (Phillips, 2004, p. 20-24).

As it is mentioned in the previous sections, opening forms were changed according to the contemporary architectural design. After 1980s, many architects turned to parametric design; accordingly, shape, size, and location of designing openings also changed based on this kind of architecture in military years.

Table 11: Brief History of Opening design through Centuries

Openings are the vehicle for the introduction of daylight into space	
Medieval period:	Openings was only as holes on walls without glazing material.
	as centuries passed, early windows were developed, openings were covered by some thin marble slabs, or mica and sometimes oiled papers .
As early as 3000BC	• Discovery of glass. • In Egypt' they used the small panes of glass setting into the bronze frames to fill the empty space of early windows. • Small panes of glass were setting into the bronze frames to fill the empty space until 17th century.
Byzantine period:	the beginning of opening design in architecture - colorful windows of churches
18th century	• Small panels became to largest panes to be made possible largest windows. • ceiling heights were raised and designers could reach more daylight into spaces.
Large openings could not reached adequate daylight so the concept of roof lighting was developed	
Early roof lighting	perceived as domes
20th century	Atrium, The modern atriums was covered by glazed skylight reduce amount of cached daylight and natural ventilation.
Early 20th century	fully glazed façade and the large-scale atrium.
contemporary century	Variety in opening design.

2.3.2 Openings and Fenestrations

According to Home How-To institute (1996, p. 48), the first step of the day lighting design is the consideration of the function of space and the people who will use it; then paying attention to both sides properly and effectively. Next step is the answer to the question: 'what and how can make a great lighting for the space?' Sometimes combining various design methods with different lighting techniques could create many moods. For example, glass block walls 'can be used to produce a dramatic lighting effect. It can allow sunlight to enter the room, but has just enough distortion to maintain privacy.' Using bright windows in the wall or roof may be another factor to combine inside and outside. Shaping opening is another one. Skylight or atrium is some other examples.

"Sources of natural light, such as windows, skylights and patio doors, not only allow natural light to illuminate a room, they also expand the sense of space in a room by removing the solid barriers created by ceiling and walls" (Home How-To institute, 1996, p. 48). Fenestrations are holes and openings in walls, sides or building's roofs (Phillips, 2004, p. 19). The main purpose of the opening is to admit daylight into space, and then associating the view to the exterior environment can be as important point (Phillips, 2004, p. 25). As Millet (cited in Gill, 2006, p. 24) states "the window is a major component of the 'spatial record' between inside and outside. With its size relative to the solid wall, it determines the sense of separation from or connected to the outside". Bean (2004, p. 13) talks about the perception of the openings that allows natural light into space, and then he says that, openings allow the occupants to look outside so it is the major factor of their level of satisfaction.

Phillips (2004, p. 20) introduces two kinds of openings in buildings, first one is the openings, setting on the side walls that are known as vertical opening, and the second one is kinds of opening setting on the roof parts of the building which generally known as roof light. As Phillips (2004, p. 4) states, the vertical openings play important role to bring a huge amount of daylight into space, but in large building it is roof openings that allow natural light to enter into the center of the building.

- **Side Openings**

  Nowadays, there are several types of vertical opening, Phillips (2004, p. 22) divides side openings in three parts as small individual windows, ribbon windows, and whole glass walls. Figure [19] shows three kinds of side openings in London. As Gill (2006, p. 2) explains "the ribbon windows demonstrated a conscience attempt, on the part of the architect, to control the quality of light inside the buildings by manipulating the size and proportions of the opening."

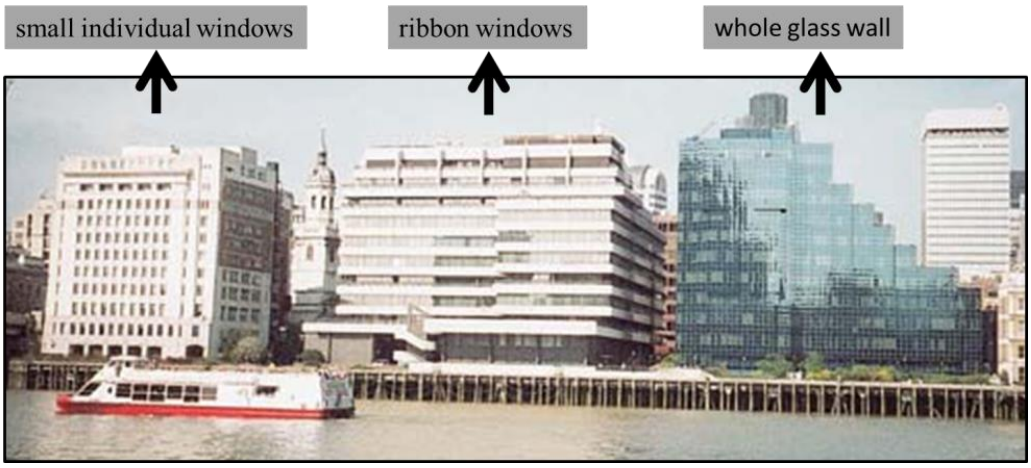


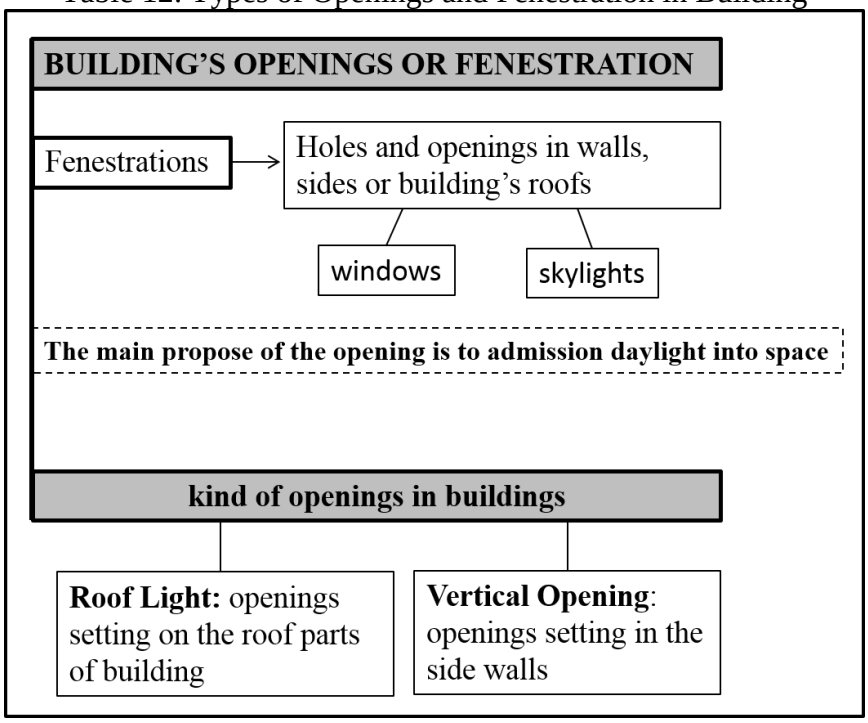
Figure 23: Three buildings on London's Embarkment (Phillips, 2004, p.22)

Figure 24: Interior views of three opening examples in figure 23

- **Roof Openings**

  The atrium is a development of the dome in Roman's houses that allows daylight enters in the center of the building (Phillips, 2004, p. 24). Both human and their environment, get advantages of the atrium, according to Phillips (2004, p. 25), by using atrium, daylight can come into the center of deep plans and it makes occupants aware of the weather, time, and the world outside, atrium also compensates the lack of an external view of the space. On the other hand, Phillips (2004, p. 25) explains the environmental advantages which include 'saving energy, assistance with the problem of ventilation, and reduction in the need for air-conditioning'.

Table 12: Types of Openings and Fenestration in Building



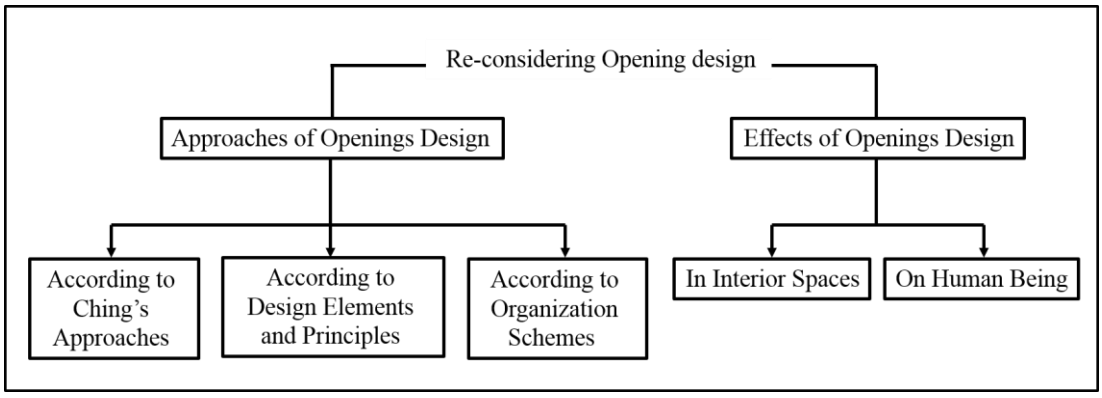
Chapter 3

OPENING DESIGN: RE-CONSIDERATION OF CONTEMPORARY APPROACHES

This section analyzes the approaches of openings / fenestration have been designed during the contemporary century. Besides, it discusses the role of openings in the integration of natural light into interior spaces in order to understand their effect both in interior space and on human being.

To achieve this, this study re-considers opening design mainly based on two different ways. In the first section, the study categorizes *design* of opening according to three various approaches where first one is based on the Ching's approaches, second according to design elements and principles and third according to the organization schemes based on Dağlı, Şahin and Güley's (2012) classification of organization schemes. And in the second section, it also considers the *effects* of designing openings on the integration of natural light into space and its effects on interior space / design and human being (Table 13). This part is carried out with contemporary opening examples with an interpretative approach (hermeneutic) by the author of the research.

Table 13: Methods of Re- Consideration



3.1 Approaches to Design Openings and Fenestrations

"Openings have important role to bring daylight into space" **(**Syed Husin& Hanur Harith, 2012). Thus, considering their design is also important because it directly affects the space and its quality. On the other hand, people's perception will also be affected by the light coming in through the openings.

Pile (1995) states that, openings are "important elements in the basic architectural design, windows are also an important element in the interiors that they serve. Since windows greatly influence the nature of an interior, designers often change or replace them as a part of their design schemes" (P.234). Openings are also classified by Pile according to their framing. He mentions fixed glazing window, double-hung-windows, casement windows, awning and project windows, jalousie windows, and sliding windows under this classification (Pile, 1995). In his approach, there is a classification according to the way they may hold glass; the type of glass and color; the way they shaded besides the use of curtains as the form of opening design and the role they possess during the integration of daylight to indoors. However, since this approach mentions just the additional elements in order to control the light rather than the role of opening itself will be kept out of the scope of this study.

On the other hand, the other important thing according to Vaughn is choosing the best way to design openings as he exemplifies that sometimes larger openings just create more problems instead of solving it (Vaughn, 2008, p. 15). Thus, as Coles & House (2007, p. 130-131) mentioned, large glazed openings are not always ideal for bringing daylight into the space. Vaughn (2008, p. 17) believes that "improper window design and inadequate levels of natural light can be detrimental to human's health." So designers should pay attention to design proper openings which are suitable for building's function. Accordingly, in the following different methods of opening design will be mentioned.

Ching (2007), Syed Husin & Hanur Harith (2012), Bean (2004), Lindh (2012), Gill (2006) and Serra (1998) mention various methods to design openings. As a result of reviewing their work, it has been revealed that opening can be designed via considering shape, size, location and wall's depth and each factor affects the penetrating natural light into interior space. As it is exemplified, "tall, narrow windows allow light to penetrate deep into the building" and this affects the perception of its users. Additionally, Pile (1995), believes that considering the design of the opening is as much influenced as the building location and orientation. He also mentions that openings vary in size and shape. Briefly, it could be said that, openings are also different from framing and glazing. All these alternatives, size, shape or location of the opening of the building and their details are the things that can affect the natural lighting of interiors. Besides, "While windows can provide excellent light, direct sun can be a problem and must be controlled" (Pile, 1995, p. 301) and this is the other point that should be considered while designing openings.

Ching (2007) has got a very systematic approach in terms of size, shape, and location of openings. The following categorization is based on Ching's classification.

3.1.1 Ching's Approach of Opening Design Based on Their Location, Shape and Size:

Location or position of opening causes view, visual comfort and daylight distribution in space; it means their location is an important aspect in its design (Chartered Institute of Building Services Engineers, 1999). According to Ching (2007), opening can be located through three ways, opening within a plane, opening at corners, and opened between the planes [Figure 24].

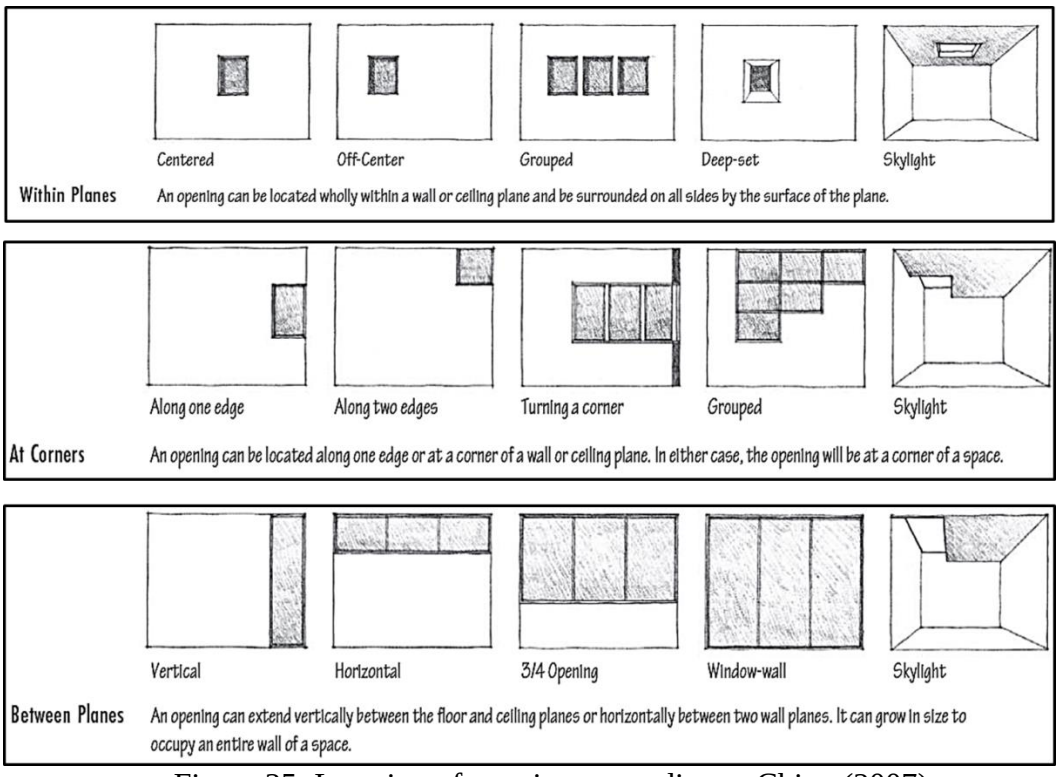


Figure 25: Location of opening, according to Ching (2007)

Opening which is located in plane 'often appear as a bright figure in a contrasting field or background', in this type, according to opening's movement from the center, a visual tension will be created between the moved object and plain edges. If opening

be located at the corners, they can give a diagonal orientation to the plane, or sometimes, they may erode their plane visually (Ching, 2007).

Openings according to their position and location can also be classified into vertical and horizontal opening. Vertical openings are the ones, which are located from floor to ceiling; visually they look as a separator element of the plane. On the other hand, there is horizontal opening which is located across the walls; they can also be defined as skylight if they take place on ceiling [Figure 21].

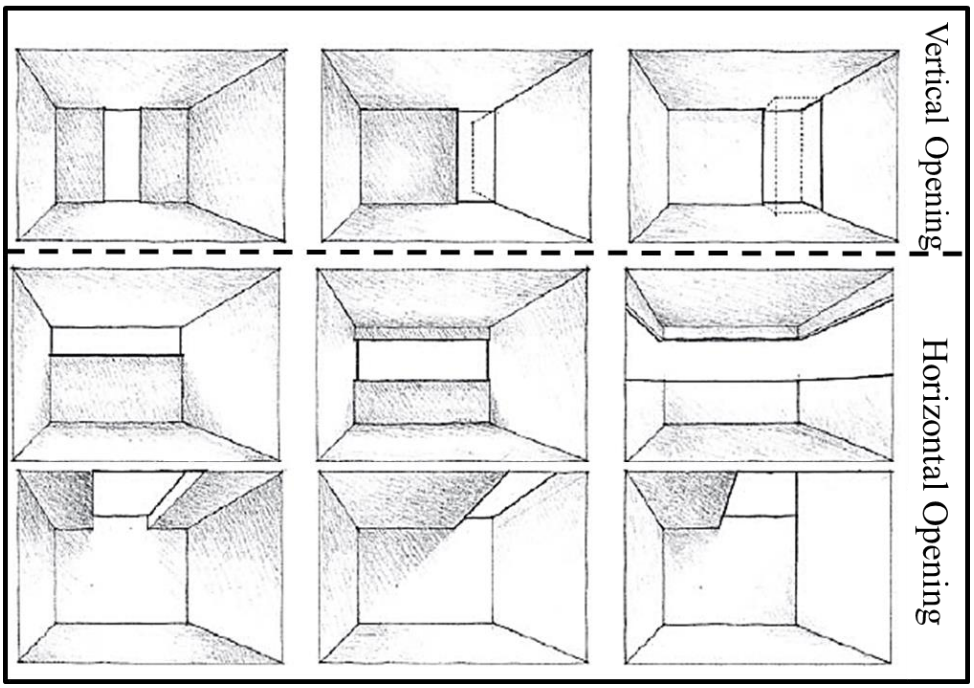


Figure 26: Vertical and Horizontal opening based on Ching's approaches (2007)

The shape of openings that is located within a plane usually is similar to its plane. According to Ching (2007, P.164) "multiple openings may be clustered to form a unified composition within a plane, or be staggered or dispersed to create visual movement along the surface of the plane".

By increasing the opening's size within a plane, it may look a figure and may be displayed as a positive element. According to Ching's words (2007, p. 164): "a sun opening within a plane increases in size, it will at some point cease to be a figure within an enclosing field and become instead a positive element itself, a transparent plane abounded by heavy frame".

According to size, small opening also can frame a view as a close up element. However, a narrow opening hint at what lies beyond whatever it is located vertically or horizontally. On the other hand, "a group of windows can be sequenced to encourage moment within a space" (p. 179).

In Ching's approach it was briefly discussed how the opening should be located and what should be the opening's size and shape as the main idea. However, in the contemporary design examples, there are many complicated designs where there is limited possibility to interpret openings' design through considering only its size, shape or location. Accordingly, in complex designs openings could be evaluated based on design elements and principles in addition to its shape, size and location. Accordingly, in the following section study re-considers opening designs of contemporary buildings with an analytical point of view in accordance to design elements, design principles and organization schemes.

3.1.2 Opening Design Based On Design Elements, Design Principles and Organization Schemes

The information under this section is developed according to the previously mentioned design elements and principles in Ching's approach. This part is carried out with the help of contemporary opening examples with an interpretative approach (hermeneutics) by the author of the research.

As it was stated in the previous chapter, advancement of technology in contemporary centuries led to the design of new buildings as a result of different design approaches and techniques of design where various types of buildings in different forms and shapes were emerged. Accordingly, this challenging building form of contemporary period affected the way of openings are designed. For instance, ZahaHadid is one of the most famous architects which follows and uses new methods of architecture and design. Figure 26 demonstrates one of her latest designs. Here, the way she designs the building also affected the opening design and it became difficult to rely on Ching's approach merely when considering opening design.

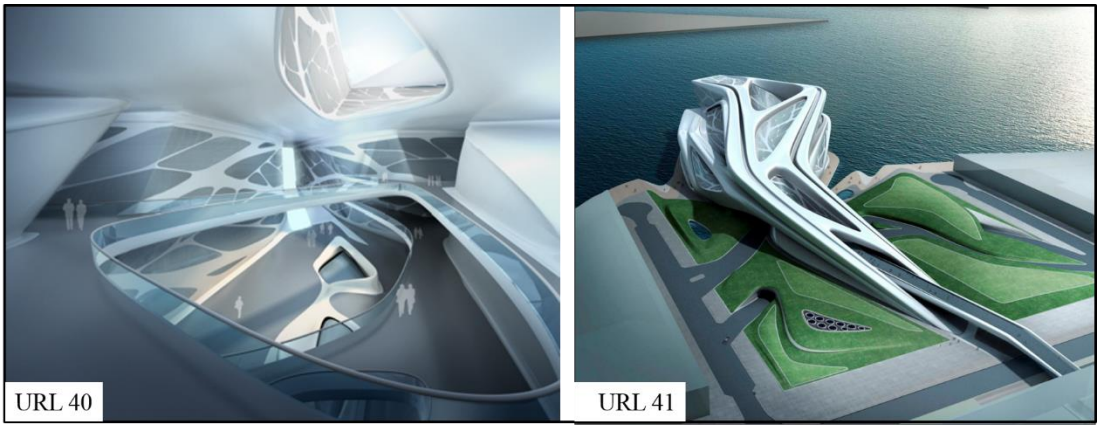


Figure 27: Abu Dhabi Performing Arts Centre by Zaha Hadid

Accordingly, in the following part of this section, there is an analytical approach for the re-consideration of new opening design of the contemporary buildings. Accordingly, at first opening design was categorized into two main groups: Openings themselves, which are designed and organized based on elements and principles and / or secondly by the composition of various design elements that create openings.

3.1.2.1 Openings Designed According to the Shape, Size and Location with the Help of Integration of Design Principles:

Openings under this classification are categorized according to their shape_ geometrical or non-geometrical; their size_ small, medium and big or mixed; and according to their location_ on the top, bottom, middle, corner, edges, overall, mixed, or even centralized. Such openings may be individual or grouped; fully repeated or alternate to create rhythm. Repetition is a principle to create a design. Repetition of opening may happen regularly or irregularly dependent to the whole building design or independently.

1. Shape_ geometrical or non-geometrical

In mathematical point of view, some shapes are known as geometrical shapes. On the other hand, all other shapes, which are not under this classification, are called non-geometrical shape. Figure 27 demonstrates geometrical shapes.

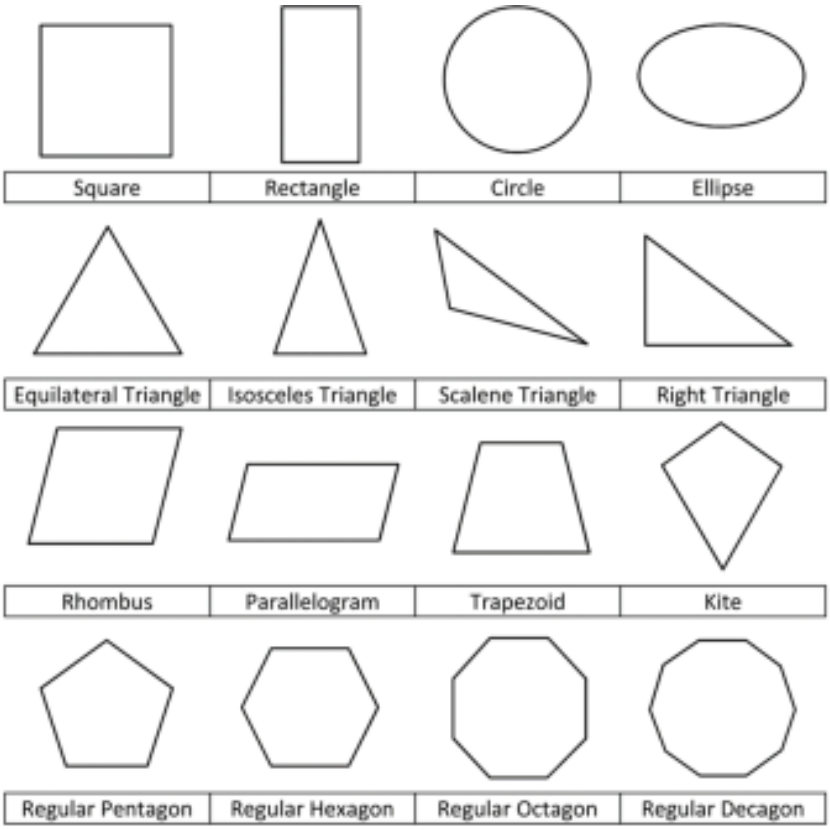


Figure 28: Geometrical shape (Ching, 2007)

a. Repeating geometrical or non-geometrical

As previously mentioned, Circle is known as a geometrical shape. Accordingly, the Kanazawa Umimirai library may be a proper example of fully repetition of a geometrical shape. Circle is the shape which creates openings which is repeated all through the facades with the same size.

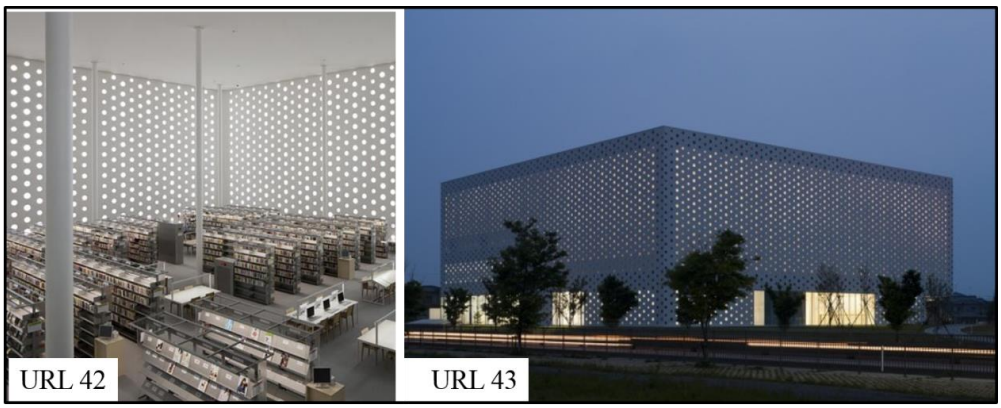


Figure 29: Kanazawa Umimirai library

Following example displays a restaurant's interior. In this case, varying pentagon shapes in different size are demonstrated. Additionally, the designer continues those respited shapes through the ceiling with the same design. According to this special organization, a contrast is appeared through the elements plus the harmony and balance of the whole perspective. There is a lightness of elements in front of facades and darkness of elements on the ceiling.

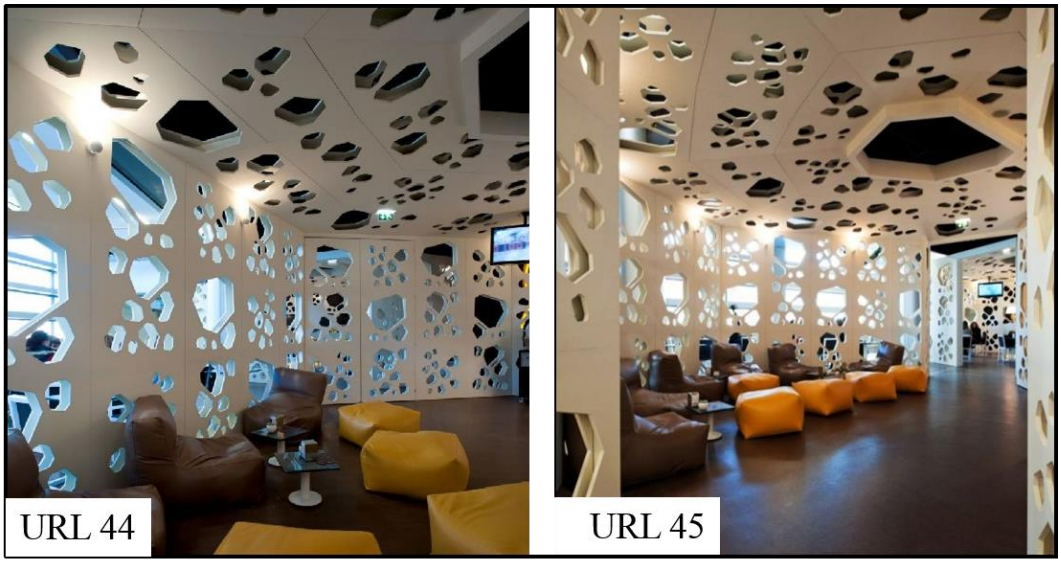


Figure 30: The Meltino Bar & Lounge designed by LOFF

On the other hand, Toyo Ito designed *Mikimoto Ginza 2* in Tokyo, which is a fashion store. In this building, he used non-geometrical shapes to create openings all over the facades. The opening design of the mentioned building is different from the shape and size where all the openings are repeated all over the façades with no special location or position.

Figure 31: Repetition of non-geometrical shapes on the Mikimoto Ginzin2, designed byToyo Ito at 2005 in Tokyo

In addition, *Labels Berlin 2* is another example of full repetition organization of non-geometrical opening design. The mentioned building is a fashion industrial building in the Berliner and designers were created opening by shaping each the façade of each level in a linear order. At each level, the openings are repeated and designed based on a symmetrical organization from the other levels.

Figure 32: Fully repetition of non- geometrical shapes at Labels Berlin 2 is a fashion industrial building, designed by HHF Architects in Berlin at 2007-2010

b. Rhythmic geometrical or non-geometrical

The organization of the openings in a special order will make rhythm. School of Economics and Business Diego Portales University is demonstrated a rhythmic

organization of the openings. In this building, designers were used square shapes for openings with the same size at different levels that was created a flowing effect with an alternation in repetition.

Figure 33: Rhythmic design of rectangular shape on the School of Economics and Business Diego Portales University, designed by Rafael Hevia + Rodrigo Duque Motta + Gabriela Manzi

2. *Size_ small, medium and big or mixed*

a. Small Openings

If the size of the opening is smaller than human proper vision, then they may fall under the small size of openings with no matter to their shape and position. There is a building in Shanghai called *Republic of Korea Pavilion.* The opening design of this building is based on non-geometrical shapes based on diversified organization over the facades. However, their sizes are small and people cannot see outside properly.

Figure 34: Small openings on the Republic of Korea Pavilion at Shanghai 2010 designed by Mass Studies

b. Medium Openings

Ravensbourne College is a building which is designed with medium size of openings. The size of its openings is in a harmony with human scale, so they can see outside properly. In the mentioned college, opening designed according to geometrical shapes with the same size. They are organized with the full repetition of circular shapes, all through the facades and demonstrate a symmetrical balance in different positions.

Figure 35: Medium or large scale of openings on the Ravensbourne College designed by Foreign Office Architects

c. Big Openings

The next building is an example of the large scale of opening design. The size of the openings in the mentioned buildings is bigger than human scale, thus they are mentioned as a big opening. In addition, this example shows a prismatic shaping of a building, as its surface is designed based on the three angular shapes, designer also tried to match the opening with it. In this building openings are designed as four angular shapes. Then, each of them is split into triangular shapes. Alternating repetition of these shapes make a view of matching elements with a whole building that creates rhythmic organization.

Figure 36: Big scale of opening design

d. Mixed Openings

Next two examples demonstrate two cubes shaped buildings. In both examples, designers also tried to match the openings' design according to the shape of the building. There are varying size and location of openings in both examples. Alternating repetition is the principle which both of the designers use to organize the elements.

Figure 37: Variety in the size of openings in the Umea school of architecture

Figure 37: Opening design in different size on the A Nine Story Building with 1900 Windows (URL 60)

3. *Location_ on the top, bottom, middle, corner, edges, overall, mixed, or even centralized.*

a. According to different locations and their design principles

La MenisArquitectos design Laguna church. In this church designer created the opening by molding the main material of the wall. The opening is two lines which intersect each other in the corner of the wall to create a focal point. The shape of this opening is based on the church. It is designed as a concept of the Cross.

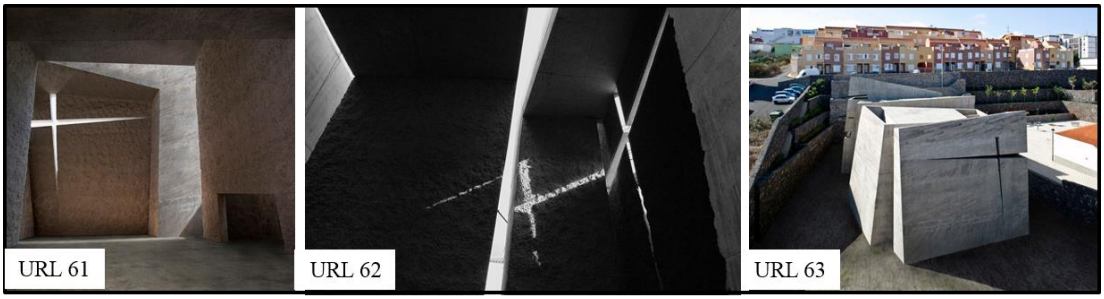


Figure 38: Church in La Laguna designed by Menis Arquitectos

In the next building, horizontal opening designed as a modern atrium. According to its design, it looks like a focal point of the space displaying the center of the building.

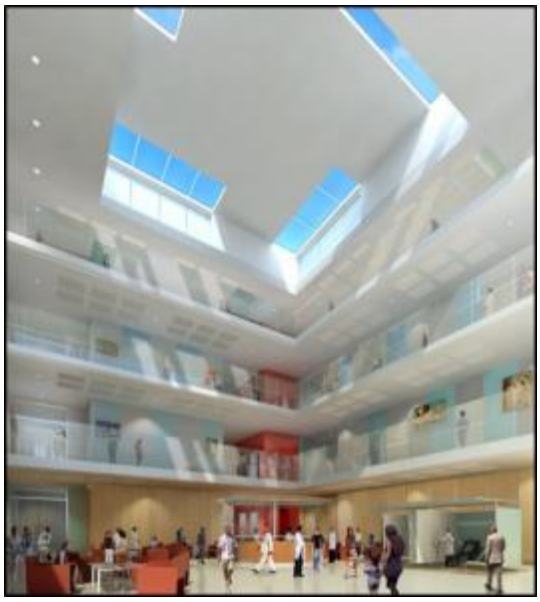


Figure 39: Modern sky lighting (URL 64)

The next example is The Nakagin Capsule Tower in Japan. This tower is designed by cube shaped rooms over each other. The openings in this building are all circles with same size and they all also are located in the middle of the each cube. In this building, the positions of the openings depend on the position of the cubes too.

Figure 40: The Nakagin Capsule Tower in Japan

The next example is a house designed by the milligram architectural studio. In this example, designer located openings in various positions. According to the structure of the building, there are three levels in this house and openings are designed in a variety of size, position and location in each level. Here the openings are four angular shapes which are repeated irregularly on the surfaces.

Figure 41: Milligdesignhitectural studio designs house as nestled box

3.1.2.2 Openings which are Designed with the Composition of Design Elements

Sometimes, it is the composition of design element itself, which creates an opening, and make fenestrations under a proper organization. Elements can vary in shape or size according to the concept of design and openings appears as a result of the design

approach and how design elements were configured. Combination of various design elements can create different openings. Accordingly, opening designs under this category could be systematically interpreted with the help of three main groups of design elements which are linear, planar and volumetric or sometimes mixed.

1. *Linear elements create openings*

International Accommodation Center for the Oenological Observatory and Sculptural Screen for ADORA Club House are two proper examples of opening design of linear elements. Designers of both buildings created linear elements by molding the main material that is concrete. In the first example, the whole building is covered with the curvilinear elements. They are repeated all over the facades and create opening whenever walls are not exist.

Figure 42: International Accommodation Center for the Oenological Observatory designed by Atelier Fernandez & Serres

On the other hand, in the second example, after building structure, floor, and ceiling; designer molded concrete and create cracked linear elements to make openings; place them between the structures on the facades.

Figure 43: Sculptural Screen for ADORA Club House, Chennai (URL 71)

2. *Planar elements create openings*

The Transparent Church is a church with whole opening facades. In this example, the church completely is created with planar elements. The elements here are organized with fully repetition all through the building. These elements are all: structure, facades, opening and pattern. The element here, create the church full of openings with same shapes but different in location.

Figure 44: The Transparent Church

3. *Volumetric elements create an opening*

Sometimes, it is the spatial organization of volumetric elements that create openings in buildings. Alcaces do Sal Residence is a hotel designed by Aires Mateus. Inside this building, the special decussate organizations of cubes next and above each other make fenestration between them, which is integrating daylight into the space.

Figure 45: Volumetric elements create opening in Alcaces do Sal Residence designed by Aires Mateus URL 74)

3.1.2.3 Opening Design Based on Organization Schemes

In addition to the previously stated, two approaches of opening design, there could be another approach that is the re-consideration of opening design based on various organization schemes. According to Ulaş Dağlı & Pasaoğluları Şahin & Güley (2012), organization schemes can be used in 2D and 3D design, composition, which are categorized as: linear organization (single axis), gird organization (double axel), central organization, mixed organization, and organization with the principle of the golden section.

1. *Linear organization (single axis):* Linear organization scheme is one of the main organization types were in this group of organization various design elements_ solid or void could be used in horizontal, vertical or radial directions with full

repetition or in rhythm. Accordingly, in this approach, openings could be defined by the organization of design elements with a single axial order or openings themselves could be organized with a single axial order.

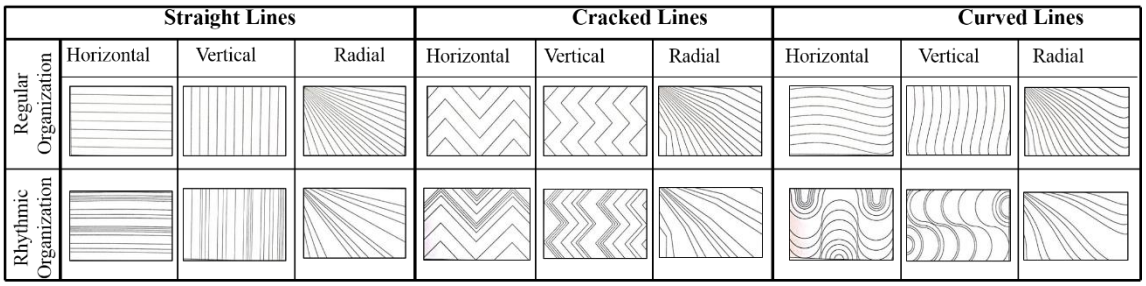


Figure 46: Linear organization of elements (Ulas Dağlı& Pasaoğluları Şahin& Güley, 2012)

Following example demonstrates some opening design in architecture according to the linear organization of the schemes.

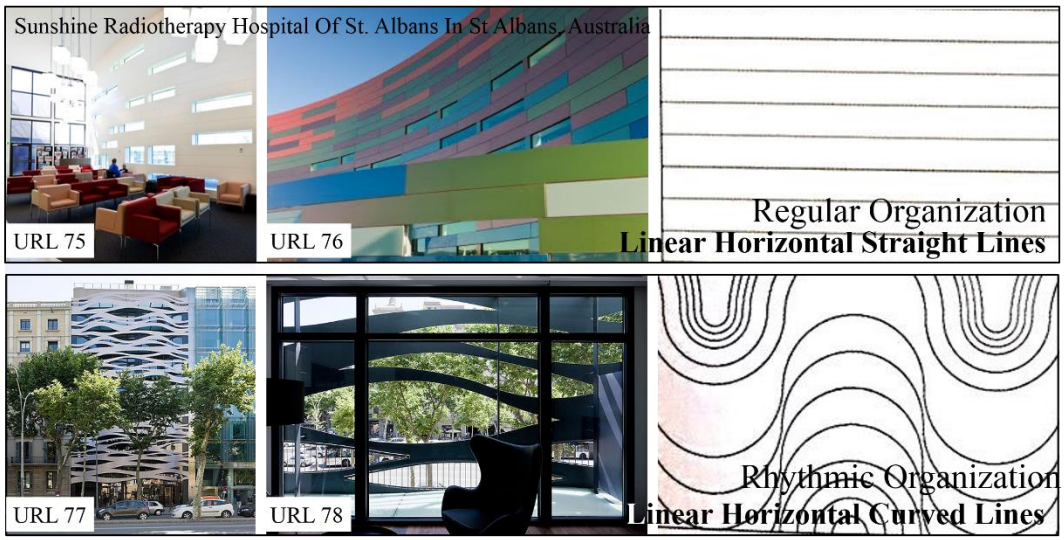


Figure 47: Opening design based on Linear Organization Scheme

2. *Grid organization (double axial):* Grid organization scheme is the second organization type were in this group of organization various design elements could be used horizontal + vertical, or reciprocal radial direction regularly or in rhythm.

Accordingly, in this approach, openings could be defined by the organization of design elements with double axial order or openings themselves could be organized with a double axial order.

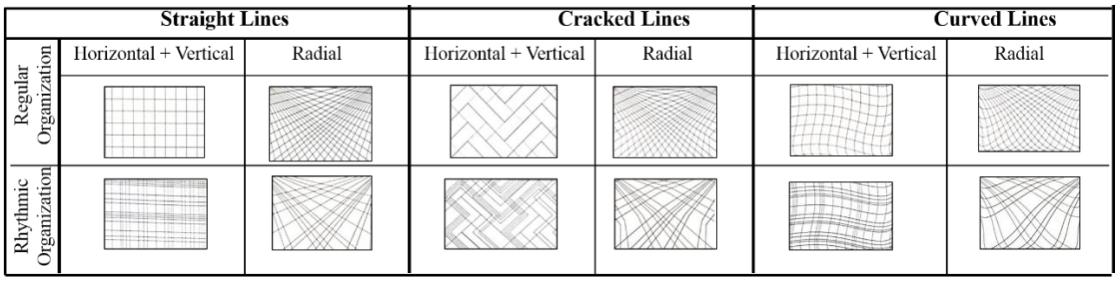


Figure 48: Grid organization of elements (Ulas Dağlı& Pasaoğluları Şahin& Güley, 2012)

The figure below exemplifies some opening design organization according to Grid scheme.

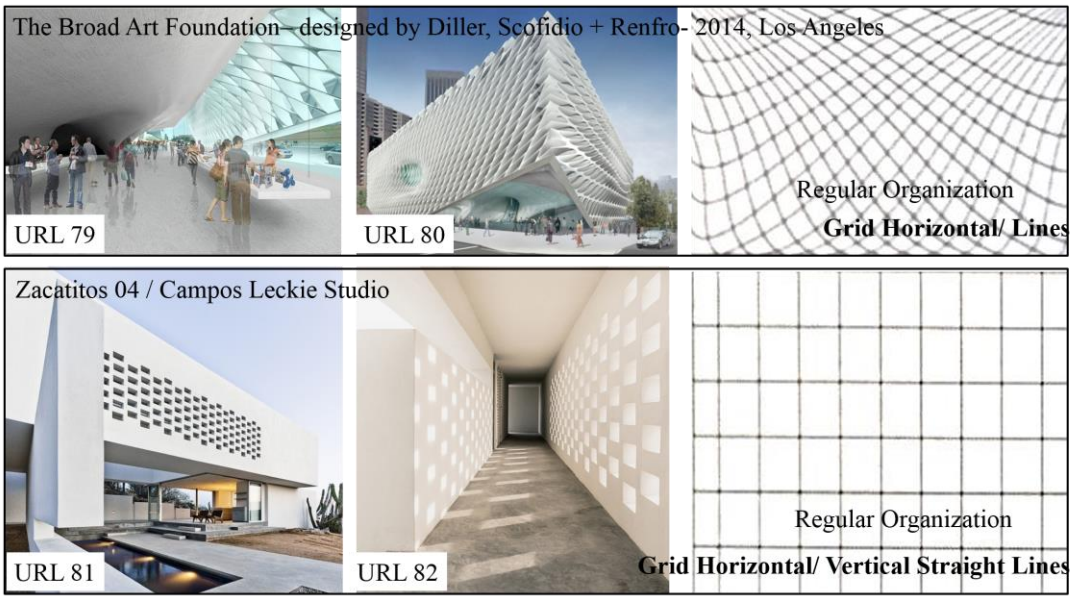


Figure 49: Opening design based on Grid Organization Scheme

3. Central organization: Central organization is the other way of organization schemes, which includes single center or double/multiple center types. Various

design elements could be organized around the center regularly or with rhythm. Accordingly, in this approach, openings could be defined by the organization of design elements around a single or multiple centers to define openings or openings themselves could be organized around the center(s).

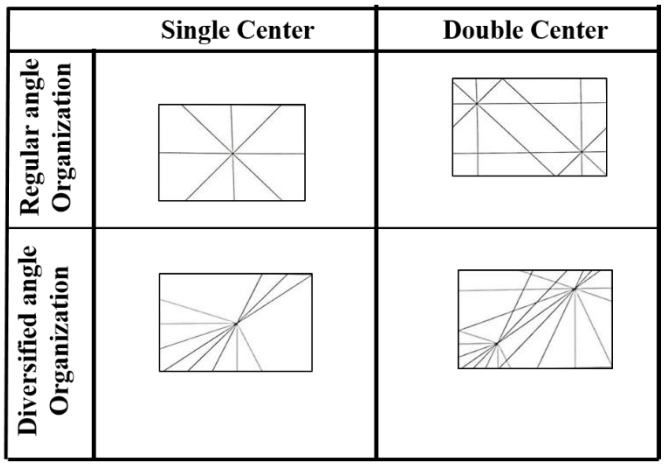


Figure 50: Central organization of elements (Ulas Dağlı& Pasaoğluları Şahin& Güley 2012)

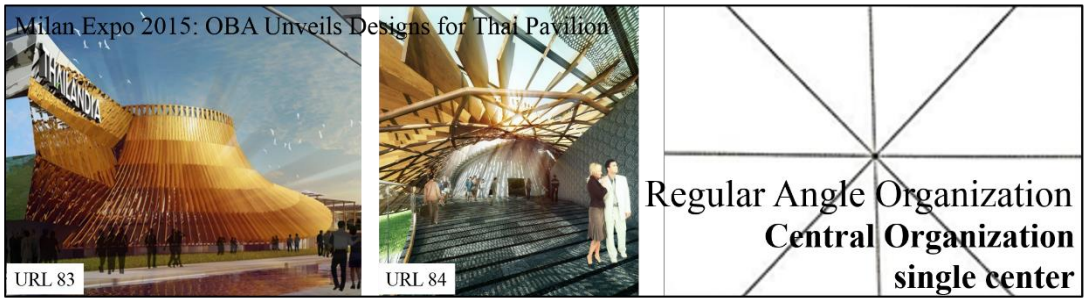


Figure 51: Opening design based on Central Organization Scheme

4. *Mixed organization:* Mixed organization achieved when designers used minimum two different or multiple types of organization schemes (linear / gird and central organization) together in the same composition

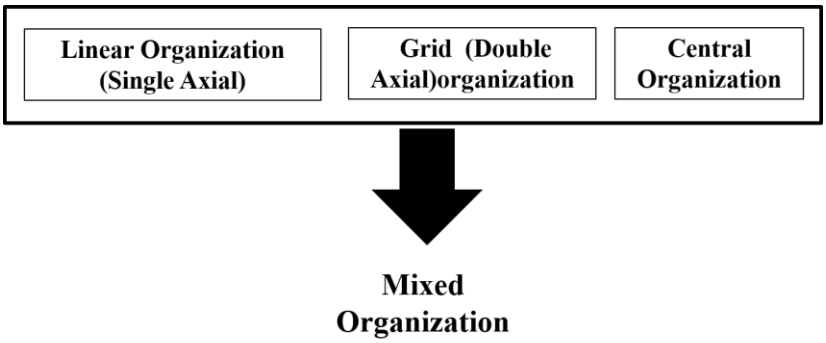


Figure 52: Mixed organization of elements (Ulas Dağlı& Pasaoğluları Şahin& Güley, 2012)

5. *Organization with golden section:* This type of organization follows the fundamentals of the golden ratio. Openings either defined by the organization of various types of design elements relying on the golden ratio, or by organizing openings in an order to achieve the golden ratio.

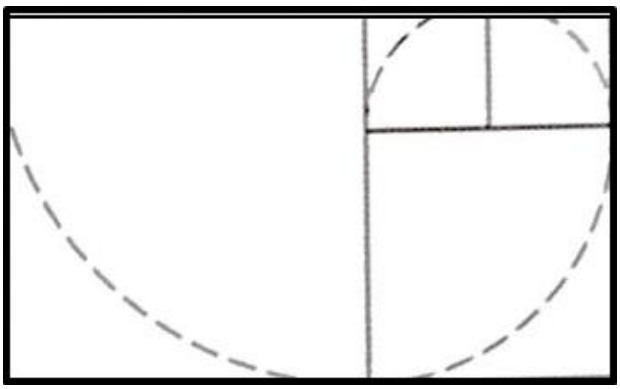


Figure 53: Golden section organization of elements (Ulas Dağlı& Pasaoğluları Şahin& Güley, 2012)

Table 14: Methods to Design Openings and Fenestrations

Methods And Techniques To Design Opening:

→ **A. Opening design based on their location, shape and size (Ching approaches):**

a) Openings according to shape: Geometrical or Non-Geometrical
b) Opening according to size: Small, Medium, Big, and Mix
c) Opening according to the location: Top, Bottom, Middle, Corner, Edges, Overall, Mix, and Centralized

→ **B. Opening design based on design elements and principles:**

a) Openings are created by linier elements
b) Openings are created by planer elements
c) Openings created by volumetric elements

→ **C. Opening design based on Organization Schemes:** based on Dağlı.et al. (2012)

a) Linear organization
b) Grid organization
} Straight / cracked / curved lines
c) Central organization
d) Mixed organization
e) Organization with golden section

3.2 Role of Different Opening Design on the Integration of Natural Light into Space and its Effect on Both Users and Interior Environment (Contemporary Examples)

Different openings with various design approaches affect both people and the interior environment. The ways opening affects these two mentioned factors are directly depended to the ways they are designed. This section will focus on the issue with interior design point of view while considering the effect of natural light makes into space (interior design / occupant's perception). Discussion will be carried out in line with the three main investigated opening design methods which are: according to the

Ching approaches, design elements and principles, and also according to the organization schemes in order to understand the effects of different opening designs.

3.2.1 Effects of Opening Design on Interior Design of Space

Effects of opening design for designing the natural light entering an interior space investigated considering firstly shape, size and location of openings. Secondly, by consideration of design issues in order to understand how the interior environment affected if the design of openings differ when there is a use of various design elements to define them.

Effects of different opening designs investigated with the help of theoretical overview. Effects of natural light to the interior space and on human being, which were stated and summarized by Table 9 and Table 10 used as the main tools to carry out the evaluation.

What happens to the interior space / environment when location, size and shape of openings differed?

Each designed opening plays a special role to design natural light coming in. For instance, in the following building use of repeating small openings on the façade creates a special texture in the space however there is a controlled eye contact with the outside.

Figure 54: Texture created by natural lighting in the space - Transmission Central / UMWELT + Juan Manuel Sepúlveda

On the other hand, when big openings used, there is a stronger visual connection appeared between indoor and outdoor spaces. In some cases, big openings create a drawing of nature with a provision of higher amount of light in the space. As it is exemplified in the following example, Tama Art University Library by Toyo Ito big size of openings draw a frame and it connected both indoor and outdoor respectively.

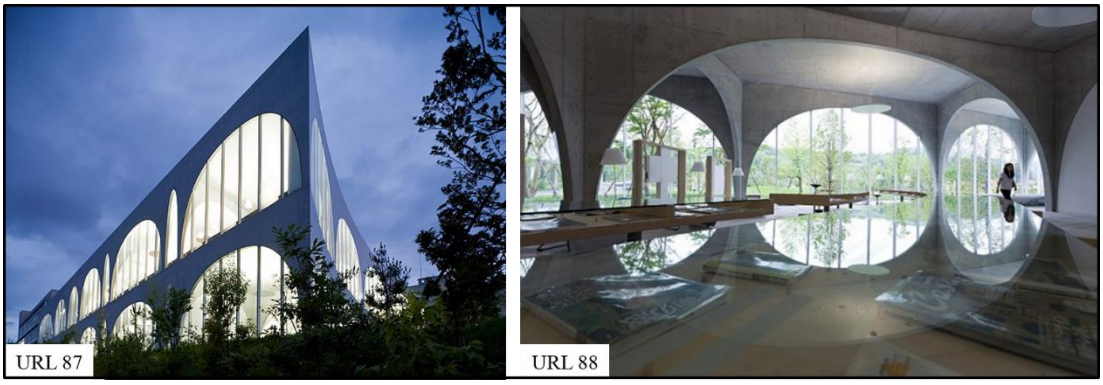


Figure 55: Big openings bring nature into space - Tama Art University Library by Toyo

The changing position / location of openings also affects the interior space. For example, wide horizontal openings give a whole view to the outside and also it shows the place bigger that it actually is. These kinds of opening design, integrate a high level of natural lighting into space and are the proper utilization of the small rooms.

Figure 56: Wide opening design makes a room bigger - Rio de Janeiro Residence / TAMABI

The location of openings is another important factor in interior design point of view. For example, if the opening is located on the top near the ceiling, it can light the ceiling and also it gives opportunity to perceive the sky. On the other hand, if the opening is located closer to the ground, it cannot give a proper view of the outside and it just lights the floor properly. Next figure exemplifies a building designed with these two kinds of opening design. Different positioning of the openings affects the perception of the outside on different actions.

Figure 57: Location of opening affects the light coming in and the view from inside to outside

The shape of the opening on the other hand is a significant factor, which effects integration of natural light into the space. As it is exemplified in the next example, different shapes of openings have different effect on the light coming in. Shape of opening creates shadows in the space or lighted shapes, all through the interior environment, which creates subdivision in the entire interior space.

Figure 58: Different shapes of openings makes different effect on the light coming in and creates subspaces.

What happens to the interior space / environment when openings defined and designed by the composition of various design elements?

Creating opening with both planar and linear elements generates visual shadow in the space; engender a changing atmosphere by the movement of the sun during the day. On the other hand, since there is no regular placement of opening, changing the size and location of the openings affects the viewer's perception of the outside. The below examples are demonstrating the effect of opening design of the composition of linear elements and its effect on the integration of natural lighting into space.

Figure 59: Effect of linear opening design on the natural light into space

Figure 60: Effect of planar opening design on the natural lighting in the space (URL 97)

In the example above, the use of planar elements in a repeating order to design openings creates illusion and mystic atmosphere in the interior space.

What happens to the interior space / environment when openings defined and designed by the use of different organization schemes?

Openings designed as a result of the organization of design elements with different schemes, effect the integration of natural light into the interior space directly. For instance, in the following example, there is an exemplification of opening design based on the radial grid organization of curved design elements. In this building, the convergence of design elements creates a focal point in the space, and the way they designed to raise is like a concept of the horizon. On the other hand, there also is a huge amount of natural lighting under this opening.

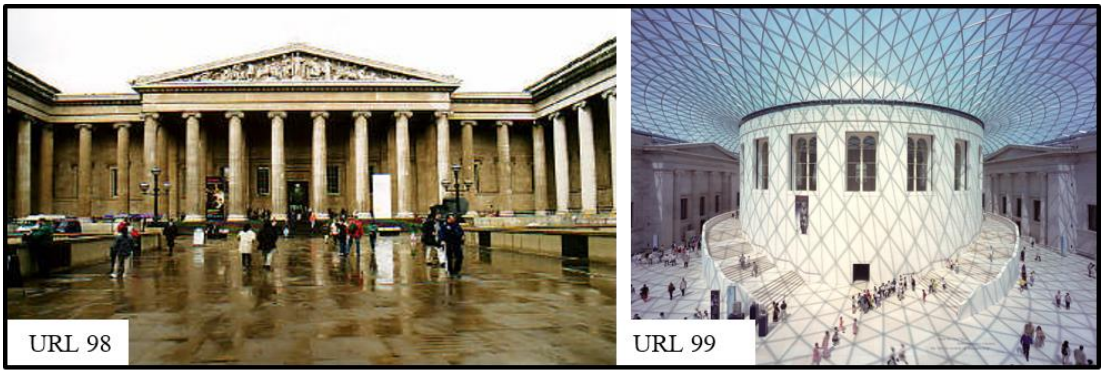


Figure 61: Opening design according to grid curved radial organization

3.2.2 Effects of Opening Design on the Human Being

Integration of natural light to the interior space also affects the people who are within the space. For instance, it has been stated in the section 2.3.5 as one of the effects as such small openings give people a miss understanding of the outside environment. Sometimes; people also mixed the time when the sky is cloudy. Small openings as it is demonstrated in the next example make the place a king of private space for its

occupants and emphasize a different way of spatial perception [Figure 62]. On the other hand, a space with big openings connected people with the time, weather, and the outdoor environment.

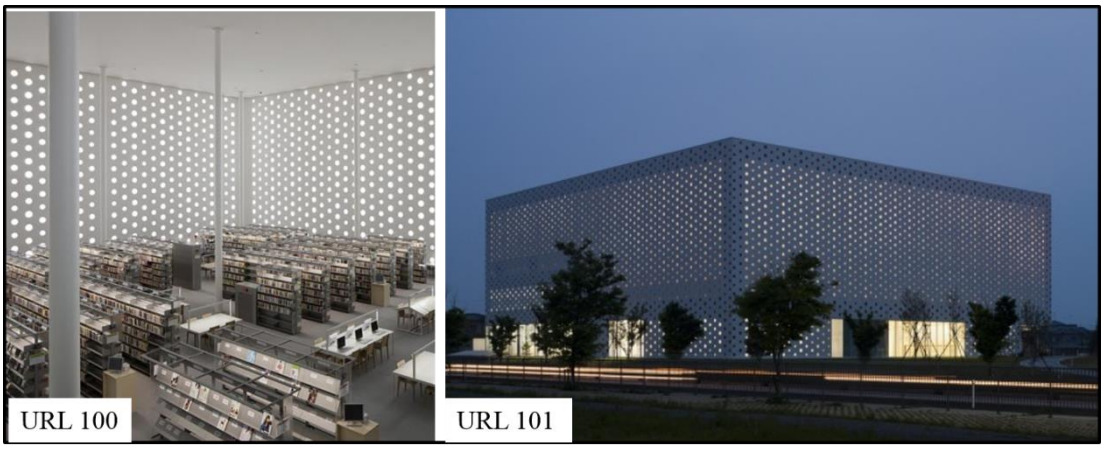


Figure 62: Effect of smaperson'sning design of the people perception in the space.

Different shapes and location / position of openings also affect users' perception of the space in different ways. For example, as it is demonstrated in the next picture, people who are inside can have a whole view to outside because of the way opening are designed. The special positioning of the openings direct or contrasted attention, aid the viewer in seeing form and texture.

Figure 63: Effect of big opening design in special shape, person'son and position on people perception.

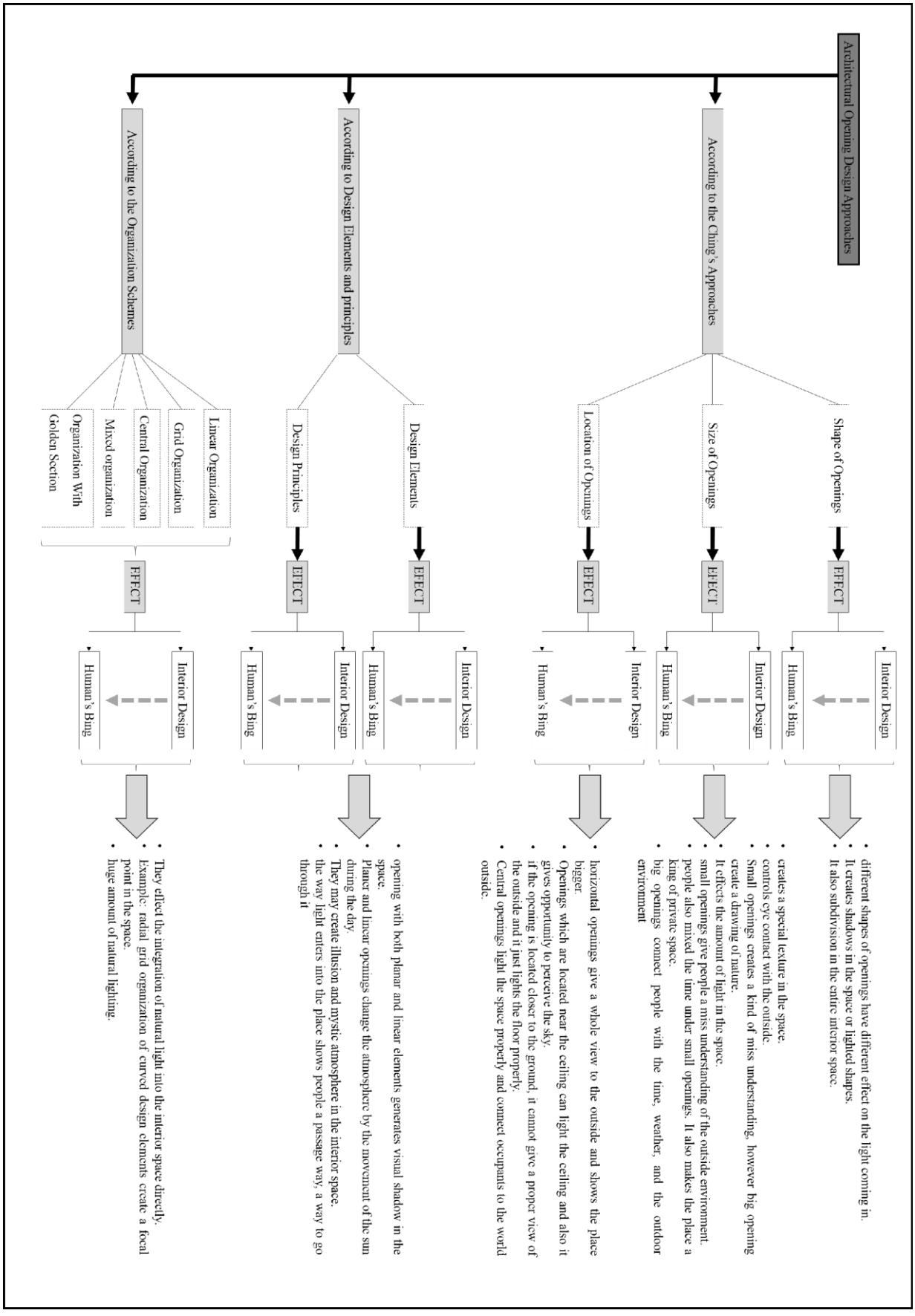
Additionally, opening design has special effect on natural lighting, which affects a person's perception. For example, in the example below, the way light enters into the place shows people a passage way, a way to go through it. Opening design in this example, supports orientation of the user within the space.

Figure 64: Special effect of opening design on the natural lighting and people orientation.

There is a limitless approach to design openings and each different design affects mainly the health, perception, performance, orientation, convenience, comfort, emotional reaction, attention of the user within the space besides visual contact of the occupant to the outside.

According to this study, it has been revealed that design of openings can be considered under three main classifications: They could be designed according to Ching's approach, which is a common way based on size, shape, and location of openings; or they also can be designed according to the decision of design elements to be used and composed with principles; or according to the special organization schemes. However, what the important thing is that the way openings are designed effect both interior design of a space and the people who are within it [Figure 66].

Table 15: Summary of the re-consideration opening design in contemporary centuries



Chapter 4

CONCLUSION

As the world changes continuously, it affects many aspects. Architecture and interior design are also one of these aspects which are changing continuously. Invented new techniques or approaches, materials, besides, new technologies affect both of the form of the buildings and design of openings / fenestrations as well. However, it should be noted that more than the consideration of form, their effect to the interior environment should also be taken into consideration. Since, the role of the light is ignored in contemporary architecture and some studies (Serra, 1998) carried out the subject emphasized that there is a huge vacuum about this issue, this study would be a representative to provide an insight on the importance of natural light plays in the interiors.

As it was mentioned by Theodorson (2006) it is important for designer to know the ways of designing light properly. Accordingly, this study concludes and provides various approaches in the consideration of openings and design of natural light in different ways. They could be designed in a very systematic manner, either according to the Ching's approaches, or they may be created based on design elements and principles, or according to the different organization schemes. However, the effect of them on the natural lighting is the most important issue in their design. Nowadays, most of the architects design opening considering the shape, form or the concept of the buildings and unfortunately they do not pay attention to the interior design point

of view. How openings affect interior design and its occupant's perception is not the main consideration. As Beever (2006) points out it is not easy to work with light as though is real or solid material. It is a transitory element and designers need to know what to want and determine what is needed in lighting design. Thus, this study with the re-consideration of opening design would give options to designers in a proper way to get the best result.

Natural lighting can make a space alive or dead, it may connect people to the outside environment / the time or do not, it also may create texture in interior spaces, which all are depended to the ways openings bring it into space. The designer can create sub-spaces, or change the scales of indoor spaces by designing natural light according to design a proper opening on the shelters. Thus, it could be said that, opening design is a sensitive part of architectural design.

According to this re-consideration, openings are the only way to bring natural light into space, they make a corporation between the two sides (indoor / outdoor), so it should be considered by both architects and interior architects. It means that there should be such a teamwork between both to create and design a proper opening from architectural point of view and a well design element from the interior architecture perspective.

On the other hand, natural lighting should be considered and related to the education of interior design. It is not something touchable and cannot easily understood or used. Educating natural lighting is also difficult for the educators to prove its magic trough traditional educational tools. Thus, showing the importance of natural lighting for professions / occupants, educators can or may should think of innovative ways to

integrate natural light more into their daily design learning / teaching / practicing activities.

As this research / study is a re-consideration of architectural opening design in contemporary centuries, it will be useful for all architects, interior designers, educators, students and all who are dealing with interior design issues. The main focus of this investigation is mainly on opening design itself and their effects on interior space, interior design and human being. The perception, psychological effect, and treatments are not considered during this investigation. So, further researchers may consider the effects of opening design according to the treatments (shelter, framing, color / types of glasses…). And also there is a need to carry out a further study on the psychological effects of the designed natural light on the occupants. Besides, the possible ways and means of cooperation between architects and interior architects should also be researched in a further study.

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