Factors Influencing and Expressing Creativity; A Study on Parametric Design and Accomplished Architects

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ABSTRACT

Architectural design is a difficult process for each individual. Every human being is unique; therefore, each people have different specialities. In the 21st century with the high level of stimulators, the process became more complex. Nowadays, just having a creative idea is not enough. Other variables come into consideration as expressing and implementing. Creativity assessment upon architectural designs and the systematic approach towards a design solution is to be taken into account.

Therefore, the link between creativity and individuals is to be discussed by the case studies. The role of parametric architecture and architects' features are important factors to understand their relationship with each other. This thesis aims to analyse the factors which affect architects' creativity in terms of background, nature, intuition, learned behaviours with respect to parametric architecture. How creative ideas appear, how they are implemented are the notions that are wondered. Therefore, the methodology consists of qualitative data that adopted a literature review of the design process by means of theories and methodologies from the 50s, 60s as well as parametric design and architecture. Additionally, architects and their projects were analysed. Five architects and their two projects from different periods were chosen. The architects are of different ages, gender, and cultural background to increase the reliability of the data. Furthermore, all of the projects are award winners from different or similar aspects. Analysis of renowned buildings by accomplished architects and the phases that they went through has the possibility to enlighten the factors that influence creativity. Through interview articles and videos, architects' features were analysed by content analysis and converted into quantitative data. In

addition, how creativity has been expressed is another question to seek for an answer. It will help for the creation of a passage to seek through some results whether the intuitional manners or the systematic approaches are the lead factors to affect the creativeness of designs.

The findings were examined by chart and 4P model (Abraham, 2015). The person is the most noteworthy point during an idea generation but each having different motives behind it. The outcome reveals that the parametric design is a supporter of creative design, however, the creativeness of the idea comes from the architect.

Keywords: Design, Architectural design process, Creativity, Design thinking, Parametric architecture

ÖZ

Mimari tasarım her birey için zor bir süreçtir. Her insan benzersizdir; bu nedenle, her insanın farklı özellikleri vardır. 21. yüzyılda yüksek düzeyde uyarıcılara maruz kalma sebebiyle mimari tasarım süreci daha karmaşık hale geldi. Günümüzde sadece yaratıcı bir fikre sahip olmak yeterli değildir. İfade etme ve uygulama bazında başka değişkenler de hesaba katılmaktadır. Tasarım süreci yaratıcılık noktasından farklı bir bakış açısı ile incelenmelidir; teknolojik gelişmeler, özellikle parametrik tasarım ve mimarinin etkileri de düşünülerek tartışılması bu duruma fayda sağlayacaktır. Mimari tasarımlarda yaratıcılığın değerlendirilmesi ve tasarım çözümüne yönelik sistematik yaklaşımlar dikkate alınmalıdır.

Bu nedenle, mimari tasarımda yaratıcılık ve mimar arasındaki bağlantı, vaka çalışmaları yardımı ile tartışılacaktır. Bu bağlamda, parametrik mimarinin rolü ve mimarların özellikleri, aradaki ilişkiyi anlamak için önem taşımaktadır. Bu tez, mimarların yaratıcılığını çevre, tasarım eğitimi, doğa, sezgi, öğrenilmiş davranışlar açısından etkileyen faktörleri parametrik tasarım perspektifinden incelemeyi amaçlamaktadır. Yaratıcı fikirlerin nasıl ortaya çıktığı ve nasıl hayata geçirildiği merak edilen kavramlardır. Bu sebepten çalışmanın metodolojisi tasarım süreci ve parametrik tasarım ile ilgili literatür incelemesi, vaka çalışması, nicel ve nitel verilerden oluşmaktadır. Bu kapsamda, 50 ve 60'ların teori ve metodolojilerine ek parametrik mimari de baz alınmıştır. Tez kapsamında mimarlar ve projeleri incelenmiştir. Beş mimar ve her birinden farklı dönemlerden olmak üzere ikişer proje seçildi. Verilerin güvenilirliğini artırmak için mimarlar farklı yaş, cinsiyet ve kültürel geçmişe sahip olanlar arasından seçilmiştir. Ayrıca, her mimarın farklı veya benzer

yönlerden ödül almış mimari projeleri yer almaktadır. Başarılı mimarların tanınmış yapılarının geçirdiği evreler, yaratıcılığı etkileyen faktörleri ortaya çıkarmada yardımcı olmuştur. Buna bağlı olarak, seçilmiş mimarların özellikleri verdikleri çesitli makale ve video röportajları vasıtası ile içerik analizi yöntemiyle incelendi ve nitel verilere dönüştürüldü. Ek olarak, yaratıcılığın nasıl ifade edildiği cevabı aranan bir sorudur. Bu durum tasarımların yaratıcılığının sezgisel davranışlar ya da sistematik yöntemler tarafından mı daha fazla etkilendiğini anlamakta fayda sağlayacaktır.

Bulgular grafik ve 4P model (Abraham, 2015) ile incelendi. Kişi, fikir üretme sürecinde en dikkat çekici noktadır, fakat her birinin arkasında farklı motifler vardır. Sonuç parametrik tasarımın kreatif dizaynın destekçisi olduğunun fakat esas yaratıcı fikrin mimardan geldiğini kanıtlar niteliktedir.

Anahtar Kelimeler: Tasarım, Mimari tasarım süreci, Yaratıcılık, Tasarım odaklı düşünme, Parametrik mimari

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Chapter 1

INTRODUCTION

1.1 Problem Statement

Discovering the correlation of individuals and their creativity level by the help of suitable case studies is to be developed. Design thinking is a complex process for people. Every human being is different; therefore, they all have different capabilities. Everyone has diverse experiences therefore intuitive approach will be unique together with their analytical thinking. Oxman (1990) mentioned (Al-sayed, Dalton & Hölscher 2010, p.212) that the root of information that an individual has is the trigger factor of abstract design concepts.

Different questions evoke such as; 'Is it the uniqueness of mental awareness which affects the creativity level? Or the context and background of people are the factors that set the intensity of creativeness? To enlighten the problem, an answer should be searched for the question which is; 'what is the relevance of different backgrounds of people and their ability to react towards to a design solution?'. Nowadays, parametric design is a contemporary architectural approach thus 'What is the role of parametric designs since they enable people to explore many alternative solutions?'. Therefore, the main issue to be searched is the factors that affect and express creativity by means of the effect of nature and nurture from the perspective of parametric architecture.

1.2 Aim of the Study

Analysis of factors that affect the individual's creativity like; background, intuition and personal characteristics forms an important part of the study. To search for answers whether the creativeness is correlated with the lifestyle, past of the individuals or does it come from deep inside of us. An intuitive approach is closely related to creativity. Additionally, the influence of the parametric design on creative design generation and creativity is to be analysed by the chosen case studies and architects' interviews. The creativity issue first started to be formed in the 1950s. Still, the descriptions improve as the design technology and cognitive science improve (Runco, 2004). Moreover, 'from where does this intuition come from?' As scientists suggest the subconscious mind is a mystery, still waiting to be solved fully. Assumptions illustrate that the subconscious mind is highly correlated with intuitive behaviour.

Furthermore, other studies show that this type of behaviour is one of a kind and it is a matter which affects creativeness. Therefore, searching for the points that affect the subconscious mind is crucial. It is also renowned that cultural background has its own eccentric effects on people; from our way of thinking up to the choice of the lifestyle of a person chose to live. Dewey explored (see Buchanan 1992, p.7) the critical correlation of science, art and practices. Parametric design tools enabled the formation of surprising, novel designs by allowing the production of complex design forms. Thus, the influence of parametric design on creative thinking is indefinite that needs to be analysed. The main aim of this study is to analyse the factors that have the potential to influence and express creativity from parametric architecture's point of view. That is supported by the analysis of accomplished architects' design views

and their projects. To reveal the new relations that appear between science and art thus how creative ideas appear, how they are implemented are the notions that are wondered.

1.3 Methodology of the Study

Documentary research, qualitative data collection techniques are benefited. Qualitative data is used to produce quantitative data for ease of comparison. The literature review is based on the subjects of design, design process, design thinking, creativity and parametric design. Basically, architects' interviews and appropriate literature are analysed by the aspects that are explained in Chapter 2. Afterwards, by the content analysis the number of the incidents that referred to the specific factors identified and listed in the table. The number of incidents, later on, supported the development of the incidence rate of the factors in terms of percentages. Those results give a general overview of the influential facts. Nevertheless, each case study was analysed by the phases to observe which stage of design adopted the parametric design tool. Additionally, the benefits which they had supplied were discussed under each case study. Certain existing models for the subject were adopted to have reliable analysis. The analytical part forms a critical part of the study; as the projects of architects are meant to be analysed. This in turn guides towards the path of finding a solid answer to the question of 'what are the factors that have an impact on creativity?' and the role of parametric design in terms of expressing creativity.

Case studies form a significant part of the research. This study covers renowned architects and their buildings as case studies. The chosen projects are competition or award winners. In addition, architects were chosen from different age groups and cultural backgrounds to enable comparison among them. Moreover, background,

education style, generation are some of the facts that will help for the research. The architects chosen are; Frank Gehry, Jean Nouvel, Zaha Hadid, Bjarke Ingels and Melike Altınışık.

1.4 Limitations of the Study

To begin with, this thesis adopts qualitative and quantitative data analysis techniques. A total of five architects who were born in different years were chosen, they all have at least five years difference between them. They are all from different nationalities also they are all renowned in the field of architecture and received many awards. The case studies were chosen by considering their success. Two projects from each architect were chosen. Their success measure was the awards received. Some of the projects are still in the construction phase or could not be constructed by legislative conflicts whereas some of them are built.

1.5 Structure of the Thesis

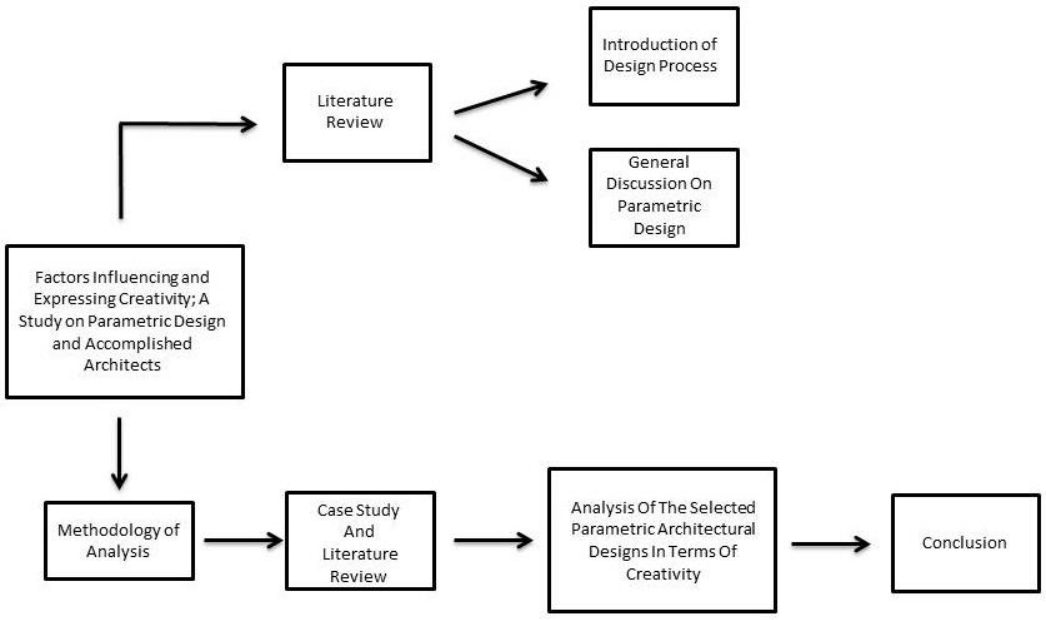


Figure 1: Structure of the thesis, by author

Chapter 2

INTRODUCTION TO DESIGN PROCESS

2.1 Definition of Design

The concept of design notion arose in the 1960s with the urge of scientists who were interested in the field of cognitive science (Ball & Christensen, 2019). Even the interest in scientific design products started in the 1920s (Cross, 2006). In the 1970s design research area had a rejection by a group of people especially from the leaders of the movement. In the contrary with the 1970s and 1980s were significant for the realization of the character of design by the help of critical discussions (Luck, 2019). Simply, design means a solution to a problem but sometimes not just a problem but problems (Darbellay, Moody, & Lubart, 2017). In addition, it is an act of transformation through "invention and intervention" (Aakhus, 2007).

Furthermore, "it is the epistemology of design that has inherited the task of developing the logic of creativity, hypothesis innovation or invention that has proved so elusive to the philosophers of science" (Glynn, 1985, p.122-126). There are two methodologies lying under the design cognition. These problems are known as 'wicked problems' because of their tendency to have the specialities of been uncertain, indeterminate, value conflict also having unexpected outcomes, lack of ready-made criteria, answers, and solutions (Darbellay et al., 2017). Therefore, design is a path of analysing the world through communication (Aakhus, 2007).

2.2 Architectural Design Layout

As the term architectural design appears it leads to think about the architecture and design in separate fields as well. The interrelation of research in terms of architecture and design is not certain. The reason for this unclearness is mainly the architecture centralised by design thus architectural design could be seen as a part of the design research**.**

Interestingly, Gibson (1976) mentioned the theoretical base of architecture and design is not satisfactory. Generally, for design framework history is the most important part since it was newly started to settle around the 1960s (Baljon, 2002; Ball & Christensen, 2019). However, nowadays architecture as a sub-part of design is one of the most popular topics which increases the number of writings related to them (Lawson, 2005). Interestingly, many studies which are conducted upon architectural design process illustrate that the design process does not have firm rules or guidelines to follow, furthermore, most of the architects claimed traditional set of rules prevent them to think freely. This, in turn, inhibits their creative thinking (Kowaltowski, Bianchi & de Paiva, 2009; Hakak, Biloria & Venhari, 2014).

The architects were more inclined to propose a series of solutions and to have these solutions eliminated until they found an acceptable one (Cross, 2006, p.6). These experiments suggest that scientists problem-solve by analysis, whereas designers problem-solve by synthesis. Lawson (1979) repeated his experiments with younger students and found that first-year students and sixth-form school students could not be distinguished as ‘architects’ and ‘non-architects’ by their problem-solving strategies: there were no consistent differences (Cross, 2006, p.7). By the analysis of

certain aspects which affected the creative design process of architecture Akin and Akin (1996, 1998) stated that an individual who is interfering with these processes should be skilled in creative problem-solving in addition to having enough design knowledge (Demirkan & Hasirci, 2009). This suggests that architects learn to adopt their solution-focused strategy during, and presumably as a result of their education (Cross, 2006). Presumably, they learn are taught, or discover, this is the more effective way of tackling the problems they are set.

The architectural design process includes a conceptual approach and most importantly the conceptual design process which is a crucial part made up of creativity, moreover, during an architectural design problem-solving plays a significant part since it is vital for the ongoing creative process (Önal & Turgut, 2017; Widiarso & Hannan, 2018).

By these explanations, another question appears to be answered which is ‘How does a design solution is generated in order to put out a creative product?’. Since it has been mentioned there are various researches that suggest a variety of different ideologies behind the creation of a design. Therefore, it is a must to understand how design thinking occurs.

2.3 What is Design Thinking?

This part of the study highlights the importance of design thinking during a design process. Firstly, design methods started to be searched in the 1960s the aim was to enlighten and in turn to decrease the subjectivity of design. Moreover, certain methods brought by Jones (1970) are still having a great significance in today's world as well (Kowaltowski et al., 2009). Those methods were arranged mainly as “input”

and “output” input forming the knowing part and output as the will to know. The supporters of the system were; “brainstorm” and “analogy and attribute” which were dedicated to open the way of mental blockage. Those methods form the basis of design thinking in which is vital for the generation of ideas and solutions which targets ill-defined problems (Cross, 2006). However, what really is ‘Design Thinking ?’. By Rowe’s book (Rowe, 1987) which has the headline of “Design Thinking”, the terminology has become the component of a collective consciousness of people who research about design (Dorst, 2011).

In the 20th century rise of design thinking appeared to be more significant (Buchanan, 1992). Design thinking is one of the cornerstones of creative action towards a design solution since it has an important role in concept generation (Choi & Kim, 2017). Additionally, design thinking is in charge in many fields such as Information Technology (IT) (Brooks, 2010) and Business (Martin, 2009) (Dorst, 2011). As Shute & Becker (2010) stated; Design thinking is a skill that includes problem-solving (Razzouk & Shute, 2012). The mission of a designer is to find a solution by concentrating on a problem. Therefore, problem analysis is the priority then the production of a solution generates. It is known that design does not have the same problems which mathematicians or scientists work on, however, they are mostly referred to as ill-defined, ill-structured, or ‘wicked’ as defined by Rittel and Webber, 1973 (Cross, 2006, p.7). Regarding those notions some questions such as ‘What are the mental processes or how a designer thinks to digest the design problems’ nature?’. There are many research and assumptions for the answers of them. For example; a certain part of people defends that the design process should be analytical

whereas some of them argue intuition should cover a major part of the design process (Clarkson & Eckert, 2005).

By the school of psychology renowned as Gestalt School, it became able to find out more data for the explanation of design thinking and its theories of thinking mainly focus on processes. The 'Gestaltists' were keen on the significance of perception as well. Thus, this approach also underlines the importance of the role of perception while designerly thinking. Schema found by Bartlett (1958) basically is an image constructed mentally. This mental image shows old experiences in order to be able to adapt future (Lawson, 2005, pp.131-133).

The cognitive science approach is the most abundant one for well-defined problem solutions (Lawson, 1979). To open up the subject more scientifically, two thinking styles are classified as divergent and convergent thinking. These are the thinking styles that form the basis of design thinking. Simply divergent thinking enhances the different points of view to form a unique design solution. There are two divergent thinking techniques that come in as different approaches; the 'structural' and the 'procedural'. Divergent thinking is highly correlated with creativity, however, convergent thinking is found similar to intelligence (Hassan, 2016). Thus, brainstorming a design idea cannot be achieved without the help of two important styles.

In addition, design thinking encompasses processes known as an analytic and creative process that directs a person to experiment, create and redesign (Razzouk & Shute, 2012). Those arguments led to a point that design thinking's dualistic nature is understandable. Therefore, to be able to solve the wicked design problems an

individual should develop a multiperspective (Plattner, Meinel & Leifer, 2011). There are commonly classified as imaginative and reasoning. Imaginative thinking is composed of artistic and creative thoughts but for designers besides imaginative thinking reasoning also convergent thinking plays a vital role (Lawson, 2005, p.130-138). Those processes and thinking styles reveal how complex design thinking is.

2.3.1 Process of Design Thinking

The design process is extremely complicated. It is a never-ending process and relies on creativity. Modern views upon design have been heavily affected by Simon's (1971) view (Edelson, 2002, p.108-109). The previous studies of the design process were mainly focused on the general characterization. The main subjects to be enlightened were the identification of procedures that were playing the lead role in developing a design, description of design by the general classifications of certain tasks and mapping of the human cognitive system (Akin & Lin, 1995).

Cross (1997) mentioned that the design process occurs by actions between the solution and problems (see Studer et al., 2018, p.416). There are two important factors that affect the design process: one is "the nature of the artefact to be designed" and the other one is the "nature of human problem solving and cognition" (Andreasen, Hansen & Cash, 2015, p.97).

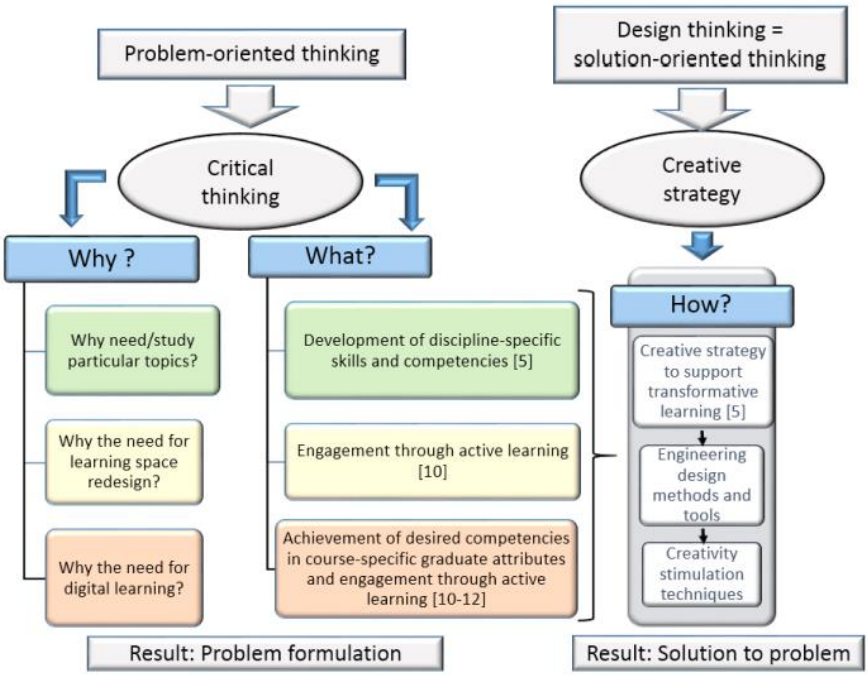


Figure 2: Design thinking ways (Pusca & Northwood, 2018)

The design protocol can be perceived as a dual-mode process in which verbal-conceptual and visual-graphic data interfered. However, since the design process is complex this kind of path cannot describe the process in an adequate way. Unfortunately, just “verbal (transcriptions)” and the “visual (drawings)” are not enough by themselves to enlarge the topic. The reason behind that is while observing that data there will be no assurance if the designer was following a clear path of visual or conceptual processing. Usually, design is based on a problem solution whist art is more self-oriented and involves intuitive expressions (Akin & Lin, 1995; Lawson, 2005).

Producing a solution for a given problem is explained by Wertheimer (1959) as structuring and reorganising a situation until the solution could be observed (Lawson, 2005, p.132) (Figure 2). The interesting subject of design protocol is the mutual relationship between verbal-conceptual and visual-graphic information (Akin & Lin,

1995). The dual-mode caused by that relationship can be explained with the help of the model.

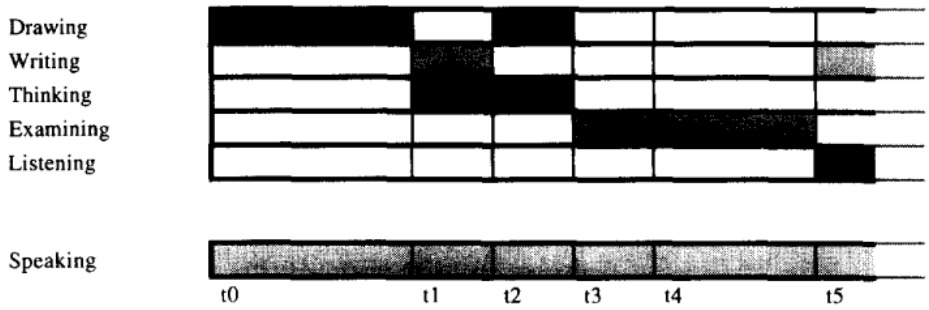


Figure 3: Activity based Model (Akin & Lin, 1995)

As the model shows there are six items: “drawing, thinking, examining, talking, writing and listening” which are forming the activity-based model and are presented in Figure 3. Akin and Lin (1995) mentioned drawing, writing and talking are directly the parts of the dual-mode model. The existing design process models are not expected to lead the way of behaving, however, those models are in need to act like a guide (Andreasen et al., 2015). Even conventional scientific activities adopted design to evoke the scientific curiosity for the concentrated topic. Design thinking’s linear model is composed of decisive problems with defined conditions Figure 4 exemplifies it. By acting precisely according to those circumstances a solution can be generated (Buchanan, 1992).

However, as Buchanan (1992) stated according to Rittel majority of the problems directed towards designers are ‘wicked problems’. Rittel was the pioneer architect of the concept named as ‘wicked problem’ and as well as a designer, mathematician, and former teacher at the Hochschule fur Gestaltung (HfG) Ulm who developed a model in contrary with the linear model of the design process which investigated by

many design theorists and designers (Crowley & Head, 2017; Buchanan, 1992). Additionally, Simon (1972) stated that design problems are open-ended and ill-defined on purpose. To open up the subject; usually, problems are given by missing information and for the possible solution even less than that amount of information is given (Studer et. al., 2018).

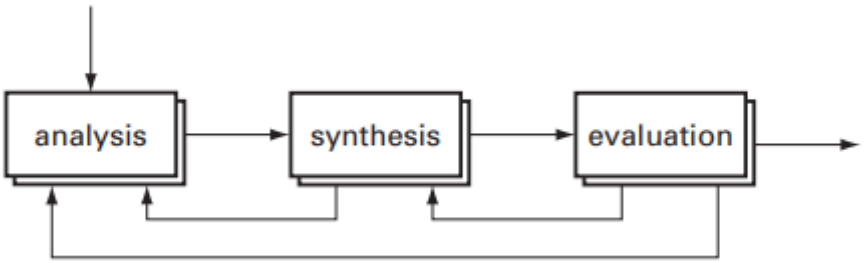


Figure 4: A general map of design process (Lawson, 2005)

Design takes place first as the implementation of the theory, followed by evaluation-oriented research. The design process is not regarded as an opportunity for learning. In contrast, design research explicitly exploits the design process as an opportunity to advance the researchers understanding of teaching, learning, and educational systems (Edelson, 2002). Besides these, it has been suggested by the "wicked problems" approach that design problems all have an indeterminate part in them. The so-called "wickedness" has been pulled out to feed analytic problems (Farrell & Hooker, 2013).

Design process has two stages which are known as problem definition and problem solution Zeisel (1984) showed an approach that included a proposal of a design that has five characteristics (Buchanan, 1992, pp. 15-16). The first three of those are imaging, presenting and testing. Jerome Bruner referred to imaging as "going

beyond the information given". Moreover, the second part of Zeisel's approach is presenting which includes drawing as the key point of it (Lawson, 2005, p.131).

According to Ziesel (1984), the other part of designing deals with two types of knowledge one is for imaging and it is called a heuristic catalyst whereas the other is for testing and mentioned it as the body of knowledge.

2.3.1.1 Design Problem Identification

As it is well known that design is a complex problem this complexity can go on by different factors like; effects, stakeholders, problems and their variety of relations. These are all depending on the way of their perceived by the designer (Andreasen et al., 2015). People's apprehension of a design problem and the ability to solve them is dependent on their conceptions (Lawson, 2005).

Goldschmidt (1995) stated that almost all of the design problems are ill-structured in other terms 'wicked' therefore this speciality of them turn them to be unique and they need fruitful processes to be able to produce an answer to those kinds of problems. Problem definition incorporates analytical aspects which a designer ought to understand and identify all of the necessary factors of the problem. Moreover, the analysis follows the problem identification which requires an analytic point of view to assess the problem (Buchanan, 1992; Edelson, 2002). Figure 5 shows the relationship of the analysis, synthesis and evaluation phases starting from the problem definition till the solution generation.

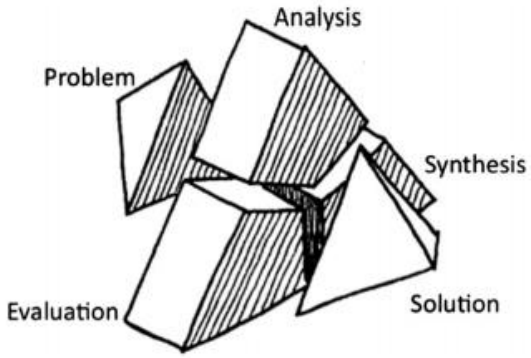


Figure 5: An illustration of the design process (Parsaee et al., 2016)

Interestingly, most of the research papers focus on process models or maps to reveal the action towards the wicked problem understanding for proper analysis and evaluation. However, this identification and understanding process does not only consist of morphological or cognitive data. It also consists of other subjects as well which can be classified as social, political and more (Farrell & Hooker, 2013). Figure 4 exemplifies the mentioned aspect successfully.

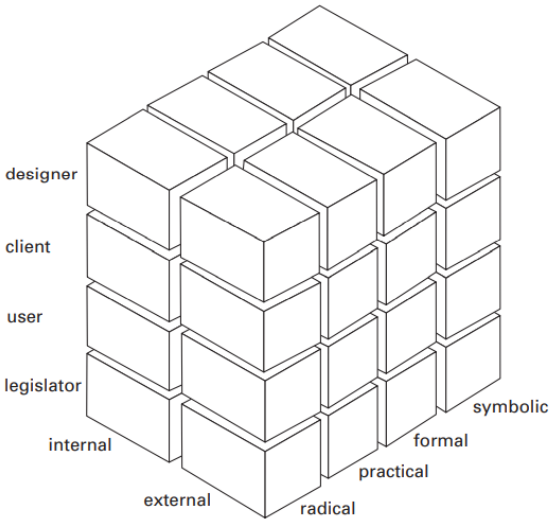


Figure 6: Different problems of design (Lawson, 2005)

As the social part is stated for architects having effective communication with the clients is crucial as presented in Figure 6. Usually, the difficult part is the uncertainty that occurs because of the now well-known or defined design demands by the clients.

If the communication between an architect and a client proceeds in the wrong way it has the potential to affect the final outcome as well. In order to overcome or decrease the level of misunderstanding that may generate from technical or behavioural patterns, a design brief is a preferable item to be developed since it will provide the chance to notice the design problems given by the client (Norouzi et al., 2015; Ambrose & Harris, 2010). It should not be forgotten that a design problem arrives with the client, however, the solution with the optimum necessities are to be developed by the designer after the full understanding of the problem. This client and the designer relationship becomes reciprocal both of them being dependent on each other (Parsaee, Motealleh & Parva, 2015).

2.3.1.2 Solution Generation

It is predictable that after the problem identification phase another phase begins which is known as the solution generation process. There is an occurrence stated with the term called contextualization, this process is brought by Buchanan (1992). Generally, it helps the solution formation stage to work with the problem identification at the same time by carefully understanding the issues. Successful analysis of the problem is also necessary (Johansson-Sköldberg, Woodilla & Çetinkaya, 2013). Decision making is the notion which forms the design without decisive actions how it would be possible to have a design solution?

Design consists of a series of decisions. Those decisions include several stages like a chain of reaction (Edelson, 2002).

1. The path of the design process which will continue
2. The requirements and alternatives which the process will show
3. The end product and the form that it will take

However, many design processes may not be as straight as this decision sequence. The importance of decision making can be explained by the model which was illustrated by Hall (1962) (Figure 7). According to the theory which was developed by Boulding (1956) there is a certain hierarchical level among the phases of design (Zeiler & Savanovic, 2009).

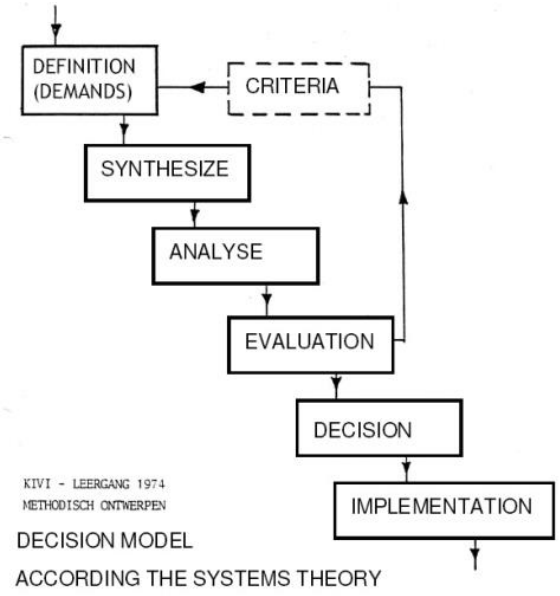


Figure 7: General System Theory representation by Hall (Zeiler & Savanovic, 2009)

Markus (1969) stated four determinants for the decision-making process/situation. These can be listed as the designer's own experience, others' experience, existing research and new research. It has been suggested that probably the mixture of those causations is the leading factor for designers' actions which sometimes reveal itself as intuitive behaviour. Also, it may lead to tardy progress (Lawson, 2005, p.133). Problem solution consists of a synthetic sequence, it combines many necessities and they also act in balance. As Buchanan (1992) mentioned the design thinking and design making processes are not basic linear processes. Figure 8 illustrates the possible design process, it is visualised how each different design step is linked and

interact with each other. Furthermore, the roles of other people should not be forgotten. During the decision-making process as long as the architect, the client, potential user and other related professions have their influence on the process (Parsaee et al., 2015).

The phase in which the design progresses and develops is known as the implementation process. The formation of a design follows a conceptual approach and it eventually shapes up the design (Chakrabarti & Blessing, 2014). The reason behind this is that according to the conceptual idea certain decisions will arise. The solution is often reached through careful management of the design problems. Complicated problems can be separated into smaller parts to understand and solve them in a simple way. Moreover, the vagueness of the problems that they have in their nature does not only have one possible answer and creativity is the key to generate alternatives (Edelson, 2002; Johansson-Sköldberg et al., 2013). Alternative generation may happen through brainstorming which is a creative idea production process and often is a result of collaborative work (Ambrose & Harris, 2010).

Mostly it has been stated as the design is the optimum solution however it has been also suggested that there is no such thing. When a design is created it's formulated from multiple requirements. Also, some of the items even could be lost during the optimisation of design requirements but it should not be forgotten that during the design solution formation graphically illustrating and thinking involves visual perception therefore a person who tries to find new solutions must think in a creative manner. Nevertheless, the success of a design cannot be measured since there is no certain formula for it. For most of the designs, the best method to understand the level of functioning is to test it. It should not be forgotten that design solutions might

not be flawless even there can be mistakes. To sum up, a solution is an answer for various problems in a holistic manner (Lawson, 2005; Laseau, 2000).

The solution generation process will include the ideation but this phase includes various methods (Ambrose & Harris, 2010). Those kinds of approaches are in need as they are beneficial and essential to express the thoughts of the designer and turn them into a solid object which can be discussed for further development. Besides these facts, those are the actions that involve creativity.

2.4 Ways of Representing Ideas

Goldschmidt & Tatsa (2005) mentioned the depiction of thoughts that are formed in the mind is essential since the ideas and conceptions give the chance to people to relate. To begin with, sketching is a form of idea revelation by transferring personal thoughts onto paper. This activity can occur almost in every stage of a design process as it is the most rapid way of visualising an idea also it is the most renowned one as well (Ambrose & Harris, 2010; Roberts, Headleand & Ritsos, 2017). The 1970s was the starting point of the analysis of sketches based on the architectural field. In contradiction with the design methods that appeared in the 1950s and 1960s, design thinking and processes became a subject that caught attention. Furthermore, the interest in art-focused disciplines such as cinema, visual arts, etc. led design sketches to occupy an important position. The research about the design sketches first came out by Herber (Chakrabarti & Blessing, 2014).

Sketching includes many variables in it such as; individualistic thinking, collaborative support and embracement of older ideas. The individualistic thinking style that it has in its nature forces the designers to pass through the issue they are

dealing with (Lugt, 2005). Furthermore, designers benefit from visual surroundings, an environment creates a medium for gathering visual information. Consequently, this prepares the path of visual ways to expose the thoughts and concepts (Goldschmidt & Smolkov, 2006). To be able to visualize and have a solid element for the discussion of thoughts sketching plays a vital role. Additionally, it helps to find an alternative solution. On the other hand, sketching is an individualistic approach that enables a person firstly to take care of their ideas. It creates a medium that shows collaborative support and enhances earlier ideas. Being a research assistant in the Department of Architecture, Eastern Mediterranean University gave the opportunity to observe the mentioned issues. In Arch 291 Design Studio the students were firstly analysing the given projects from multiple dimensions then based upon their analysis conceptual layouts and sketches were generated. It is crucial for them to be able to show their conceptual approaches by depicting their ideas and sketching is a necessary action for it. Ferguson stated three varieties of sketching which are known as the thinking sketch, the talking sketch and the prescriptive sketch (Lugt, 2005; Baskinger & Bardel, 2013).

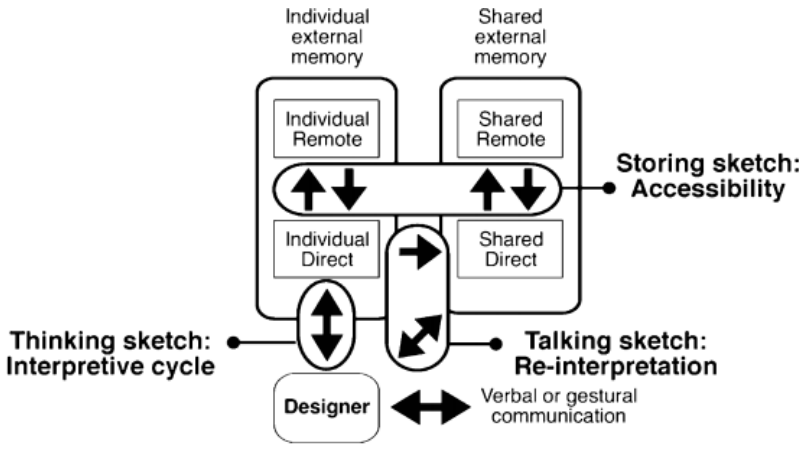


Figure 8: Immediate sketching by thoughts (Lught, 2005)

As Goldschmidt (2003) mentioned sketches of architects' can be unclear. According to her, this has a correlation with the design process which is known to be a creative situation. Furthermore, it had been suggested that the vagueness of the sketches are because of the immediate idea generation. The image visualised is not definite therefore it cannot be reflected in a crystal clear format. This is the main reason for those unconfident lines (Lugt, 2005).

Figure 9: Representation of a conceptual sketch (Laseau, 2000)

Figure 9 illustrates the abstractness of the sketches which are valued as a result of the core cognitive processes (Farrell & Hooker, 2013). This can be seen as an individualistic approach but it is not only the individualistic approach but the collaborative manner of sketching which is called a C-Sketch is a useful method for the ideation stage as it provides the opportunity for different idea generations from different people (Sun et al., 2014). Figure 10 represents a model of sketching.

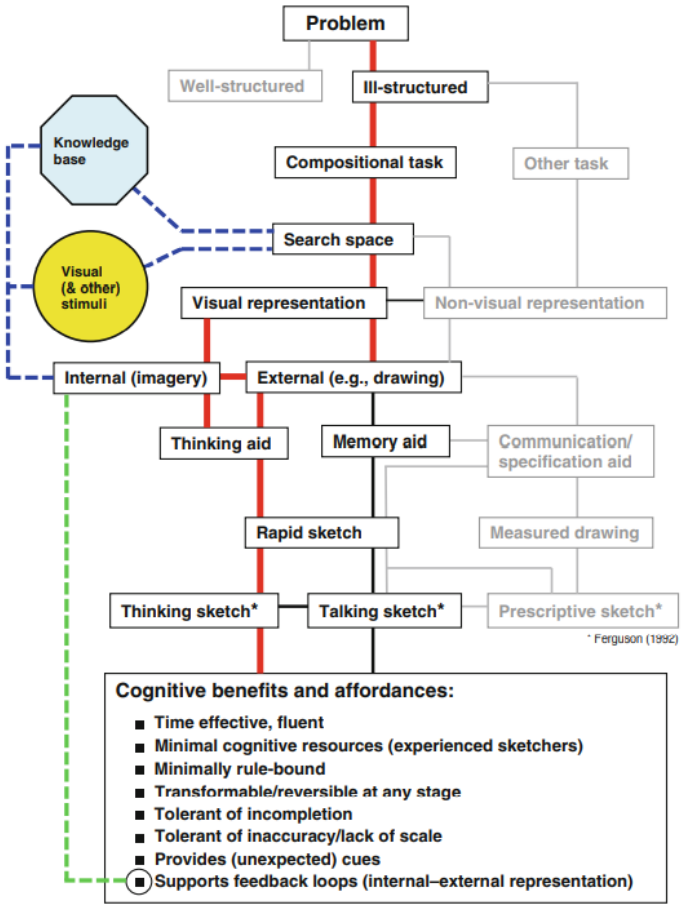


Figure 10: A model of sketching by Goldschmidt (see Chakrabarti & Blessing, 2014)

Besides the importance of sketching, in this technological era it is significant to consider the benefits of computer-based programs. With the help of those programs nowadays architects can generate multiple alternatives of the finished state of the design according to the necessities. It is critical to understand that these alternatives are the ones that have been stemmed from an almost finished design. After the initiation of the design idea, this kind of technology will improve the creativity of the design as well. Complex architectural forms can be drawn and visualized by the 3D programs and these sets free a designer because an architect can now feel free to design the craziest project (Grobman, Yezioro & Capeluto, n.d.).

On the other hand, while one research argues the freedom achieved by the Computer-Aided design the other ones may suggest the opposite. Computers and other technological devices are in use for the representation of architectural design especially in certain stages such as in the production of working drawings or presentations and more can be listed. Besides, these advantageous and beneficial use in certain areas, one stage cannot be thought o be replaced by Computer-Aided Design programmes which are sketching. Sketching is the path to enter someone's inner world. There are programmes that provide simple form generation for conceptual parts as it tries to imitate the actions of hand sketch but the real effect of them on creativity still needs to be discussed (Smith, 2005). As in this case, Roberts et al. (2017) stated the importance of not being fooled by the digital expression of ideas. It cannot be denied that computer visualizations are great at showing the most likely situation of a finished state. On the contrary, this issue implies the power of sketching as it helps people to question the ongoing design solution. In the process of sketch, designers feel free to search for other solutions or at least to have a try at improving the result. The feeling of a pencil is unique to the one holding it and it is explained that this creates a link between the architect and itself. The new technologies introduced other options to replace the traditional pencil, like a stylus. However, it cannot replace the place of the traditional way since the conventional method provides rapid control over the item and gives chance to express the ideas in a better aspect. It also promotes a different thinking style, a different perspective (Roberts et al., 2017; Smith, 2005).

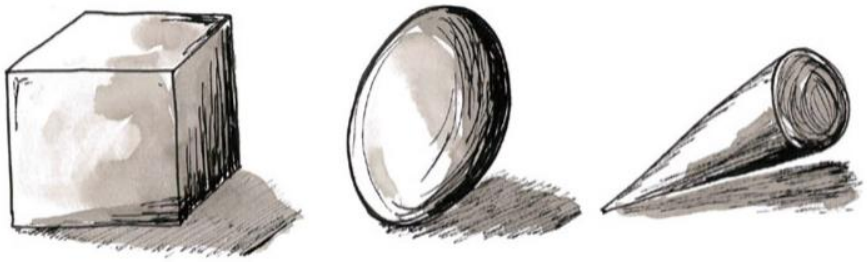


Figure 11: Sketches of 3D masses (Roberts et al., 2017)

These images (Figure 11) are examples of simple 3D sketches but these are more than what they suggest. The mind has the tendency to link these shapes with other materials in life. For instance; the box can be a brick of a house. Imagination is a notion that can be inspired and create relations through basic things. Most probably the feelings that it gives are rough, unfinished, etc. Therefore, besides having a finished computer product and limiting the idea generation, in the preparation and brainstorming stage sketch is the must tool to be enhanced by architects, engineers and all the designers (Roberts et al., 2017).

Model making is crucial in the concept development stage; it helps to express the designer's ideas. A model can be called as the revision of the sketches since it evaluates the success of the formed sketch. It may give a glimpse of hint towards the later constructional procedures as well, it will be beneficial to understand the potential structural work (Chakrabarti & Blessing, 2014).

Computer-Aided models are widespread in use, however, the traditional ones differentiate from the technological ones. The main reason behind this is that the conventional models also have the nature of a sketch. It eases the way to notice the masses and spaces hence give the opportunity to play with the form until finding the

desired design. In architectural education and at professional practices this is one of the tools which is in charge (Sachanowicz, 2019).

In the middle of the 1970s and 80s, computer-aided design (CAD) started to appear with the increased level of personal computer usage. Firstly, 2D drawings began to be drawn with the help of CAD software which helped to reduce the time spent by traditional drawing tools. Some examples of those software programs are; AutoCAD, Revit Architecture and more (Fakhry, Kamel & Abdelaal, 2021). In architectural drawing and modelling digitalisation has a huge impact since the technological advancements continue to improve day and day offering a new opportunity. The 2D based CAD programs evolved into the software which includes intelligent 3D based on parametric modelling (Stavric & Marina, 2011).

2.5 Discussion of Different Design Methodologies and Theories

The theoretical background is crucial for the initiation and the ongoing process of design since it is a part of collecting information which in turn helps the generation of conceptual designs (Bashier, 2017).

The publications about design methodology and methods started to be seen in the 1950s and 1960s. For instance; Hall (1962), Asimow (1962), Alexander (1964), Archer (1965) (Figure 11), Jones (1970), Broadbent (1973) (Cross, 1993, pp.16.). They were known as the first generation who initiated the methods and the ones started to appear in the 1960s relied on the first generation in terms of theoretical and technical aspect (Dorst & Dijkhuis, 1995). The term generations found by Rittel known as the theory of generations according to his view first generation which is the 1960s had a scientific thus rational background. The second generation which is

the early 1970s focused on a different alternative of solutions for the problem owners who are clients and users (Cross, 1993). In the 1970s and the beginning of the 1980s, the theoretical findings began to be susceptible as the nature of design problems started to be defined as 'ill'. Furthermore, in the 1960s Christopher Jones, Christopher Alexander were the ones who were the experts of design theory subject and they developed vast amounts of research regarding the field which contributed to the realization and understanding of the design process. Later on in the 1980s, Donald Schön's most important contribution to the design education domain was achieved by the literal called 'The Reflective Practitioner' (Chakrabarti & Blessing, 2014; Kowaltowski et al., 2009).

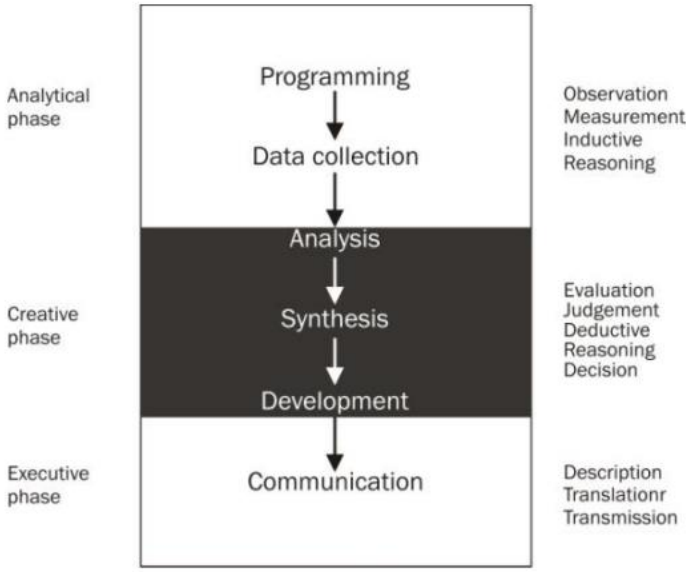


Figure 12: Archer's design process model (Linden, Lacerda & Aguiar, 2011)

Table 1: Different views of design process, remade by author (based on Parsaee et al., 2016)

Scholar	View
Roozenburg and Eekels (1995)	Mainly "analysis", "synthesis" and "evaluation" forms the model
Wallas (1926)	Model for the creative process developed known as; "preparation, incubation, illumination and verification"
Guilford (1950)	Six phases of an intellectual process; "cognition, memory recording, memory retention, divergent production, convergent production, evaluation"
Koberg and Bagnall (1974)	A creative-problem solving model suggestion consists of six stages; "Accept the situation, analyse, define, ideate, select, implement, evaluate"
Lawson (2005)	Five phases of the design process; "first insight, preparation, incubation, illumination, verification"
Laseau (2000)	In order to reach the design solution consists by; "problem definition, developing alternatives, evaluation alternatives, selection and communication".The creative design is achieved by; "representation, abstraction, manipulation, discovery, verification, stimulation"
Alexander and Chermayeff (1965)	"Analysis" and "Synthesis" form the design process. An object's life begins if a new design is in need and ends whenever the expected outcome is achieved by the new design. The lifetime includes six phases; "research, design, manufacturing, distribution and became a common object to use object disability"
Lang (1988)	Logical design process activities are; "analysis, synthesis, prediction, evaluation and decision". The design process of the environment consists of; "cognition, designing, selection, implementation and evaluation after implementation"
Archer (Alexander and Chermayeff, 1965)	Found model which suggested the connection between design process stages as the designer returns from one stage to another. Added "connection" to Alexander model.
Markus (Laseau, 2000)	"Sequential" and "Iterative" design processes are two significant parts of design formation

The recent findings of that period forced the research to be rationalized by the scientific theory and the design theories formed upon the basis of that logic. This led to the formation of General Design Theory, Axiomatic Theory and C-K Theory.

These approaches specifically influenced professional practice (Chakrabarti & Blessing, 2014).

The theories were raised by a positivist background therefore design is recognized as a rational process (Dorst & Dijkhuis, 1995). The second generation showed improvement in the 1970s and 80s especially in the field of architecture and engineering. In those times methodologists believed design problems can be indefinite but the solution can be scientific. The target of a design discipline creation became a major issue in the 1970s and 80s (Bashier, 2017). However, in the 1990s which was the era of third-generation; the models were a combination of Cross' and Archer's ideas which were giving explanations of design problem solution and its nature. In the late 1980s and 90s work on the problem, types showed an increase especially since Schön and Oxman were pioneers in this area. Unfortunately, nowadays the complexity of the design problems led to the traditional methodologies being insufficient (Cross, 1993; Bashier, 2017). However, it should not be forgotten that the existence of the past theories is the source of light of the new formations. As stated by Bashier (2017) the formation of a theory in the design domain is dependent on the generalized past knowledge which is gained from the problems solved in previous times.

The duality of design suggests that it exists through creativity and rationality therefore a suitable theory is required for its explanation. Nonetheless, a suitable theoretical approach could not be fully developed to point out the details of the dual nature of the design. Even from the 1950s theoreticians were aware that the theoretical concepts of both creativity and rationality cannot be defined individually.

The rational concepts introduced by Schön were known as “reflective practice” and Simon developed “rational problem solving” (Bashier, 2017).

As Demirbas & Demirkan (2003) mentioned; design acts as a medium that creates the opportunity for mental and social activities’ moderation. The cognitive talents of a designer are supported by the design theory. 1962 a conference held which was having the subject of design methods and this was the first time to have a conference in the field of design methodology. The scholars stated the three main phases of a design process known as analysis, synthesis and evaluation (Parsaee, Motealleh & Parva, 2015). In the 1980s new methodological approaches were started to be used the new approaches were aiming to reveal the relationship between a design product and its surrounding (Linden, Lacerda & Aguiar, 2011).

Design thinking had been affected by the thoughts of René Descartes. He claimed the problematic parts of a design should be minimised to smaller portions until achieving the optimum solution, his formed the basis of the Cartesian principles (Linden, Lacerda & Aguiar, 2011).

Simon was the one who developed a framework for design work which provided a possibility to analyse designers and the design problems from a technical perspective. About 15 years later another paradigm was introduced by him; the reflective practitioner was the base of an original theory in the design field. According to his view, the approach of the teaching generalises the uniqueness of the design problems. Schön had the perspective of adopting the philosophy of the constructionist manner (Dorst & Dijkhuis, 1995). People develop themselves in a designerly way by reflection-in-action as its name suggests this theory offers learning

by doing it. It also benefited from the mutual relationship between the tutor and the student. Furthermore, it is important to underline that this approach carries the traces of John Dewey's philosophy as he sees the experience as a key to understanding (Telier, 2011).

C-K theory helps to separate the models and they are the models which can be accepted as scientific because of their kinds of theoretical structures, definitions and objects (Chakrabarti & Blessing, 2014). Benoit Weil and Armand Hatchuel were the people who found the C-K theory (Figure 13). In this theory, the 'C' represents the space in a conceptual manner whereas the 'K' represents the space of knowledge. The theoretical approach aims to form a relationship between the individuals who work in the design field and the objects that they design (Le Masson, Weil & Hatchuel, 2017).

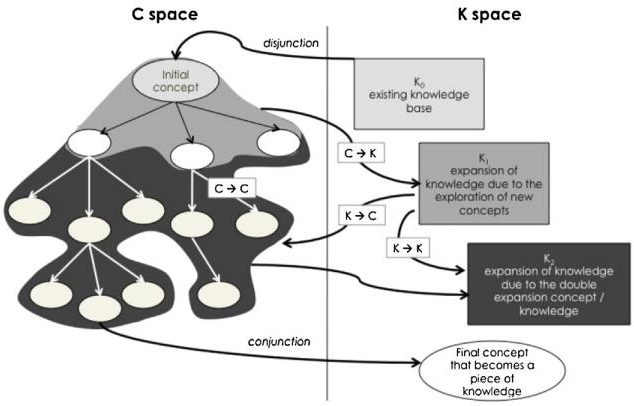


Figure 13: Characteristics of C-K Theory (Agogué et al., 2014)

2.6 The Concept and Meaning of Architectural Creativity

The word creative may depict the denial of the limitations of human beings' skills. However, the main trigger of interest in the subject of creativity showed itself in the 1950s by the pioneer J. P. Guilford who was the president of the American

Psychological Association. Through his notice about the spare research upon the field of creativity, research has started to appear (Rhodes, 1961). J. P. Guilford (1950) and E. Paul Torrance (1962, 1974) are two names who had a remarkable part in the development of the creativity field (see Sternberg, 2006).

A unique idea or product formation is defined by the term creativity (Boldt, 2019). Furthermore, there is a vast amount of definitions of creativity starting with Webster who defines creativity as a making process of bringing into being and the subject is critical for many disciplines which involve design (May, 1959; Doheim & Yusof, 2020). Creativity simply has been explained as the term which given its name for the phenomenon of an individual undergoing a new concept (Rhodes, 1961). According to Amabile (1983) creativity is something that gives rise to an outcome that is judged (see Sarkar & Chakrabarti, 2011). On the other hand, Boden describes it as a mystery (Boden, 2009).

Creativity is a part of human intelligence and it finds its position in every possible place in life. This means it is established by the actions of everyday life which are "perception, memory, conceptual thinking and reflective self-criticism". Therefore this brings up the assumption of each people being creative at different levels (Boden, 2009). One of the first explanations was referring to P-creativity (P represents Psychological) and to H-creativity (H represents Historical). Boden (1999) defined H-creativity as an idea that is the first time it is happening throughout history. It means the idea is new for the founder and the rest of the people as well. Novel productions demand an H-type of creativity (Sarkar & Chakrabarti, 2011; Boden, 2009). Moreover, P-creativity is new for the person who had the idea however unlike H-creativity there are people who had that idea before. According to

Boden P-creativity is enormously valuable as well as H-creativity, she claims that even learning is related to P-creativity at some certain points. Also, it is easily determined if an idea comes out of as a result of P-creativity rather than H-creativity since it cannot be readily determined (Lustig, 1995). Boden (2009) states H-creativity is the one significant but the P-creativity is vital.

One of the pioneers of creativity subject is Csikszentmihalyi, who stated that creativity is the outcome of social systems' judgements made about again to an outcome of a person. His concept about creativity is about domain and field. A domain is the environment of the person which is formed namely, cultural manner and the field is the social aspect. If an interaction among those two occurs the creativity happens (Williams, Ostwald & Askland, 2010). Nevertheless, Gruber analysed highly creative people and found out that creative action is a slow process (Welling, 2007). From the 1950s creative ability measures started to appear, however, recently in addition to those findings the factors of creativity were identified. However, the functioning system of the creative idea generation was not supplied with explanations to understand the process which occurs. Later on, certain models were proposed for example; Wallas' model is one of them (Table 1) (Le Masson et. al., 2015).

There are three important features of the novel ideas. The first one is that it should be unique, high calibre level and finally the solution of the problem should be consistent with the demand (Kaufman & Sternberg, 2007).

2.7 Architectural Creative Process

Creative processes occur by mental abilities and this situation had led many scientists who were interested in the cognitive field to research about it, some of those scientists were Newell and Simon. Mental processes help creative production by synthesising new elements that came from knowledge (Kristensen, 2004).

Some of the previous models illustrated the concept of creativity as a process made up of certain phases which can be seen in Figure 14. Firstly it begins with, problem definition (preparation), unconscious information understanding (incubation), idea generation (illumination) and idea testing (verification) (Boldt, 2019). A similar model which has been introduced by Wallas acted as a reference point in which other models are based on that main model which had stages as "preparation, incubation, insight, elaboration and evaluation" (Kristensen, 2004). This kind of four-phased models also affected other kinds of models; Amabile's model of the creative process is an example of it. Besides, it has been argued that a creative process cannot be linear or uniform since there are sub-processes that interact in a dynamic manner. One of the earliest models of the creative process was claimed by Campbell was in the 1960s and like this model in the 2000s Bink and Marsh also suggested a model having sub-processes interacting with each other. Those sub-processes are called generative and selective. However other researchers such as Runco and Chand claimed that there are more than those two groups of sub-processes. Which are the most significant or which one happens beforehand still remains a mystery (Boldt, 2019). However, besides these issues, it is certain that for a creative product to be produced interaction of those sub-processes occur.

Additionally, the process of creativity can be looked at through various points of view for example; it is known that concept generation acts as a base point for creative thinking. This situation is related to perception as well it is recognition of a whole and part relationship and this is the underlying element of creativity which is in mind and the world (Andersson & Sahlin, 1997). Moreover, a creative process can be defined as the realization of an individual via emotional expressions (May, 1959). As it has been defined as an emotional expression it does not limit to it, motivation and inspiration also part of important aspects of the creative process. It has been explained before that sketching is a vital part of a design process and those aspects of creativity occupy a great space in design processes as well (Nakakoji, Tanaka & Fallman, 2006).

The creative process has two significant stages as ideation and implementation (Yu-Shan et. al., 2018). Csikszentmihalyi (1999) had a view upon the creative process through the "cognitive processes, personality and motivation". He suggests that specific personality traits are correlated with will, self-esteem, being tolerated for uncertain facts (Williams et al., 2010).

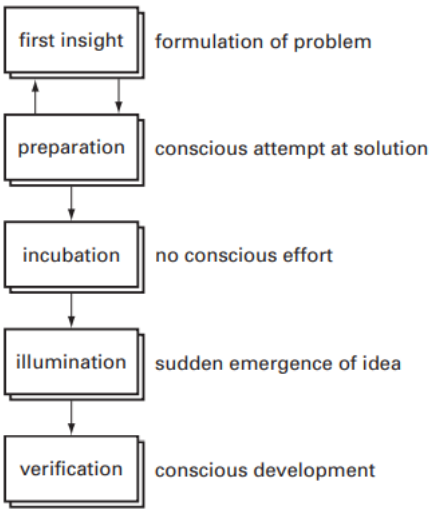


Figure 14: Five phased model for the creative process (Lawson, 2005)

2.8 Influence of Certain Factors on Creative Design Process and Thinking

There are many factors that affect the process of creative design (Agogué et. al., 2013). Interestingly, it was identified by Jansson and Smith (1991) (see Agogué et al., 2013) that the continuation of the new alternative solution generation is enormously dependent on the first solution. This issue might be correlated with a phenomenon so-called 'fixation effect', unconsciously it limits the designer to produce multiple ideas even they end up being similar to each other (Agogué et. al., 2013, pp.33-34).

Unfortunately, most of the ideas which are rich in terms of creativity can be lost due to the lack of knowledge that cannot direct the person on how to apply those thoughts. Thus, this can result in the neglect of creative thoughts during a design process. Overcoming this situation is possible by developing an inclusive design process (Yu-Shan et. al., 2018). In addition, idea generation in a design process has many theoretical suggestions however the creative process behind it can be explained simply by distinguishing it into two phases as generative and exploratory which Finke claimed (McKilligan & Seifert, 2011). Novel design generation is referred to as creative design and the process of this issue includes more speciality than regular creativity since it requires a certain amount of expertise (Yu-Shan et. al., 2018). Accordingly, the ability of design is related to generating solutions to ill-defined problems by using different and creative thinking styles (Cross, 1990).

A design process consists of dual aspects which include problem-solving and in relation to it a concept generation. Following the design processes creativity and

creative processes also being stated mainly consist of problem identification and solving of the problem (Williams et. al., 2010). The term creative leap is used for defining the action in the design process which is a happening of a major case (Dorst & Cross, 2001). In creative occasions cognitive side of the process can be challenging for the individuals therefore Jansson and Smith claimed that the first generated solution creates a path for the alternative solution generation (Agogué et. al., 2013).

At the beginning of Chapter 2 it has been explained that the design process includes convergent and divergent thinking styles moreover the theoretical model found by Guilford in the 1950s and 60s suggested that they are part of the intelligence. This is a part of the model. Opening up this subject divergent thinking is the one related to creativity since it is composed of novel idea formation. Also, it includes seeking out various solutions from the known knowledge (Potur & Barkul, 2009).

It has been mentioned that for creative ideation there are three key processes. The first one is selective encoding which is about perceiving the related factors for the solution of a problem. Secondly, known as a selective comparison which enables a person to compare the aged and new information also gives the opportunity to form a link between them. Lastly, the selective combination helps an individual to relate the suitable linked information. It should be not forgotten to achieve those and overcome those phases an appropriate level of domain knowledge should be known by the person (Williams et. al., 2010). These processes were found by Sternberg and Lubart (1993) (Williams et al., 2010). Some of the procedures made by designers may not be fully reliable however those kinds of explanatory studies are in need. Studies about creativity are essential to enlighten the association of design and creativity and

the process of creative design production. The creative design is problematic by its nature since there is no promise for such an occasion to occur in every design process (Dorst & Cross, 2001). Some parts are not clear through the underlying mechanisms of fixation. There are miscellaneous processes of creative reasoning but only a certain number of them are predicted and described to serve for the understanding of those creative solution generations (Agogué et. al., 2013).

Design comes from problems that are often referred to as 'ill-defined' or 'wicked' (see Williams et al., 2010). To produce a possible solution for those problems, novel design strategies are needed. Innovative ideas stem from creativity and the point of view of a person where she/he perceives a problem possesses a great role. If the habit of searching for an answer to a problem in a design process becomes extraordinary the solution has the potential to be a ground-breaking design (Williams et al., 2010). Therefore, it can be concluded as both of the notions go in hand to hand one cannot be formed without the other.

Surprisingly, it is usual to perceive non-identical conceptual approaches as novel ideas but they are alternative versions of the existing ideas. This situation highlights the importance of H (historical) and P (Personal) creativity and reveals that still, the idea found is creative since it is genuine for its designer (Dorst & Cross, 2001).

As it has been mentioned one of the most important factors in design is creativity. Creativity is an assessment factor of a design even the explanation of the term creativity is not definite and uncertain, it is an important concept to be discussed (Williams et al., 2010). Mainly, most of the research papers describe the phenomenal effect of creativity during the design process however at the same time it reveals

itself that the process is mutual. All the sketching, modelling and images trigger creativity in the architectural design process (Daemei & Safari, 2017).

The working environment is one of the environmental effects on the creativity level of an individual. The surrounding of a person who carries out an original product heavily affects the process therefore the product produced as well (Chulvi et al., 2020). The notion of creativity is mostly observed at the initial stages of a design process because due to the number of factors contributing the level of alternative solutions also increases (Chulvi et. al., 2020). Moreover, different alternatives for a design problem are not limited. As Cross and Dorst mentioned since a design problem is a fact to be taken care of through various approaches, creativity possesses its position as one of the most important notions in the design process of the architectural field (Daemei & Safari, 2017). Three models were developed to classify the methods for a design process approach known as logical rational, creative intuitive and participation collective model (Daemei & Safari, 2017). The unconscious state directs the process of an architectural design and the unconsciousness is composed of past experiences and ideas. Eventually, a conceptual idea is formed. The creation of an architectural place is achieved by creativity, it is one of the prior demands for it (Daemei & Safari, 2017).

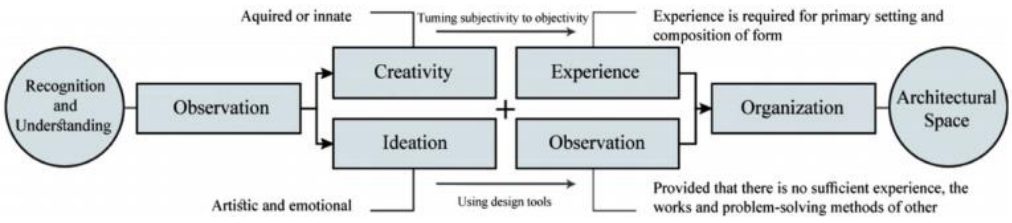


Figure 15: A model for the architectural design process (Daemei & Safari, 2017)

Creative thinking is induced by the problem-based nature of the design. There is no exact true answer for a problem since it is not a math question. It forces a person to seek an answer by an explorative approach (Williams et al., 2010). It is not to be forgotten creativity cannot function without the presence of knowledge (Figure 15), enough level of knowledge is necessary for performing creative actions (Doheim & Yusof, 2020). Without knowing the essential domain-related information an individual cannot show progress upon the subject. Surprisingly, knowledge is a quite tricky issue because it can either suppress or support creativity (Sternberg, 2006).

Experience holds an important part in the creative design process since the creative thought is in need of domain knowledge this situation shows the remarkable difference between an expert and a novice (Sternberg, 2006). In line with this statement, the theory known by the name of investment suggests that if creativity has been taken into consideration as an act of decision it means that it can be improved (O'Hara & Sternberg, 2010). However, why is it considered as a talent of decision-making? Simply, according to the investment theory, it is thought that an individual might have all the essential and marvellous capacity fulfilled with the skills but still may not be able to apply them in practice (Sternberg, 2006). In consonance with the theoretical work, it is a challenge to determine whether creativity is a skill to be used naturally or a skill to be learned by multiple factors.

2.8.1 Effect of Nature and Nurture

As it has been mentioned in the previous sections it is a dilemma whether creativity is affected by human nature or is it something a person is affected by an enormous amount of stimuli?

To begin with, there are many models created upon the concept of creativity. For instance; models that are known as “Cognitive” or “Integrationist”, “Associative theory” and “Problem Solving” (Welling, 2007). These are not the least it continues by incubation and insight phenomena, effects of mental imagery, intuition and other meta-cognitive phenomena, the role of personality, prior knowledge, domain specificity and more (Welling, 2007). However, to summarise the main variables which play a part in creative actions and processes are classified as cognitive, environmental and personal (Danacı, 2015). Creativity is a wide subject, to be able to understand the concept of it; various elements need to be taken into account. Especially, 4P plays an important role; “person, process, product, press” (Abraham, 2015). It is crucial to have a wide perspective, one of the factors alone does not help for the development (Abraham, 2015; Runco 2004).

Creativity may come by nature in the form of intelligence which is mentioned by Howard Gardner. Also, he detailed intelligence in multiple forms such as; linguistic, spatial, musical, mathematical, kinaesthetic and finally in form of personal. It has been identified that design skills are affected and interfered with by those six structures of intelligence. This statement can be exemplified; through the process of problem-solving, during the solving phase, the spatial part is mostly responsible whereas practical solutions include the form known as kinaesthetic intelligence. Guilford as well claimed that creativity is a natural source and the intelligence and link of creativity was a topic being highly interested which has been researched from the 1981s. Even the subject of creative person was being published earlier than the 1950s. This situation reveals how deep and complex is creativity (Cross, 1990; Runco, 2004). These are part of nature however the nurture of design skills has the

potential to be developed. By those intelligence types, it is easier to identify and improve certain specialities. According to the threshold theory by Runco and Albert, it has been stated that a high level of intelligence is not a necessity for creative action, a moderate level is assumed to be enough (Cross, 1990; Runco, 2004). Therefore, it will not be wrong to mention that the educational aspect becomes extremely important to develop those design abilities. Nevertheless, the biological aspect cannot be underestimated as well as the effects of personality and motivation. Thinking creatively is not just composed of those intrinsic values; also extrinsic factors are enormously influential. Social, cultural and environmental manners are all specified as extrinsic issues (Barkul & Potur, 2010).

Those kinds of factors of being human nature cannot be changed thus the role of nature and nurture together becomes vital for the further development of an architect. Intuition, personality, social context are related factors and each of them affects creativity. Moreover, even there are still some uncertainties but many of the notions are determined such as incubation, insight phenomena, mental imagery and verbal interference, priming, prior knowledge as well as domain specificity (Welling, 2007).

Creative skills are also inherited like a person inheriting a feature of an organ, however, the critical part comes into play in the fact of developing and improving those abilities. The interaction of the individual and the surrounding becomes crucial, however, it is affected by the environmental answer for an individual's interest (Torrance, 1966). On the other hand, it is claimed that creativity is something which all people have in them (Andersson & Sahlin, 1997) that statement of Sternberg becomes more significant by revealing the impact of environmental factors which

leads to the nurture part. The influence of culture cannot be underestimated and explanations upon the effect of the creative abilities can be found (Torrance, 1966).

When the word culture is mentioned it should not be limited by the lifestyle of people, it also forms three important subjects arts, science and technology. For instance; they all have an impact on the domain knowledge, technical ability and values (Torrance, 1966). Furthermore, it is known that even the regular activities that people go through in their daily lives require an amount of creativity which underlines the issue he creativity not just a problem-solving action (Welling, 2007; Runco 2004). This issue has been explained by the differences in activities, none of them is exactly the same one (Welling, 2007).

The notion of creativity became more significant than in previous years because of the evolution processes which proceed. Cultural evolution can be observed easily by looking at generations. This is a Lamarckian idea which is faster than Darwinian evolution theory since it is not a biology-based evolution being differentiated from Darwin. Those reasons are features that trigger the formation of complex life, this complexity requires creative actions. Therefore creativity seems to be an effective answer for evolutionary changes (Runco, 2004).

Nowadays, with the development of technology, there are more possibilities for architectural expressions. Fiction and reality can crossover now since the imaginary line which lines in between them is not strict anymore. This suggests that new possibilities might give rise to more emotionally rich architectural edifices (Hakak, Biloria & Venhari, 2014). Even though lots of studies mention all people have

creative capabilities, it should not be forgotten that each individual is unique in their own ways. Thus, the same level of ability cannot be expected (Abraham, 2015).

2.8.1.1 Education System and Cultural Background

Design education helps by the teaching of those essential attitudes and skills to be able to enter these behaviours and the ability to enter into an expert medium by the necessary proficiency. In architectural education design studio is a realm in which a knowledge transmission occurs between a tutor and student. Studies of design thinking have developed the understanding of the structure of knowledge by the supports from different conceptions. Moreover, the most striking part of a design studio was the creative phase that leads to concept generation for a design project. Accordingly, the examination of those cognitive creations achieved by a human being reveals that the individual's cognition is affected and shaped by the creative stage of concept generation (Önal & Turgut, 2017).

L'École des Beaux-Arts was having a peculiar schedule for the education of the students. Firstly, it has to be mentioned that the students were chosen by exam. The Ecole was similar to today's universities which provide education in the field of architecture and fine arts like sculpture and painting (Fricker & Fricker, 2010; Tzonis, 2014). Ateliers were having of great importance since design actions were taking place in that space (Carlhian, 1979). Therefore it is obvious that the institution has a strict concept for the design process which the students were passing through it. However, the general overview of the design conception was to teach how to solve design problems via at first starting them with sketching then passing to the actual drawings (Carlhian, 1979). Beaux-Arts is famous for the spectacular renders of the projects which were usually engraved with many details (Fricker & Fricker, 2010).

The structural layout that came until the 1990s formed the basis of architectural education. Education possesses a huge impact on design thinking in terms of developing design knowledge by improving the realisation of design thinking's characteristics and processes (Önal & Turgut, 2017). The educational system involves the critical aspect which is related to design thinking. The things that are learned shape the character and perspective of an individual towards the design process (Razzouk & Shute, 2012). Royal College of Art states that the subject of design in an education system should mainly focus on the things that should be known, approaches of knowing and, how to find the related matter which is dedicated specifically to the area of design (Cross, 2006, p.5). In 1857 with the American Institute of Architects a form of Beaux-Arts started to appear in America. In 1893 the society of Beaux-arts was founded and the staff were generally from America. Some of them are in coordination with universities like MIT, Columbia, however, some of them were not in correlation with them and they were having their studio lecturers (Fricker & Fricker, 2010). The adoption of a foreign education style had an impact on the way of designing buildings, it affected the aesthetical understanding and caused the rise of classical Roman styled buildings (Fricker & Fricker, 2010). Rudolf Arnheim and Suzanne Langer were the people who incorporated the meta-disciplinary approach with the education system (Jarzombek, 1999).

Education of design-related subjects is one of the highly reputational research fields. The reason behind this issue is that design exercises can be examined as the information transfer occurs and outlines the teaching and learning style of the design education. The studio acts as the focal point of education also it is accepted as a

system that is cognitive and social. Creativity has the most significant place in the system whereas knowledge and the creation of it together with social communication included as well (Önal & Turgut, 2017).

Later in the 20th century research for creativity increased and aimed to train creativity. The Beaux-Arts and Bauhaus based educational methods have a romantic manner for creativity whereas vocational education accepts creativity cannot be learned (Williams, Ostwald & Askland, 2010). The main aim of studio-based learning is to teach design knowledge through cultural compositions, knowledge design and globally accepted methods (Önal & Turgut, 2017). A design studio aims to create a medium that allows the exchange of views which also supports the social side of the design since it gives the opportunity of switching between the social and mental aspects. Recently the design studios are becoming virtual studios perhaps pandemic accelerated the process of online education. A new era has begun. Therefore, the latest researches are on the subject of computer-aided and online education (Demirbas & Demirkan, 2003).

The significance of cultural integration with the design process is not much stated (Önal & Turgut, 2017). Hofstede (2001) suggest people can be unconsciously affected by culture as mental actions progress with the influence of culture (Razzagh & Ramirez Jr, 2005). Therefore from this suggestion, it can be understood that design decision has the impact of designers' cultural motives.

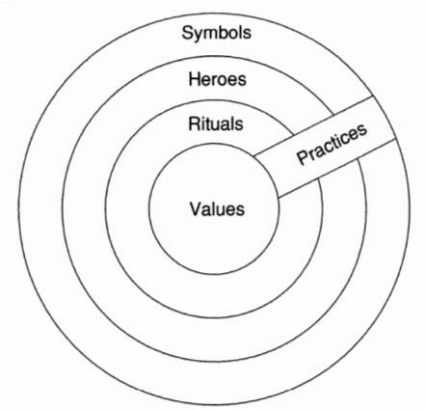


Figure 16: “Onion Diagram” (Hofstede, 2001)

According to Hofstede (2001) as presented in Figure 16 every individual has the patterns illustrated which are defined as the “cultural layers”. To be able to explain that situation, Collins and Pinch (1982) developed a phraseology known as ‘frame of meaning’ which has a major point in the description of the influence of cultural schema on designers’ attitudes and values. Carlson (1992) refers to this issue as ‘cultural creep’ describing usually the design products came out of intrinsic feelings by designers’ previous experiences rather than forming a new outline (see Razzagh & Ramirez Jr, 2005, p.2). Thus, can be suggested as there is a special relation between designers’ culture and the outcome they produced (Razzagh & Ramirez Jr, 2005).

Culture is a part of the personality since individuals try to explore their identities for bringing value to their life (Yong, Mannucci & Lander, 2020). The person’s personality level has a relation with the uncommon part and the common one is related with another level which is called collective. Culture is linked with the collective part and as it is common it can be observed within the people who belong to the same social class. The collective level includes the common one. Thomas saw culture as a milieu to guide an individual by orienting a person’s perception, thoughts

and behaviours that are a part of distinct social class (see Gautam & Blessing, 2009). Thomas described culture as a tool that adapts a human's perception and thinking that they are a part of a social class. This situation is known as 'cultural standards'**.** Therefore, culture shapes the way how people think and behave also distinguishes people in social groups according to their cultural stigma (Gautam & Blessing, 2007).

Interestingly, Lloyd and Snelders (2001) studied the design process of Philippe Starck which gave an idea that personality and perceptions affect even a basic design (Razzagh & Ramirez Jr, 2005). Individuals are affected by the culture in many ways. For example; behaviours, thoughts are all influenced by cultural norms. A cultural framework is extremely important in the design process since it has an impact on perception, decision-making processes also on individuals' understanding of the way of life, moral values and moreover. This conceptual frame of cultural schema affects understanding and learning abilities as it leads a person to have differential interpretations as a result of cognition. Thus in the case of design cognition, cultural norms play a vital role (Önal & Turgut, 2017). Collective activities include habits as well in which serves for a purpose of reaching a target (Razzagh & Ramirez Jr, 2005).

Design thinking has many models, one of them is the cognitive process in which thought that the process of reasoning is a part of it. This issue proves that cultural schema is one of the most important variables to affect design. The so-called cultural schema comes out from structures of thoughts of common knowledge which had an impact from culture (Önal & Turgut, 2017). Additionally, for people who belong to different cultural backgrounds this situation reveals itself by their actions. Therefore

as a result the specialities of cultural differences show variations between those individuals' thinking styles. Hofstede sees culture as "software of the mind". Moreover, Hofstede suggests that each of the people has a systemised way of thinking, reacting and feeling. These notions all have a part that undergoes commonality together with special characteristics. The special part is related to the personality level of the individual (Gautam & Blessing, 2009).

For learning cognitive layout has a major contribution in terms of organizations of knowledge in different classifications and the relation among them via system behaviour. A personal way of design is formed by a person's cultural schema since it is the one that affects the behavioural pattern (Önal & Turgut, 2017). As it has been mentioned the way of thinking among cultures is different, thus this can be exemplified by the situation in different regions; analytical thinking is the type that dominates Western culture. The reason behind this issue is that entities are not connected whereas Eastern regions have a holistic way of thinking in dominant. Unlike of Western culture, the surrounding is observed as entities in connection with each other. This is one of the reasons why people have a variety of experiences (Gautam & Blessing, 2009).

Design process and activities related to it are considered to be affected by cultural characteristics (Gautam & Blessing, 2009). The cultural schema and cognition is related to each other therefore consideration of the link between a creative human being and an architectural design process, the design studio is vital (Önal & Turgut, 2017). Culture has multiple dimensions which are not dependent on each other. Previous researches about creativity based on cultures revealed that most of the cultures have people who are more creative than the rest. This is correlated with the

cultures' creativity target and how much it is highlighted. This view helps to analyse the relationship between the "creativity – domain-relevant skills, creativity-relevant skills, and task motivation – and creativity" (Yong, Mannucci & Lander, 2020).

Herskovits described the culture as a part of a human-made surrounding. Therefore, it is right to argue that produced designs are influenced by the culture. Thus, De Souza's (1999) statement for diversity to be sustained throughout the cultural variations (see Razzagh & Ramirez Jr, 2005). Press and Cooper (2003) state for a product to be successfully designed and used the setting should be well understood but a designer's intuitions and creativeness are in charge of the first design phase, especially for concept generation.

The initial stages of design are the part that enables a designer to be "divergent, creative and innovative" at the most and towards these circumstances leave their place to be "more convergent, boxing and leading" them to face with the marketing restrictions (Razzagh & Ramirez Jr, 2005).

2.8.1.2 Gender Roles and Age

The studies that were carried out reveal that there is not a correlation between creativity and gender (Kaufman, 2006). The scientific claim for this issue is not having a relationship between gender and intelligence (Potur & Barkul, 2010).

It is argued that age is important when considering cognitive abilities because the research suggests that people tend to be more conservative as they get older (Vranic, Rebernjak & Martincevic, 2019). Thus personality factors can be argued to state depends on age. Concurrently, it has the potential to develop a relation with age and creativity.

2.8.1.3 Intuitive Behaviour

The word intuition itself suggests that it is an unconscious process. Studies illustrate that the subconscious mind is highly linked with intuitive behaviour. Moreover, other works reveal that this type of behaviour is one of its kinds and it is a matter which affects creativeness. Intuition has many outcomes like feeling, action but all of them are in absence of consciousness (Evans, 2010). It plays an important role in design thinking. The designers who use their intuitive feelings when designing tend to be imaginative and curious. Architects and artists form that group (Durling, 1999).

However, it is claimed that intuition is not as unconscious as it is thought and it is more composed of feelings. Moreover how that feeling is intrigued and reveals itself by which experience is certainly not conscious (Evans, 2010). The emotional state of an individual affects intuitive behaviour. According to this statement, Isen & Daubman (1984) and Kahn & Isen (1993) have suggested that by the control of an optimistic mood people tend to systemise patterns more willingly, have the ability to correlate an extensive amount of material and recognition of differentiation among the materials in the pattern rapidly. According to the studies, a stable emotional state is related to behaviour and mostly creative attitudes linked with it (Eubanks, Murphy & Mumford, 2010).

Intuition has been described by many researchers in various ways. It was mentioned intuition is a skill which a person is able to predict the outcome, also there is not a certain task and it is complicated that is interlinked with creativity (Shirley & Langan-Fox, 1996; Eubanks et al., 2010). Kahneman (2003) mentioned that heuristics started to be called “intuitions”. Some researchers began to prove that intuition is can be as impressive as definite analysis (Witteman et al., 2009). Another

definition of intuition was stated by Policastro (1995) as a form of orientation that guides an individual towards a bright path. There can be various explanations of intuition, however, they all underline particular characteristics of intuition.

Firstly, intuition occurs with a limited amount of information and leads to the understanding of the system. Intuition does not specifically have consciousness and objectivity. In different fields like arts or management, intuition is still argued to be the central part of creative problem solving (Eubanks et al., 2010). Usually, intuition influences logical reasoning (Evans, 2010). Besides, it acts like a navigator which helps to find a way to study complicated tasks. To summarise, the notion of intuitive actions basically generates an unconscious guide to find a solution for complex problems (Eubanks et al., 2010). By this explanation, it sounds as intuition involves tacit or implicit knowledge. Reber (1989) studied tacit and unconscious knowledge and identified that tacit knowledge induces intuitive actions. Moreover, the cognitive operations that make intuition possible remain unclear. The cognitive processes which allow intuition to process are not clear (Eubanks et al., 2010).

Human beings' mind is eccentric in terms of the processes that it undergoes. To open up this situation it can be explained by a specific word known as 'dual mind'. Dual suggests that it will incorporate two functions. One is the analytical part since; it will form the intellectual capacity of a person as has been mentioned previously. The other one is known as intuition. The intuitive mind is often related to the heart and inner motives of an individual (Smith, 2009). This duality brings up some questions, to exemplify this; 'which one is the most effective during a design process? , 'how do designers think?' are some of them. Designers, architects, artists and many other occupation groups are creative therefore intuition is used by them. In

MacKinnon's it was reflected as “the more creative the architect, the stronger that intuition was represented”. Intuition is the core of thinking in a designerly manner, however, it is difficult to explain. Thus, the certain ways in a design studio to teach this are in doubt. Mental models are one of the ways in order to be able to understand the issue (Durling, 1999). For a novel design to be created creativity is in need. The influence of intuitive thinking on design idea development is critical to understand to integrate intuitive thinking into design methodology (Moore, Sauder & Jin, 2014). Ryle (1949) defined it as a matter of “knowing how” unlike trying to understand it. This statement supports that it is not just education and basic skill practices that cannot sustain it (Cross, 2006). The bipolar mental processes were claimed by Murphy (1947) and explained that because of the bipolar nature mental processes are both affected from the internal and external world (Lawson, 2005).

For distinguishing the relationship between intuition and deliberation dual-process theories are to be benefited. The terms rapid, holistic character, automatic, preconscious are some of the depictions that are used for the description of intuitive processing. On the other hand, rational thinking is usually described as slow, conscious, “deliberative”, “rule-governed” (Witteman et al., 2009). The dual-process approach suggests the generation of design ideas occur by two types of processes. One type is intuitive and the second one is analytical thinking. The type of thinking style which is applied more than the other determines the quality and amount of the different design ideas which are formed (Moore et al., 2014). One kind of thought is tardy and reflective whereas the other kind is fast and intuitive (Evans, 2010).

In the field of psychology, the types of processes the dual-process includes are categorised as “Type 1” and “Type 2”. As it has been mentioned the first type is

intuitive which makes it to be quick and influential with the help of heuristics however it can lead to some faults (Moore et al., 2014). Also as it has been mentioned previously, intuitive reasoning is controlled by the feelings thus it belongs to Type 1 whereas heuristic judgement falls into Type 2 as it has its basis from certain rules (Evans, 2010). In contradiction with Type 1, Type 2 is the tardy one since it is analytical and includes methodologies as well. Also, this type takes control over when it is felt an inaccurate assumption can be made (Moore et al., 2014). Type 1 can include more information than Type2. Intuition is a fact that has many mutual points with perception. They both include some unconscious and unconscious processes almost at the same level. This issue can be enlightened by a simple example when people listen to music they consciously undergo the experience, however, the unconscious part is that the knowledge which leads to that experience (Evans, 2010).

Intuition has an important role in peculiar occasions. Intuitive thinking is beneficial when there is a limited amount of time that exerts pressure and when the task is complicated (Witteman et al., 2009). According to Lawson (2005), architects have a joyful approach to problem-solving and it is mentioned that this type of cognitive manner is natural for designers. Also, this is developed by the architectural education system (Durling, 1999). Modes of thinking have a relationship between “culture”, “personality” and “motivation” as well as situation (Evans, 2010). Those were not including all the necessary information of a task to be completed and requiring people to produce solutions. The findings of the study illustrated the individualistic variations among people due to the desire they have to use their intuitive thinking and unconscious identification of patterns is revealed. Personality is a person’s

individualistic way of receiving information, feeling and expression of unique reactions. Performance and behaviours are dependent on personality therefore the study of personality traits become important for understanding the reasoning (Vranic et. al., 2019). These differentiations led Westcott to implement a measure for intuition and by this measure, it became possible to observe the diverse skills of people for intuition (Eubanks et al., 2010). Although, this study has been criticised by others.

Interestingly, in the world of reality decisions are often dominated by intuition but it is not much trustworthy because definite reasoning is in need as well (Evans, 2010). Runco (2004) has stated the importance of creative personalities in human life as they are the ones to find innovative ideas (Kandler et. al., 2016). Moreover, creativity is a mysterious feature of an individual's behaviour and the most crucial factor for a human being's improvement (Potur & Barkul, 2009). Kettler and Puryear have mentioned about a measure of creativity, which is called the "Biographical Inventory of Creative Behaviors" it was asked whether the subjects produced anything in the last year which leads to the conclusion that the production of a thing and will that has urged its production are the basis of being a creative person. Despite this, the factor of being open to new experiences is a fact that reveals creative people (Puryear, Kettler & Rinn, 2017).

It is clear that the personality of an individual occupies a great role in creative thinking. In addition, there are many studies that support this claim. In this manner, the will of a person is almost one of the key factors which affect creative actions. It is a will of overcoming handicaps, taking logical risks, accepting uncertainties and being self-confident (Camargo, Çelik & Storme, 2020). Creative people usually try to

think in a contrary way according to other people (Sternberg, 2006). Furthermore, the psychological characteristics of a person as a part of their personality are some of the factors which help to determine creative persons. Among those features, the most abundant ones are" humour", "autonomy", "openness", "flexibility", "realistic self-assessment" and as it was mentioned "willingness" of carrying out functions (Cropley, 1995).

According to the studies of Guilford creative people have common characteristics; it is not just upon thinking creatively however they are also showing sensitivity to obstacles together with showing divergent thinking specialities such as flexible and fluent thinking. Nevertheless, they can define the known objects or concepts in a different way (Rhodes, 1961). Intuition's role in creativity is one of the mysterious points. It is the implicit concept that turns the ideas into explicit knowledge. The main occasion in this process of explicating the idea is the inspirational fact which comes to the scene. Inspiration is a representation of the mental concepts which builds up the whole work. Generally, these concepts are separated part by part for the reveal of the process (Andersson & Sahlin, 1997).

Since personality is a notion which shapes mundane beings by intrinsic feelings it is not a surprise that intrinsic motivation holds the largest place for the creative personality standards. The will that is felt from inside actually referred to as motivation. Motivation is one of the factors to increase the level of creativity, there are two types of motivation which are classified as extrinsic and intrinsic. An individual's surrounding has the potential to activate the motivation and successful results may arise from it (Martens, 2011). A person mostly follows intrinsic feelings especially interests which provides the opportunity to be self-motivated but there is a

drawback of those intuitive reactions. An individual may isolate him/herself from the truth and may not consider the evaluations. This situation in turn may act as an inhibitor by preventing the creative thinking process which has been mentioned by Amabile (2003) and Stohs (1992) (see Runco, 2004).

Most of the psychologists have worked on the subject of personality and creativity for many years (Puryear et. al., 2017). A meta-analysis has been done in two different fields as scientific and artistic the subject of the analysis was creativity and personality, this was directed by Feist (1998) (see Puryear et. al., 2017). Feist's most renowned and significant achievement is the usage of Big Five personality traits (Table 2) for examining the relation and he adopted those measures in the studies of ACL (see Puryear et. al., 2017).

Table 2: "Five Factor Model Trait" and "Empirical Personality Scale" (Feist, 1998)

Factor label	Abbreviation	Empirical Correlates (Scales and Items)[a]
Neuroticism	N+	Anxious, defensive, depressed, emotional, excitable, guilt-prone, hypochondria, insecure, labile, neurotic, psychasthenia, schizophrenia, shrewd, succorant, tense, worrying
	N–	Achievement via conformance, adjusted, calm, ego-strength, good impression, guilt-free, happy, intellectual efficiency, personal adjustment, personal soundness, psychologically minded, stable, well-being
Extraversion[b]	E+	Achieving, **active,** adventurous (parmia), ambitious, assertive, autonomous, capacity for status, confident, cyclothymic, dominant, **energetic,** enthusiastic, **exhibitionistic, expressive, extraverted, gregarious,** hypomanic, impulsive, independent, initiative, leader(ship), need for recognition, power (oriented), positive emotion, self-accepting, self-assured, self-confident, self-esteem, self-sufficient, sensation seeking, **sociable, social presence,** surgent
	E–	Abasement, deferent, dependent, depressed, **internality,** introverted, radical, reflective, reserved, **social introversion,** submissive, unambitious, **unsociable,** unadventurous
Openness	O+	Aesthetic, achievement via independence, change, creative, curious, flexible, humorous, imaginative, intelligent, open, open-minded, original, sensitive, sophisticated, wide interests
	O–	Conventional, inflexible, rigid, socialized
Agreeableness	A+	Affiliative, agreeable, communality, cooperative, easy-going, empathic, feminine, friendly, generous, intraceptive, nurturing, nurturing parent, peaceful, supportive, warm
	A–	Aggressive, argumentative, cynical, egotistical, exploitative, headstrong, hostile, masculine, psychoticism, suspicious
Conscientiousness	C+	Careful, cautious, conscientious, controlled, endurance, fastidious, orderly, persevering, reliable, responsible, self-controlled
	C–	Direct expression of needs, psychopathic deviant

2.8.1.4 Learned Attitudes and Behaviours

Despite the personality traits and characteristics as Amabile (1983) and other researchers signified the importance of environmental factors. It has been referred that it is one of the most major elements which play role in creative thinking and behaviour. It has been highlighted that both genetic and environmental factors affect the creativity of a person (Kandler et. al., 2016). It is accepted that attitude about life and the individualistic decisions about it forms creativity, it does not just consist of personal abilities but how a person shapes them (Yu-Shan et. al., 2018). Creative behaviour is in charge during the process of designing creative products, however, it is not just the behaviour it collaborates with creative situations in order to increase the performance of a person (Yu-Shan et. al., 2018). Creative behaviour includes major points which it is strongly related with and leads to that kind of attitude those are the “nature”, “nurture”, evaluation of the process and products of creativity (Razik, 1966).

As it has been mentioned previously certain personal traits have an influence on creative acts those were openness to differential experiences, self-efficacy and awareness of surrounding in addition to accompanying an intrinsic motivation. When the subject comes to motivation it is an interesting fact, motivation cannot be found in humans by their true nature it can only be induced by the people. Therefore, an individual is the only one to have a decision to feel motivated (Sternberg, 2006; Razik, 1966). In the case of the architects sketching takes a part of being a creative behaviour, this is one of the reasons that this attitude holds a significant place in the design process. It is vital to understand that sketching does not develop the creativity

level but serves as a path for affecting the experience during the creation process (Cseh, Phillips & Pearson, 2016).

There are creative attitudes that are affected by the duration of the design process. For example, it is affected by “social”, “perceptual”, “physical” and “emotional” facts. Emotional stability is a significant issue and if it is not stable may have a negative influence on constructive characteristics. Additionally, during the generation of a design solution “completion”, “negativity” and “movement” are included. Those processes have a tendency to affect the characteristics in a rebellious manner which leads to negativity (Demirkan & Hasirci, 2009).

Fromm describes creative manner as; “Conditions for creativity are to be puzzled; to concentrate; to accept conflict and tension; to be born everyday; to feel a sense of self.” (‘Creativity and Innovation Quotes | LeadingThoughts - Best Quotes on Creativity and Innovation - LeadershipNow.com’, n.d.).

2.8.1.5 Importance of Expertise

There are different levels of abilities among the designers but what are the reasons for this? It has been thought by many researchers that expert designers differ from novices in various numbers of ways (Clarkson & Eckert, 2005). There are arguments which state knowledge may increase the creativity level or can cause the inhibition of creativity (Sternberg, 2006). Some brain-image studies have illustrated that perception takes an important role in the production of behavioural and physiological responses (Gelder & Tamietto, 2011). This situation implies the question of ‘how does the perception of people affect design?’ As an architect, while thinking of a design, the process of producing alternatives happens through the artefacts of the mind of an individual. People cannot decide upon things that have not been

underlying in their thoughts. Each one of them should have heard, seen or even read about it. Every design is now a modification of a known object.

At that stage, the action of perception receives significance (Oxman, 2002). When the subject is in mind it has another factor that has a lead role in affecting it which is called ‘perception’ (Gelder & Tamietto, 2011). As Oxman (2002) has mentioned the visual emergence occurs by perception. Visual cognition supplements and supports theoretical background at a major level. Notwithstanding, the act of observation is one of the key elements but it does involve a person being perceptive. These two words are different although the same in the action. The issue of understanding information of what an environment offers has a relationship with the person who perceives it. Additionally, it is a matter of fact that reveals the creative potential. This situation has been proved by a creative test which showed that people who perceived the environment had achieved higher results (Oxman, 2002; McCoy & Evans, 2002). Radical constructivism theory (Schmidt, 2002) explains the restructuring of perception and recognition processing through the earlier experience and expectation of a human being. This description emphasizes the importance of knowledge digestion and how an individualistic occurrence it is. The uniqueness of a design work arises from these processes and as a result personal problem solutions (Tschimmel, 2011). Perceiving is mostly about recognising the environment and digesting the knowledge that has been collected through observation (Oxman, 2002).

The term expertise is defined by Ericsson as a matter that acquires expert behaviour as an effort. To reach that level many practices are in need. For being an expert the notion of experience holds an important place. Accordingly, an inexpert person needs to pass through many practices such as education and training in the area of the

selected field. Thus to be an expert, a person needs to undergo multiple stages (Cross, 2004).

Mathias (1993) figured out that expert designers tend to care more than novices, novice designers had a habit of skipping the major parts of a process they go through (Figure 17). This situation is especially applied to the solution generation process (see Kokotovich, 2008). In contradiction with the general assumptions of experts, they solve the ill-defined problems from a difficult perspective rather than we thought that they can solve them easily. Furthermore, they tend to consider the problem more complicated than novice designers. The most abundant and obvious distinction between a novice and an expert is achieved by the number of experiences they had been through. According to this statement, experts observed and took part in more problem-solution occasions related to their field. However, the most striking ability of an expert is to stand further apart from the known cases and to generate a unique conception (Cross, 2004).

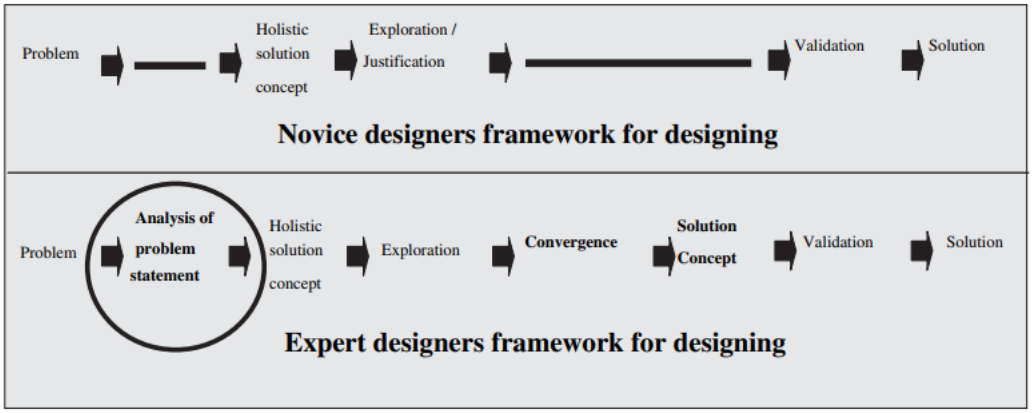


Figure 17: Framework of designing for experts and novices (Kokotovich, 2008)

Designers usually have a variety of approaches to be able to solve an ill-defined problem (Ho, 2001). Most of the experts have the routine behaviour of spending much time on identifying the problem this can be seen as a proper approach however studies suggest extreme focus on problem identification does not create a pathway for successful design products. Detailed problem examination is not the only reason for having an outstanding design attitude, a focused problem orientation on the right subject and finding relative data about that problem also are very important (Cross, 2004). A lot of researches show that many of the expert designers just make assumptions and pass to the solution stage earlier. In fact, these are used by the designer to identify the problem and generate the solution at the same time. Also, it has been revealed that experts are more in favour of generative reasoning rather than the deducting type which is mostly used by inexpert designers. Designers usually detect the characteristics of the problem then they go through the problem identification process. The ones who dealt with similar problems and gained experience had more peculiar suggestions than the novices. In addition, the architects who had more experience had some common features in their approaches known as "guiding themes". Darke (1979, pp.36-44) stated the guiding themes like the "primary generators". Some studies showed that the 'opportunistic' behaviour of the designers was predominating (Cross, 2004).

Education has much well-thought training encountered in it to improve a novice designer's abilities to become an expert however there are still some uncertainties of what are main distinctions between expert and novice efforts in design processes to help a student through the educational system. The interesting fact of the design training is that they show some of the designers have the superior ability for

designing. In that manner, successful designers come from talented or extremely creative individuals (Cross, 2004). This finding also highlights the significance of fluctuations between different forms of activities. For instance; sketching, representation of the visual through sketches, perception of visuospatial specialities in them and realizing the factors that are necessary for the design when matched together (Cross, 2004).

Comparing the descriptions between the expert and novice designers there are certain obvious distinctions, to exemplify this; in an experiment, experts explained sketching and design drawing quicker than novice designers. Another difference was the experienced designers found design drawings to be explained simpler than sketching whereas novice designers mentioned completely the opposite (Lawson, 2004). One of the main differences between novices and experts is the way they choose to form a solution for a specific problem. Novices usually do not go through a systematic way which is called working backwards. In spite of this issue, experts undergo a totally opposite known as working-forward which they follow the first phases from the start to collect all the necessary information regarding the problem (Ho, 2001). Novices do not tend to apply more restraints for a design problem but they produce more alternatives when compared to the experts (Chai et al., 2015). The most observant feature of expert designers is that they are solution-oriented rather than being problem-oriented. This feature is a part of design cognition which develops itself with the help of education in a related field and also with experiences gained throughout the domain. Another design attitude is the generation of multiple alternatives for one design problem which are advised by theorists, however, not favoured much by the expert designers (Cross, 2004).

There are different modes of design one of them called reasoning. This mode has three important features which are; structure, behaviour and function. The function is the initial phase which can be referred to as an abstract idea generation through a designer's intentions. Behaviour is as its name suggests is the manner in which the designer chooses to follow to achieve his/her target. Structure applies to the end phase as the solution part (Ho, 2001). One common point of experts and novices is the good use of analogies which is found out by a study carried out by Casakin and Goldschmidt (1999). According to this study the designers who belong to both of the groups were reasoning by visual analogical thinking to design (Chai et al., 2015).

For the generation of creative design output, the designer's level of exposure to certain examples is crucial. The reason behind this issue is seeing examples of design products which do not alike to each other will increase the novelty of ideas for the design. Therefore to keep up the creative design ideas as a professional is an endless process. It always has integration with understanding and being in the world. In the pathway of becoming a professional, it is critical to understand that the existing theoretical structures needed to be exceeded and go out of the boundaries they possess (Chai et al., 2015; Adams et al., 2011).

Being an expert does not mean that the individual will be more precise or rapid when designing, however, it does mean a person with more experience will be able to generate more alternative paths to reach the end product through the design (Yilmaz & Seifert, 2011). Especially, in the 21st century being an expert architect is not the only factor that just embraces the conventional design strategies. Nowadays, many skills are required to sustain the existing necessities.

Chapter 3

GENERAL DISCUSSION ON PARAMETRIC DESIGN

3.1 Parametric Design

Architectural design is heavily influenced by technology and it is not just limited by the design construction part is also affected by this issue. Phrase by Luigi Moretti (1971) “the relationships between the dimensions” underlines the factors of the design which is dependent on a parameter (Caetano, Santos & Leitao, 2019). Parametric design is one of the pioneer subjects of this new design generation (Stavric & Marina, 2011). The parametric design opened up a new way for architectural design, as it enables the most complex forms to be constructed with ease (Yu, Gu & Ostwald, 2018).

Firstly, before the deep analysis of parametric design methods, it is important to understand what is parametric? The definition from the Cambridge dictionary states that it has a relation with the parameters. As the dictionary defines, parametric design is designed by certain parameters. To begin with, it is crucial to understand the framework of parametric design (Wahbeh, 2017). Cambridge dictionary defines the words parameter as “a fixed limit” therefore even the name itself suggests the work method. “Parameters”, “constraints” and “relationships” are the main factors that permit the formation of the model. The design is developed by “parameters”, “dimensions”, “quantity” and the use of geometry. There are many ways to achieve

the model of parametric; a parametric modelling program relied on an object, other conceptual digital design spaces and visual programming (Wahbeh, 2017).

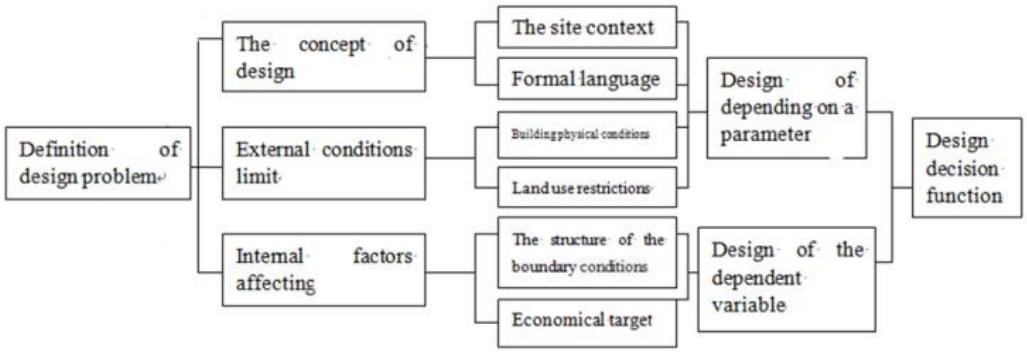


Figure 18: "Definition of Design Problems" (Liang & Wenshun, 2019)

Parametric design is incorporated with an algorithm that enables to set the constraints (Jabi, 2013). New architectural design formations by computer-aided facilities based on "topological space (topological architecture), isomorphic surfaces (isomorphic architectures), motion kinematics animate architectures and dynamics, keyshape animation (metamorphic architectures), parametric design (parametric architectures) and genetic algorithms(evolutionary architectures) or fractal geometry(fractal architecture)" (Kolarevic, n.d.). These are known as "computational concepts" (Kolarevic, n.d.).

The parametric design is classified into sections, one is about the conceptual and the other one is the constructive part. Nowadays, for conceptual design mostly Maya and Rhinoceros (Rhino with Grasshopper or Rhinoscript) are favoured whereas, for constructive Autodesk Revit, Soft Plan, Nemetschek, ArchiCAD are adopted (Stavric & Marina, 2011; Lee & Ostwald, 2020). Generally, generative design software use algorithms for the entry of the parameters such as Grasshopper and CATIA (Lee &

Ostwald, 2020). Topology related factors and geometry simply forms the foundation of parametric design (Caetano et. al., 2019).

The parametric design gives the opportunity of achieving complex structures, forms. However, this design type brought many controversial issues to be discussed. It is argued that it is beneficial for the production of novel designs. Moreover, the developing technology influences the architecture in multiple aspects. For instance; construction, form generation and structural design are some of the paths on which the technology had an impact. Now design thinking evolved according to the age's necessities and parametric design thinking theory found itself a place among the literature (Al-Azzawi & Al-Majidi, 2021).

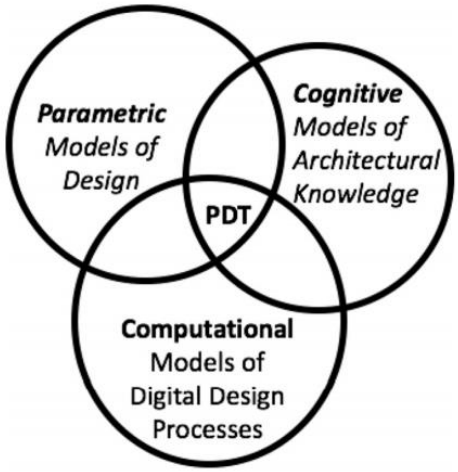


Figure 19: Illustration of fields that intersects Parametric Design Thinking Research (Oxman, 2017)

Other views suggest that a design is parametric all the time. A self-explanatory quote for this situation is "It must be stated that architectural design is inherently a 'parametric' process and that the architect has always operated in a 'parametric fashion' " (Peteinarelis, 2016).

Davis (2013) stated;

> "...a parametric model is unique, not because it has parameters (all design, by definition, has parameters), not because it changes (other design representations change), not because it is a tool or a style of architecture, a parametric model is unique not for what it does but rather for how it was created." (Peteinarelis, 2016).

Creativity is a wide and deep subject but simply to understand it the product, process and press are the factors to evaluate for the creativity level (Abrahan, 2015). Therefore, since the design process thinking is the most important phase for creative idea generation as mentioned in Chapter 2 another question appears as 'Do the new methods affect the creativity of a person or the product?' Is it right to argue whether the improved technological tools can enhance creativity in all manners? Schumacher (2009) referred to this issue and stated that there is a correlation between computational design and the creativity level in which creativity increases. The logic behind this claim is these computational design environments allow the designer to search and experience more alternative solutions. The happening of the exploration from the initial stages is advantageous for creative solution generation (Lee, Gu & Ostwald, 2015).

Basically, the relation with the mathematical rationality of the product and parameters express itself in various ways. The change of the parameters will immediately show itself, the computational design software enriched by genetic algorithms for the regulation of design solution (Alcaide-Marzal, Diego-Mas & Acosta-Zazueta, 2020; Al-Azzawi & Al-Majidi, 2021; Hernandez, 2005).

3.2 The Reasons behind the Rise of Parametric Design; an Overview from the Past to Present

Luigi Moretti was the first person to refer to the term ‘Parametric’ in the field of architecture. “Parametric Architecture” used in the 1940s those times was based on the link between the parameters of their measurements and the relation with the architectural systems. Although Luigi used parametric together with architecture the combination of the word with the design was written by Maurice Ruiter in the late 1980s and afterwards in the 1990s “Parametric Design” started to find a place for itself (Al-Azzawi & Al-Majidi, 2021). The reason behind this issue is that in the 1980s people having their own computers became more abundant (Assasi, 2019).

Another example for early parametric design through analogue aspect would be Gaudi’s Colonia Güell, who experimented with “structural forms” by parametric logic (Assasi, 2019). Figure 20 represents the system. Church of Colonia Güell is not the only example from the rationalized systems he favoured, Sagrada Familia was composed of a rational parametric system (Halabi, 2020), however, with traditional methods and strong mathematical calculations such as; “string length, anchor point location, birdshot" weight” (Peteinarelis & Yiannoudes, n.d.). Concurrently, parametric systems are evolving by adapting themselves to the new era’s necessities.

Figure 20: Analogue parametric system used by Gaudi (Assasi, 2019)

Frei Otto is another important name to mention when discussing parametric design. Usually, Gaudi's and Otto's approach was relatable to each other. Especially, their manner of using models for the freeform (Burry, 2016). They were mainly shaping their design around the fact of gravity which can be stated as one of the most crucial parameters. On the other hand, Van Doesburg classifies gravity as a parameter that is a 4D non-Euclidian (Burry, 2016). This leads to their experimental models which use gravity (Burry, 2016). This can be explained by Davis' (2013) writing;

> "A hanging chain has at least four parameters: its length, its weight, and the two points it is attached to. Left to hang under the force of gravity, the chain makes a curved shape. This curve is an explicit function of the chain's parameters with the added property that when inverted the curve stands in pure compression. While there is no computer, the hanging chain is a parametric model due to the presence of parameters that control a shape derived from an explicit function (in this case calculated by gravity)" (see Peteinarelis, 2016).

Prousalidou (2006) suggest that the building by Iannis Xenakis and Le Corbusier called Philips Pavilion (Figure 21) adopted a parametric system (Alvarado & Munoz, 2012).

However, manually used a similar parametric layout since hyperbolic paraboloids and many mathematical equations were in charge of the construction of such an edifice (Özcan, 2013). It was mentioned previously as Italian architect Luigi was the first one to discuss parametric in architecture through a stadium design (Alvarado & Munoz, 2012).

Figure 21: Philips Pavilion (Alvarado & Munoz, 2012)

It is crystal clear that the parameter based design is not a new subject in the field since if there is no parameter there will be no input to generate the design. On the other hand, the developing technology architecture is one of the domains which received the impact. Around the 1960s computational techniques had begun to be used, Ivan Sutherland was the person to develop a model in a digital form to accelerate the speed of parametric formulas (Assasi, 2019). Patrik Schumacher became one of the leading names in the field of parametric design and this design owned the name ‘Parametricism’. This design is related to digitalised design procedures (Halabi, 2020).

Table 3: “Context of parametricism according to Schumacher’s principles” (Al-Azzawi & Al-Majidi, 2021)

Dogmas								
Design process				Shapes				Internationality
Script rather than model	Generative components	Use NURBS & Splines	All parts are paramet rically	Interarticulate	Hyperdize	Morph	Deform	Deterritorialize

Taboos					
Forms			Repetition		
Familiar topologies	Platonic objects	Straight lines / right angles	Juxtaposition of the unrelated elements	Simple repetition	Do not add / subtract without elaborate interarticulations

Table 2 represents Patrik Schumacher’s parametricism manifesto. Certain dogmas and taboos defined by himself related to the parametric designs. Parametric design is a controversial issue and cannot be concluded whether parametricism is an international style or not.

Towards the end of the 20th century, the parametric design was observed to be in contradiction with the modernist ideas and having traces of medieval principles but by benefiting from the digital mechanisms (Assasi, 2019). On the other hand, through the years the construction and manufacture of the buildings became dependent on the software programs. One of the most renowned examples of this situation is one of the edifices designed by Frank Gehry. The golden fish sculpture called Peix was constructed for Barcelona Olympics in 1992 (Figure 22), it was the first design by him to adopt the use of a program. CATIA enabled the curvature of the form and the steel structure which was successful at achieving the geometrical arrangements (Halabi, 2020).

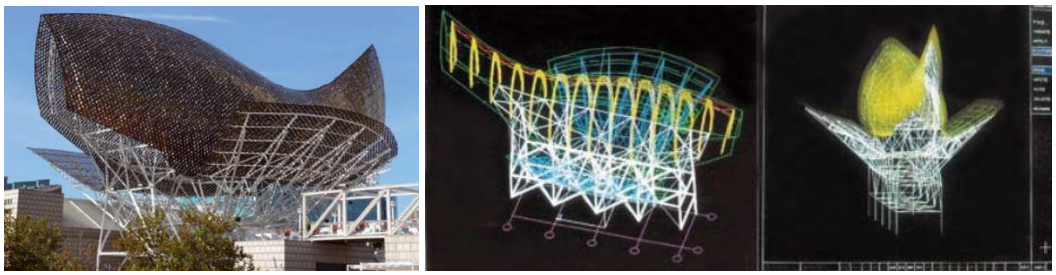


Figure 22: Golden fish sculpture (Halabi, 2020)

In historical times scientists, astronomers made contributions to architecture and arts especially mathematical achievements and highly improved algorithmic techniques advanced the mentioned fields (Assasi, 2019). Last twenty years, especially recently the use of programs that were not intentionally designed for architecture attracted the attention of architects. The programs such as Maya, 3Ds Max, and Rhinoceros are all functioning by the parametric equational system. However, Grasshopper, Dynamo, Maya Embedded Language (MEL) are some of the variations of plugins which have are based on algorithms. These script embedded editors are dedicated to overcoming the limitations of the parametric model creation through the use of codes (Assasi, 2019; Burry, 2011; Peteinarelis & Yiannoudes, n.d.).

3.3 Role of Mathematics, Algorithm and Artificial Intelligence

Mathematics plays an important role in architecture thus a brief overlook towards the rationality behind the design is essential (Al-Azzawi & Al-Majidi, 2021). Parametric design originally comes from the parametric equations from mathematics (Choudhary, Dogne & Maheshwari, 2014). The word parametric is as stated before refers to the parameters, variables that can be modified to finalise as a result of a system (Al-Azzawi & Al-Majidi, 2021). Algorithmic thinking forms the basis of parametric designing since it allows the illustration of parameters that reveals the relation between the design input and its possible solution (Choudhary, et. al., 2014).

Since historical times mathematics and architecture have had an effective alliance. Simply, the relation of mathematic and architecture even can be expressed in short with the well-known principle proportion (Azevedo, Ralha & Santos, n.d.). Space is a mathematical representation as Gaspard Monge mentioned “architectural space is nonhomogeneous, highly structured, and consistent; and qualitative differences are of its very essence” (Booth, 1996). It is the reason which makes an architectural space or form to be effective in a variety of aspects. Geometry, arithmetic, etc. were cornerstones of an architectural entity’s formation therefore an architect had to be knowledgeable. Additionally, understanding geometrical arrangements were highly in accordance with the recognition of space. Nowadays, the level of interaction between mathematics and architect is not clear. The fact which led to this is the developed programs, the use of algorithm and script in which the user cannot see the mathematical functions happening and just focused on the geometrical modifications for a space formation (Picon, 2011).

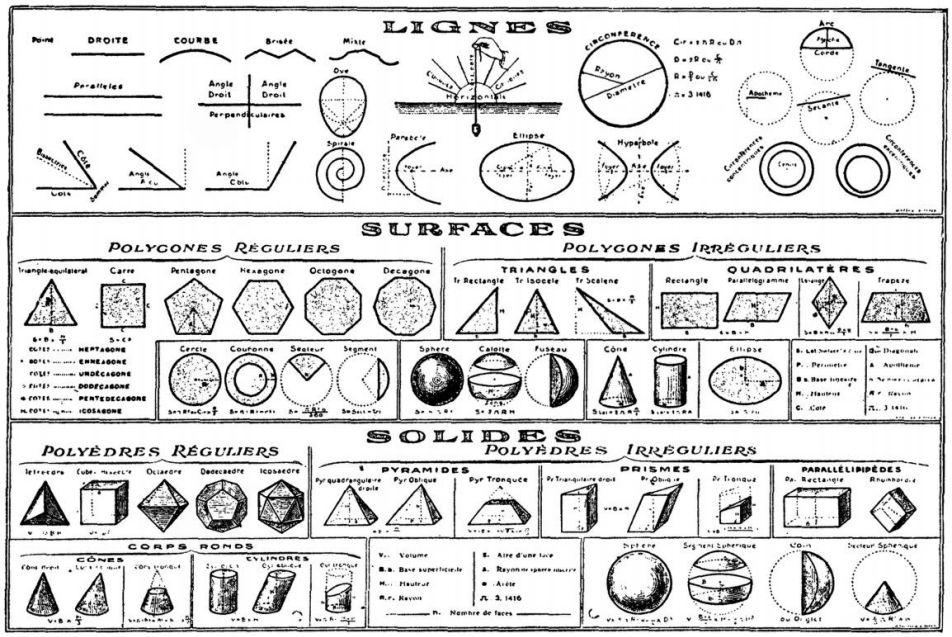


Figure 23: Geometric forms by “Le Corbusier’s The City of To-morrow and Its Planning, 1929” (see Schumacher, 2018)

As the figure illustrates since the antique times building was dominated by geometry for instance cubes, cylinders and more which are represented in Figure 23. Before the arrival of modernism, symmetry was in charge but with modernism, the asymmetrical approach began to be used. In the postmodern era, complexity appeared, however, still in a formal manner (Schumacher, 2018). In the approach parametric design geometric ontology is related with splines, NURBS (Non-Uniform Rational B-Splines) surfaces, blobs which enable certain processes to occur like; deformation, morphing (Schumacher, 2018).

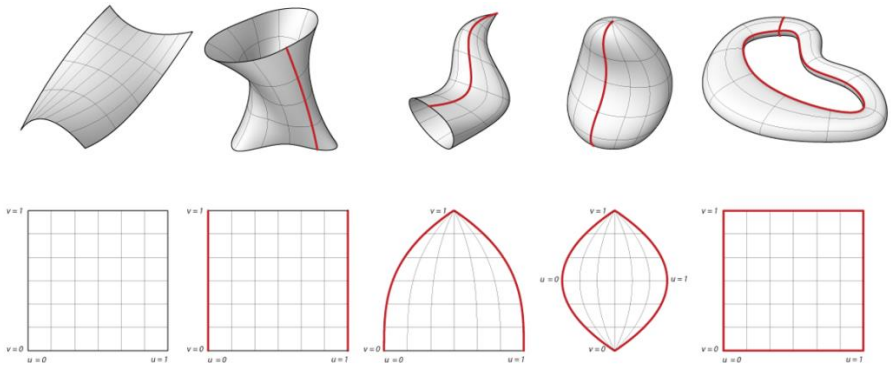


Figure 24: Illustration of NURBS (‘NURBS Fitting’, n.d.)

Algorithms are a significant part of the parametric design since it configures the geometric variations and by edited input, the design varies accordingly (Lee, Gu, & Ostwald, 2014). Generative modelling components based on algorithms are very influential in parametric designing (Ramilo, 2014). Guoyan suggested a method known as Genetic Algorithm, this was dedicated especially for the early phase of the design process. The algorithms are predominantly in use as a design methodology. The individual who designs interacts with the system by “variables, constraints, objective functions and search strategy” (see Krish, 2011).

The grand progress which has been achieved in technological and digital tools has opened a new gate for architectural design formation (Al-Azzawi & Al-Majidi, 2021). Demand for new materials appeared. The main reason for this issue started in the 20th century as integrative and geometric design approaches triggered the process (Bhooshan, 2017). The finalisation of a construction process is the reflection of an architect's dream, vision (Azevedo et al., n.d.). In the field of architecture artificial intelligence (AI) started to show itself by parametric designs. Different types and several parameters can be tested by the programs (Varma, 2021).

The schema theory suggests the architectural formation is related to abstract rationality. The experience of an architect especially in terms of the cognitive approach is reflected in the logic which will create the architectural form. By the parameters set the computer simulation reveals the factors which affect the form, also the abstract thought which in turn generates the form. This system of parametric architecture relies on the algorithm schema (Zu, Zhang & Qing, 2015) which can be seen in Figure 25. Basically, an algorithm is a sequence of commands which enables problem-solving. An algorithm is classified with certain characteristics like; deduction, induction, abstraction, generalization and powerful organizational rationality. Mainly the outline of parametric architecture is the reflection of the environmental conditions that interfere with the design formation by the digital language (Zu et al., 2015).

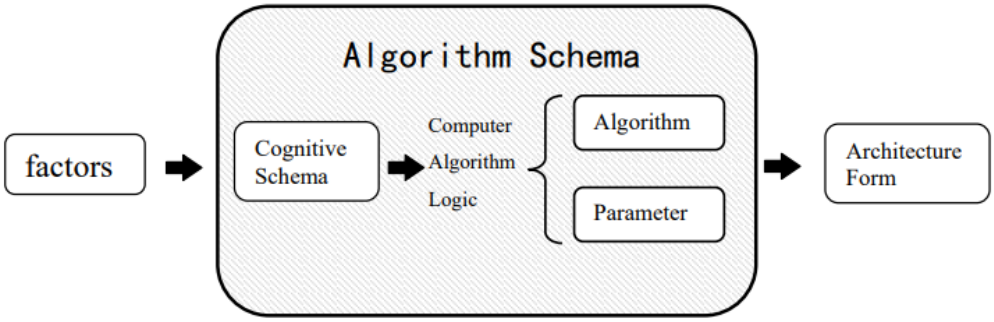


Figure 25: Algorithm Schema of Parametric Mechanism (Zu et al., 2015)

3.4 Characteristics of Parametric Design

As has been mentioned in section 3.2 parametric design is an issue that is still being discussed. Thus, it is argued that taking parametric as a style would distract a person to think in a parametric manner which is the most crucial issue (Burry, 2016). Nowadays, a parametric design still has similar elements although the ontology of the geometry has been changed (Schumacher, 2018). Otto and Gaudi are the most common names to be discussed in the aspect of parametricism. They were both experimenting and presented a full understanding of the materials and structure at different levels (macro and micro) (Burry, 2016).

However, the fact known as parametricism is strongly related to tectonism (Schumacher, 2018). The engineering part together with the aesthetics plays an important role in the understanding of parametricism. Concurrently, Otto's method can be called analogue computers which were showing a real-time situation (Peteinarelis, 2016). Mark Burry is another influential architect when it comes to digital design as he has been extending the limits by his creative mind also by adopting digital design tools (Cowley & Vallée-Tourangeau, 2018).

Parametric design can have a role to broaden designers', architects' minds, however, it is critical not to let the software to direct an individual. Otherwise, mathematics will just help to form fancy forms. Therefore, an architect should clearly determine the real-life parameters before starting to use digital tools for designing (Assasi, 2019). Parametric design is believed to enhance creativity by showing different varieties of arrangements and the modelling becomes the point that lies in the centre (Schumacher, 2018). Moreover, the technology which allowed the use of parametric software is advantageous since it enabled to the observation of real-time processes (Peteinarelis, 2016).

3.5 The Relationship of Creativity and Parametric Design

Parametric design has the ability to improve and develop the creativity of a design and its impact on education and professional life is significant (Yu, Gu & Ostwald, 2018). The opportunity of generating alternative solutions addresses this situation to benefit creativity as it has a great role in creative design productions (Lee & Ostwald, 2020). In order to understand the logic behind the relationship of parametric design and creativity the main two thinking styles should be understood which are; divergent and convergent thinking (Lee et al., 2014). These play an important role in creativity as it was mentioned in Chapter 2, however, in parametric design it is still important as well since creativity can be classified as a skill of decision-making. In parametric design divergent thinking is responsible for generating different solution alternatives whereas convergent thinking spots the best answer by the rules (Lee et al., 2014).

Learning is associated with the concept of creativity. Computational thinking and creativity are complex. Previously STEM (Science, Technology, Engineering and

Mathematics) was thought to be the one to have a relationship with computational thinking. On the contrary, this idea is observed to be a crucial skill in a variety of fields (Hershkovitz et al., 2019).

3.5.1 Parametric Design in Terms of Nature and Nurture

As it has been discussed in Chapter 2 it was dedicated to explain the facts related to the paradox of whether it is the creative person by his/her nature or by nurturing of the abilities. The parametric design part holds a significant part of being the indirect element and many researchers claim it does enhance the creativity level. Therefore, this section will take the topic of nature or nurture in the direction of parametric design.

Creativity has two classifications which are historical and personal creativity. Moreover, other classifications include human and computational creativity. Creativity can reveal itself from a historical, social or cultural accomplishment even may involve personal and computational processes (Lee, Gu & Sherrat, 2011). In addition, many researchers suggest parametric design is one of the key factors for creative design generation specifically for the conceptual stage. This will support the alternative design solution generations by changing the parameters. As this differs from the traditional design approach it is argued to promote creativity (Lee et al., 2014).

3.5.1.1 Educational and Cultural Relationship of Parametric Design

Parametric design has affected many aspects of architecture in a variety of ways. Therefore, it becomes a skill that needs to be learned (Al-Azzawi & Al-Majidi, 2021). This implies the importance of nurture since learning falls in the category of nurturing abilities.

Processes are all different from each other thus, appropriate abilities are in need to be able to solve the problems and generate new ideas (S. Y. Lee & Lee, 2017). Kolaveric (2003) and Iordanova (2007) claimed that parametric design enables the creative alternative ideas to be formed by referring to the divergent thinking style which is the influential thinking style (Lee et al., 2011). It is suggested that the formed alternatives without any exhaustive work have the possibility to increase the level of creativity also not limits the knowledge as well (Lee et al., 2011).The opportunity of generating alternative solutions addresses this situation to benefit creativity as it has a great role in creative design productions (Lee & Ostwald, 2020). Parametric design has the ability to improve and develop the creativity of a design and its impact on education and professional life is significant (Yu et al., 2018).

Creativity subject is significant not just in terms of individual well-being, however, as an accomplishment in social manners (S. Y. Lee & Lee, 2017). Designing is the fundamental block of causing changes in a society in which the parts that are in need of a change can be developed (Gero, 2000). Therefore, education that is dedicated to the promotion of creativity plays an important role (S. Y. Lee & Lee, 2017). Novelty with the accepted aesthetic standards is respected in the field of arts whereas technology, engineering, math, science-based fields require functional aspects. These can be grouped under STEM (science, technology, engineering, math) which involves the skill of problem-solving. STEAM (science, technology, engineering, art, math) education system is the type in which architecture can be included. Mainly, it is focused on creativity based function rather than the art being the focal point but as a supportive factor (S. Y. Lee & Lee, 2017).

Innovative design can be produced by the support of the parametric design but Gero (2000) claimed it may not produce a creative design via creative design processes (Chien & Yeh, 2012). Thus, during parametric designing, the traditional creative process might not benefit. According to this issue educating the students towards the new necessities of the era must be considered. The improvements should be considered by the architectural education and adapt itself accordingly. It has been mentioned that the profession shows differences which suggest the change of the architect's position. Three classifications have been made as "designing, process and product" architects. This situation underlines the fact that the ICT parts of an architecture faculty must support and prepare for the upcoming changes (Sariyildiz & Ozsariyildiz, n.d.).

Sketching enhances creativity (Prats et al., 2009; Schon & Wiggins, 1992; Tovey, Porter, & Newman, 2003) and the fixation effect that (Jansson & Smith, 1991) is stated is a barrier in front of the alternative solution generation. By the parametric design system, it is assumed that this kind of limitation could be overcome. Moreover, this method allows the designer to interact with the problem and solution in a continuously developing manner (Alcaide-Marzal, Diego-Mas, & Acosta-Zazueta, 2020). Oxman and Oxman (2014) mentioned the effect of new methodologies. New design environments like; having a script base forms a path of another design thinking strategy which has been referred to as Parametric Design Thinking (PDT) (Oxman & Gu, n.d.).

Parametric designing differs from the conventional one by simply just having a set of rules. These rules form the basis of parametric designing as it becomes a set of actions that need to be thought before designing. The main object is not the point

where the designer is concentrated but it is the rational relation of rules which possesses the greatest importance in the parametric design thinking (Oxman & Gu, n.d.).

Woodbury (2010) claimed three classifications of parametric design thinking;

1) Thinking in an abstract way
2) Thinking in a mathematical manner
3) Thinking in an algorithmic manner

Abstract thinking allows the parametric design to have the generative route for the production of similar alternatives. Mathematical thinking involves the part where the scripting is used for the part that the theories and construction are necessary for the script language. Algorithmic thinking shows itself through the illustration of the design as it requires modifications through a set of actions by removing adding parts of a parametric design (Oxman & Gu, n.d.). These three actions suggest a variety of cognitive functioning thus this kind of design process is claimed to foster or support creativity (Lee et al., 2014) and it is shown that working with digital mediums enriches creativity (Hershkovitz et al., 2019; Azizinezhad & Amini, 2011).

3.5.1.2 Intuitive Actions in Parametric Design Environments

Parametric design environments may lack the intuitive patterns by the algorithmic and scripting which process at the behind of the screen. The whole process became more abstract since the events cannot be observed (Picon, 2011). The parametric design environments generally have two degrees in which the design activity occurs. They can be explained as the level of design knowledge and algorithm. Knowledge is dedicated to the users, surroundings, culture, etc. whereas the algorithm deals with the application of the knowledge via the design tools. In this case; an arrangement of

the parameters, setting of the rules and variants are included (Tünger & Pektaş, 2020).

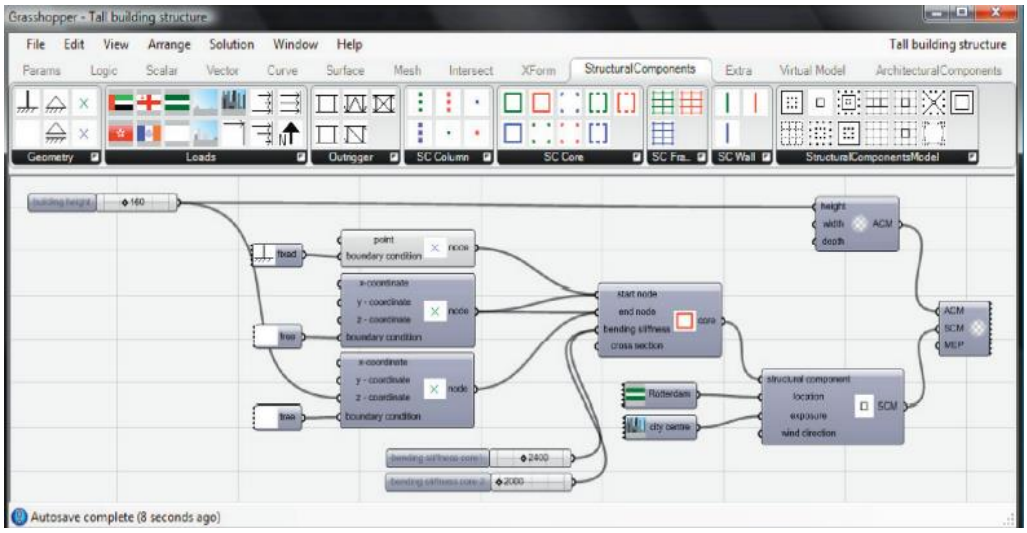


Figure 26: A modelling process in Grasshopper (Rolvink, van de Straat, & Coenders, 2010)

Parametric design is generally a complex process in which complexity comes from the action of decision-making (Motta & Zdrahal, 1996). There are visual algorithm editing tools some of them are; Grasshopper (McNeel) (as shown in Figure 26), Digital Project (Gehry Technology) and Dynamo (Autodesk) and for the scripting tools Python, Rhino script, Processing and Maya script. The debates upon the impact on the cognitive side of the situation and the possible limitations it can cause on the design process and education continue (Tünger & Pektaş, 2020).

Design is simply solution generation to a problem, however, it is not that basic. It is more complex since it is not only a solution formalisation. A designer should reanalyse a given problem. Nevertheless, this re-examination and reanalysis should continue for solution alternatives. (Yu, Gu, & Ostwald, 2013)

The computer-aided design took place of hand drawings. This is not just one fact but it also supported creative design processes. Exploration of challenging forms can occur. Therefore, solution-focused design alternatives usually have a richer creativity level whereas problem-focused is weak in terms of creativity, however, has a better level of quality (Al-shukri & Al-Majidi, 2020).

3.5.1.3 Parametric Design as Learned Behaviour

To begin with, the architectural field's engagement with computers was afterwards of the engineering-related fields. Concurrently, the CAD software was for those fields thus as the demand for such tools arose it is introduced to the architecture as well (Sariyildiz & Ozsariyildiz, n.d.).

From the perspective of Vitruvius, an architect needs to be an expert of "grammar, music, painting, sculpture, medicine, geometry, optics, philosophy and history." (Casale et al., 2013). An architect should know all the specialities of a shape to be able to decide among them. By the necessities of each era, an architect's role is evolving. The relation of form and technology made the architects' position to be the one to control the total image and regulate the implementation (Casale et al., 2013). The manufacturing process is developed by technological advancements thus, architects and designers can program a new scheme for manufacturing since the time schedule is short by the new techniques. These are all enabled by robotics and visual programming (Lublasser, 2016).

The educational schema should not be the same as the past educational system, digitalisation must be accordingly suited by the needs of the time. Furthermore, people's attitudes, behavioural patterns are also changed by the new technological developments (Robinson & Tarmawan, 2020).

3.5.1.4 Significance of Expertise for Parametric Design

For instance; in an educational environment a novice such as a student may be confused by the unexpected outcomes of the parametric design and can require help from the instructor. This brings up the concern of being an expert in parametric design. The parametric design tools are believed to increase the capability of design level of a novice designer (Chien & Yeh, 2012). Having an expertise level of knowledge from certain design fields is a major issue as it will reveal its presence during a design process in a repetitive manner (Bernal, Haymaker, & Eastman, 2015).

Computational procedures should be understood that they are diverse and it should not be mixed with a way of a designer think. The designer's thoughts are not exactly presented in the computers, they are nothing alike. The analysis that has been done upon the design behaviour; they have a distinguished variety of expertise which formed by their background and experience such as; novice, competent, master, etc. (Bernal et al., 2015). Besides many definitions, explanations of creativity it is also recognised as a process of an individual in which she/he develops awareness for the problems in terms of problem identification, solution generation and similar actions (Hershkovitz et al., 2019). It is not a secret that to be able to achieve parametric architecture certain skills are required like; 3D modelling, rendering, animation and many more techniques. On the other hand, it should not be forgotten that other necessities of architecture should be taken into consideration (Azizinezhad & Amini, 2011).

3.6 Supportive Tools for Parametric Design

With the technological advancements now there are more opportunities to create the idealised thought. To exemplify this, digital fabrication, virtual reality (VR) and augmented reality (AR) are some of the methods. To begin with, digital fabrication allows specialized production. A custom-made formwork, materials are some of the possibilities (Sojo, 2021). AI and AR support the production of architectural models via 3D printers therefore usage of digital tools during the design process becoming popular. There are multiple advantages of AR it creates a link between the real and the virtual world by combining them. Nevertheless, it is not only possible by 3D model demonstration but even can provide visual data for a detail of a plan. This technology acts as a medium for intermixing the real world and digital data (Song, Koeck, & Shan, 2021). The benefits are not limited to these it can act as a guide for the manufacturing process, the conventional 2D drawings can be limited to reflect the complexity however by this method it will not be complicated as the holographic images of the drawings has the possibility to be integrated with real-life (Song et al., 2021). Furthermore, digital fabrication is the term that covers all the machines which are under the control of computers and aids manufacturing. Computer numerical control (CNC), rapid prototyping (RP), 3D printing and laser cutting can be listed as examples of the digitalised manufacturing procedures (Sojo, 2021).

For the architectural education of the new era usage of VR technology is highly discussed by researchers and in general, it has been advised that in the initial phase of the design process it is beneficial for the students to use this technology together and change between VR and sketching or computational design models. The main

argument claims by this action will act as an exploratory virtual environment (Abdelhameed, 2014).

There are different technologies available, interdisciplinary digital visualization is one of them. This field just presented a new range of occupations, educational schemes and research areas. Whereas the disciplinary type of digital visualisation is adopted for the interpretation of architectural knowledge related to the manufacture of the buildings. VR technology helps to view the detail and enables more accurate decisions based on the model (Carasco & Chen, 2021). In this case, VR, animation making, rendering and 3D modelling are widely used to visualize the architectural edifice (Azizinezhad & Amini, 2011). Mentioning the renderings XR (Extended Reality) had begun to affect it. This technology creates a real-and-virtual environment by devices that can be worn also by graphics that are produced by the computer. AR (Augmented Reality), VR (Virtual reality) and MR (Mixed Reality) belong to the XR technology (Carasco & Chen, 2021). These technologies are not just beneficial for the architect in terms of solution generation, however, clients can benefit from them in advance. Instead of an architect trying to convince or explain the project details they can create a demonstration for them. MR will show the holographic model on the physical site and it may give a more dense feeling by revealing the actual integration of the architectural design and the environment (Carasco & Chen, 2021). Without the parametric design tools which generate the 3D model, it would not be able to make compatible interactions with other developing actions.

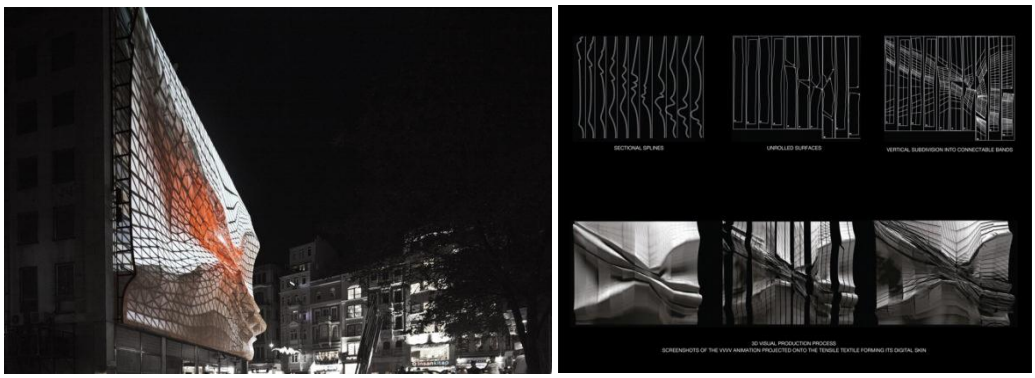


Figure 27: “Augmented Structure” (Arkitektuel, 2019)

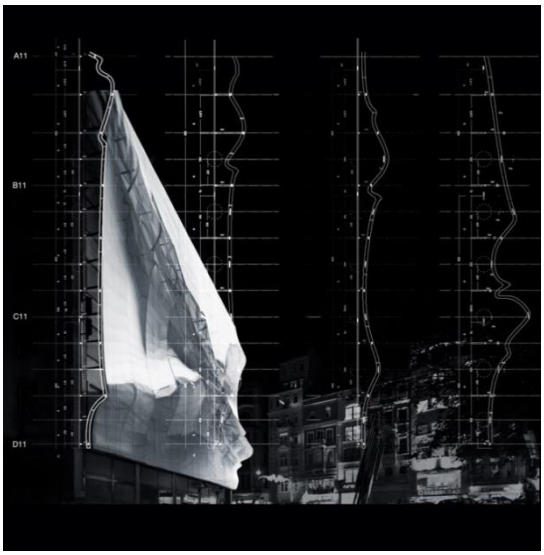


Figure 28: “Augmented Structure” (Arkitektuel, 2019)

In 2011 Alper Derinbogaz and Refik Anadol collaborated for “Augmented Structures”. For the installation, they used Rhino Grasshopper and VVVV to gather and turn the sound waves into sections. Figures 27 and 28 illustrate the installation.

3.7 Form, Function and Structural Relationship

Creativity is always found more related to an artistic point of view however, as creative outcomes are used in a person’s everyday life this requires being functional as well (S. Y. Lee & Lee, 2017). Therefore, besides aesthetics how they are function is important as well. Nowadays, contemporary architecture is having a wide range of possibilities for form and structure. This opened up the way of the development of

complex designs (Al-shukri & Al-Majidi, 2020). Geometric relations achieved by parametric design tools allow kinematic forms (Casale et al., 2013). The creation of rule-breaking outstanding designs unfortunately is a matter of wealth. Casale et al. (2013) mentioned “creating a clear break between an “everyday” architecture and an exceptional architecture that is suitable only for satisfying the desires of wealthy clients”.

‘Structura’ is originally a Latin word that has a definition of joining parts together. Mathematics especially geometry is fundamental to structural studies because of understanding the relationship of the architectural parts between each other. Richard Buckminster Fuller depicted geometry as a science that demonstrates structures and spaces (Choudhary et al., 2014). The aesthetic appearance of a structure is dependent on the form and the materials (Gherardini & Leali, 2017). The latest architectural examples show the critical link between the façade and structure (Gherardini & Leali, 2017).

Figure 29: An example for different material usage (Rycke et al., 2017)

Digitalisation enabled the achievement of complex forms. The NURBS (non-uniform rational basis spline) that form the basis of the tools enabled the generation of unique architectural forms (Rycke et al., 2017). For instance; Grasshopper’s algorithm illustrates how different parts come together and this issue increases the structural

endurance (Erdine & Kallegias, 2017). These issues all illustrate the benefits of using parametric design tools. However, there are claims that Grasshopper's manner consumes time in the case of highly complex buildings (Aguiar, Cardoso & Leitão, 2017). The structure should be an effective design taken the material behaviour into account. New materials are more abundant in the building sector as there is a 3D printing option (Rycke et al., 2017), Figure 29 exemplifies different material usage.

Parametric design software such as Rhinoceros uses certain plug-ins like; Ladybug, Honeybee and Grasshopper. These help to overcome crucial analysis as the performance of a building. The parameters can change and these tools are advantageous to be used to understand how a building is affected by changes that happen during design. Another plug-in called Karamba permits the designer to observe structural behaviour (Aguiar et al., 2017). Obviously, parametric design characteristics keep developing and improving day by day. Nevertheless, technological developments which assist computational design continue within the same path. The architect's position in a project is not the same as the previous times. The new PDEs add divergent roles to the architect (Erdine & Kallegias, 2017). In this sense, architecture keeps evolving and expanding via benefiting the scientific advancements and turning to a more interdisciplinary based approach (Erdine & Kallegias, 2017). The subject of artificial intelligence is part of technological and scientific developments. It is not a secret that it is a sensitive topic to be discussed in terms of human versus artificial intelligence. It is argued that computer-based designs are not simplifying the job and controversially it is becoming more complex (Halabi, 2020). The control of the elements which will be the form is more accurate

since it gives chance to detect the breaking and contradicting points (Casale et al., 2013).

It is interesting that how the importance of geometrical arrangements has not differed considerably since Renaissance until now. Even if it is computer-based parametric design architects still seek those specialities in the aspect of architectural thinking. Apparently, the traditional thoughts can still be observed in the digital discipline (Rycke et al., 2017). Convergent and divergent thinking styles come into play when mentioning creativity. Which thinking style is responsible for which section is not certain but according to the suggestions convergent is the type that leads the coding process whereas divergent thinking is involved in choosing the design solution (Lee et al., 2014). Furthermore, as software use is integrated by different disciplines this issue also supports collaborative and interdisciplinary working (Anton & Tanase, 2015).

3.8 Parametric Design throughout the Construction

The concept and the manufacture are closely linked to each other through digitalisation the information from a file becomes real by the CNC machines (computer numerically controlled) (Azizinezhad & Amini, 2011). Simply, 3D printing works on the principle of transforming the 3D volume by a computer into a 2D sequence. Each 2d layer is later on processed by laser rays (Teizer et al., 2016).

Through those fabrication techniques, certain advantages are achieved. To exemplify this; the time issue is more manageable since outdated drawings are not essential. This in turn decreased the time consumed (Azizinezhad & Amini, 2011). The time for the fabrication diminished which is a significant advantage (Teizer et al., 2016).

The new architectural formations formed by the parametric approaches usually have a complex shape and are generated from non-Euclidian geometry. These are supported also by new strategies such as kinetic systems, algorithm design techniques (Robinson & Tarmawan, 2020). Digitalisation opened the way of creativity since decision-making processes started to be more advanced as each phase of the design process can be directly controlled by the architect (Erdine & Kallegias, 2017).

Chapter 4

ANALYSIS OF THE SELECTED PARAMETRIC ARCHITECTURAL DESIGNS IN TERMS OF CREATIVITY

This chapter encompasses the analysis of features of the architects and the globally accepted competition winner projects of their studios' will form the basis of analysis. Through this approach, it is aimed to deprive the correlation of creativity with certain attitudes of them and having an attempt to understand the role of parametric design environments and technological advancements through their buildings. Since time is not a finite matter adaptation to time's conditions possess priority.

4.1 Analysis Method

To begin with, the views of accomplished architects from the various interviews they had given help to understand their inner motives, habits and vision. These issues direct to an answer of 'Which factors do affect creative actions?'.

In this manner, renowned architects from different nationalities and generations are chosen. This fact allows understanding the significance of expertise, attitudes, cultural and educational background in the notion of creativity. The interview gives a glimpse of an idea of their characteristics. Moreover, their ideas are enabled by technology underline the place where the parametric design lies. Additionally, the architects from different generations enlighten if there is a change of creative design

actions. The content analysis was adopted to highlight the key terms, concepts that match with the factors which affect creativity found in the interviews from architectural magazines and videos. Nevertheless, the qualitative data was quantified to see the most influential factors on creativity. Besides the interviews, the buildings are to be studied as case studies. In order to, evaluate the role of parametric design actions throughout the buildings. Five architects and two projects from each of them were selected. The entities are chosen specifically from the projects that they were the winners of an architectural competition. Some of the projects are from the older times whereas some of them are recent ones; this situation will point out the differences of achieving a novel design throughout the time. Moreover, the edifices are analysed in terms of aesthetic and usefulness to enlighten the creative parametric design part. The architects and projects chosen for the analysis are;

1) Frank Gehry
    - Guggenheim Museum, Bilbao (1997)
    - Fondation Louis Vuitton (2014)
2) Jean Nouvel
    - Louvre, Abu Dhabi (2017)
    - National Museum of Qatar (2019)
3) Zaha Hadid
    - Heydar Aliyev Centre (2013)
    - London Aquatics Centre (2011)
4) Bjarke Ingels
    - Astana National Library (-)
    - Amager Bakke (Copenhill) (2019)

5) Melike Altınışık

- Robot Science Museum (expected in 2022)
- Istanbul Camlica TV and Radio Tower (2020)

Amabile (1983) developed a model known as CAT which is a measure of creativity of a design product. There are certain factors to be checked for creativity. Complexity, evolution, flexibility and the genuine are the parts that belong to the CAT. Novelty, Value, and Aesthetics are the three main classifications (Lee et al., 2014; Lee et al., 2011). Creativity mainly consists of features that came from the nature of a person and by nurture. These can be grouped by intuitive actions, expertise, age and gender although they do not have much correlation, learned attitudes and behaviours, educational and cultural background. Within the part of nurture parametric designing finds itself a place and as analysed in Chapter 3 it has the main creativity notions within itself. On the other hand, in respect to the person who uses the parametric design tools, it is shaped accordingly.

4.2 Analysis of the Selected Architects' Parametric Designs

In this section, important buildings of the selected architects' analysed. From the first design phase until the construction stage every part is to be discussed. As it has been mentioned previously successful architects who had designed competition winner projects are to be analysed in terms of the factors which has the possibility to be correlated with creativity. This section focuses on their attitudes on various subjects via the information gathered from the interviews as videos, published articles and literature reviews. Frank O. Gehry, Zaha Hadid, Jean Nouvel, and Bjarke Ingels. The order of the analysis will start with the oldest architect Frank O. Gehry. The analysis

of the case studies progressed by focusing on the form, structure and discussions on the space quality.

4.2.1 Frank Gehry

Frank Owen Gehry is Canadian American who was born in 1929 in Ontario, Canada. He went to Los Angeles together with his family in the year of 1947. In 1949 he started to study architecture at the University of Southern California. Afterwards, he continued his education at Harvard University by studying city planning (The Editors of Encyclopaedia Britannica, 2021).

Frank Gehry found his company in 1962 which was called Frank Gehry & Associates. Later on, in 2002 Gehry Partners was second (The Editors of Encyclopaedia Britannica, 2021). Frank Gehry is one of the pioneers for digitalisation in the field of architecture and used matching the construction requirements. Digital design has enormously benefited the construction stage as precise execution is enabled (Korody, 2015). One of the reasons behind the formation of Gehry Technologies is to be sure of the standards of the manufacturing in means of craftsmanship. Therefore, they developed a version of CATIA. Also, it allows the control of budget by precise designs and contractors can understand how to build by reading the 3D files (Davidson, 2020). Frank Gehry started a company for technological purposes even though ironically he does not use a computer (Chang, 2015). Gehry Technologies is not limited to Gehry partners it also helps other architects' projects the most famous examples are; Burj Khalifa, National Stadium in Beijing (Korody, 2015). In an interview, Davidon (2020) directed a question to Gehry about the whole process of design starting from the sketch until the building phase. He mentioned the role of the technology,

computational design effect on buildings for instance; he highlighted the fact that before building towers with curves was not usual (Davidson, 2020). He also continued by stating that architecture is related to intuition therefore the individual cannot be understood at the beginning and needs to continue because there will be no other choice as it is difficult to describe. Frank Gehry depicted architecture as an art and admitted that he does not paint or play music but he performs art through architecture (Davidson, 2020).

Frank Gehry was asked how he can carry out his idea until the end of the process. He stated that in his company they build models and he does not use a computer even underlined the fact that he does not know how to use it. For him, it is more like an exploration of his dream and making models supports his approach (Davidson, 2020). He explained that he used to sketch and it was the way for him to think "out loud", however, when they made a book from his sketches he became "self-conscious" and does not sketch much. Besides, he expressed that he needs to sketch more. He is keen on going to concerts even though he does not like to listen to music when working (Minner, 2017).

Frank Gehry had many works which were dedicated to fish (Figures 30 and 31). He explained this by pointing out his childhood. His grandmother used to buy a live carp and he would watch it in a bathtub (Solomon, 2014).

Figure 30: Fishdance Restaurant in Kobe (Martin, n.d.)

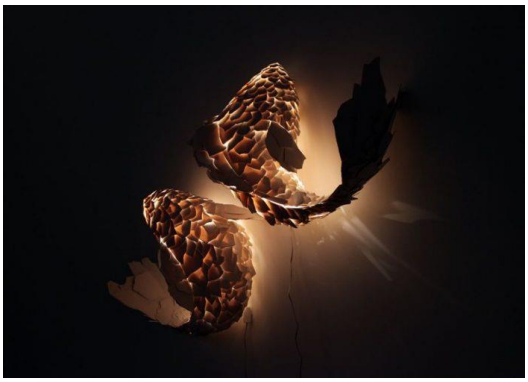


Figure 31: Fish Lamps ('Fish Lamps| Frank Gehry', 2020)

His architectural style was linked with the movement known as deconstructivism because he used conventional materials in a different manner which was not expected by the people. He used a similar approach for his own house which is located in California in the region of Santa Monica (The Editors of Encyclopaedia Britannica, 2021). During his professional life, he is awarded many awards but the most significant one is the Pritzker Architecture Prize in 1989 (The Editors of Encyclopaedia Britannica, 2021). Moreover, he received an honorary masters degree from Los Angeles University SCI-Arc because of his extraordinary influence in the field of architecture. In addition, his honorary degrees are not limited to this he also has from Princeton, Harvard and Yale are some of the renowned universities (Cogley, 2021).

He has been influenced by certain architects and artists. For instance; Gian Lorenzo Bernini had an impact on him when he saw the sculpture of Saint Teresa in 1960 (Minner, 2017). Furthermore, Michelangelo , Pablo Picasso, Marcel Duchamp and Giorgio Morandi (Poursami, n.d.). "It's not new that architecture can profoundly affect a place, sometimes transform it. Architecture and any art can transform a person, even save someone" (Hassanzadeh, 2019). Frank O. Gehry pointed out the

importance of experience by these words; "Architects will only be really good at fifty or sixty because their work depends on experience and they need many years to develop a unique language" by referring to his renowned career which started around 1989s and considered late (Wünsch, 2017).

Table 4: Relevant data coding and correlating by the use of the interviews, by author

Effects of Nature and Nurture	**Facts Identified and Correlated**
Educational and Cultural Background	• Studied urban planning domain knowledge one of the reasons behind his iconic buildings (Torrance,1966) • Fish memory is unconsciously affected by Hofstede's "Onion Diagram" related (Hofstede, 2001). • Keen on going concerts. Sees architecture as a form of art as Gardner suggest these are different forms of the creative intellectual mind. • Collaboration with other people for the creation. Social context is in charge Sternberg (2006)
Gender and Age	• The studies carried out reveal that there is not a correlation between creativity and the gender (Kaufman, 2006) • According to him, an architect can be outstanding at the age of 50 or 60 reveals the fact of integration with expertise as well.
Intuitive Actions	• Sketches for the projects As Goldschmidt mentioned sketches of architects' can be unclear. This is related to the design process which is a creative situation (Lugt, 2005) • 'Sketches of Frank Gehry' made him self-conscious. Intuition is an action that occurs in absence of consciousness (Evans, 2010) • States designing is an intuitive feeling • Gian Lorenzo Bernini, Michelangelo, Pablo Picasso, Marcel Duchamp, Giorgio Morandi (Poursami, n.d.). Intuitively affected by the past memories
Learned attitudes and	• Follows recent developments • He mentioned the role of the technology, computational

Behaviours	design effect on buildings for instance; he highlighted the fact that before building towers with curves was not usual (Davidson, 2020). • Going to concerts reveal the fact that he nurtures his creative side. (Davidson, 2020). • Traditional modelling and sketching (Davidson, 2020).
Importance of Expertise	• He became renowned around the 1980s but he suggests it is appropriate for an architect since it needs time to have a unique approach (Wünsch, 2017).

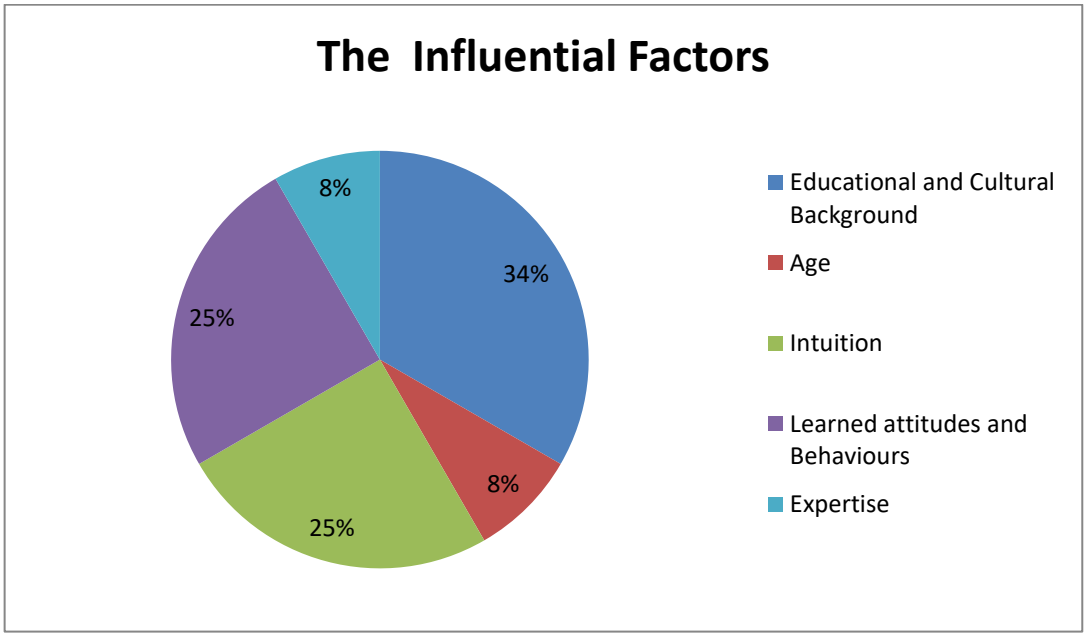


Figure 32: Presentation of factors derived from the table, by author

4.2.1.1 Guggenheim Museum, Bilbao (1997)

Table 5: Information of Guggenheim Museum, Bilbao, by author (based on Keskeys, 2019)

Project: Guggenheim Museum	
Location: Spain, Bilbao	 Source: URL 1
Year (Constructed):	1997
Project Type:	Competition
Awards received:	Cambio 16 Award (Arts category), 1997 Actualidad Económica Award "Top 100 Ideas of 1997" 2000 European Museum of the Year, 2000 are some of the awards

To begin with, the first building to be analysed is Guggenheim Museum Bilbao designed by Frank O. Gehry's (Gehry Partners, LLP. The reasoning for the selection

of this remarkable project can be explained by the simple phrase “the Bilbao effect” (Haarich & Plaza, 2012). This by itself suggests the significance of the place, therefore, the motives which directed the design and the analysis of the role of parametric tools in the generation of the creative parametric design. The conceptual approach based on a fish, its textures and form were inspirational for Frank Gehry (Guggenheim Bilbao - Data, Photos & Plans, 2020).

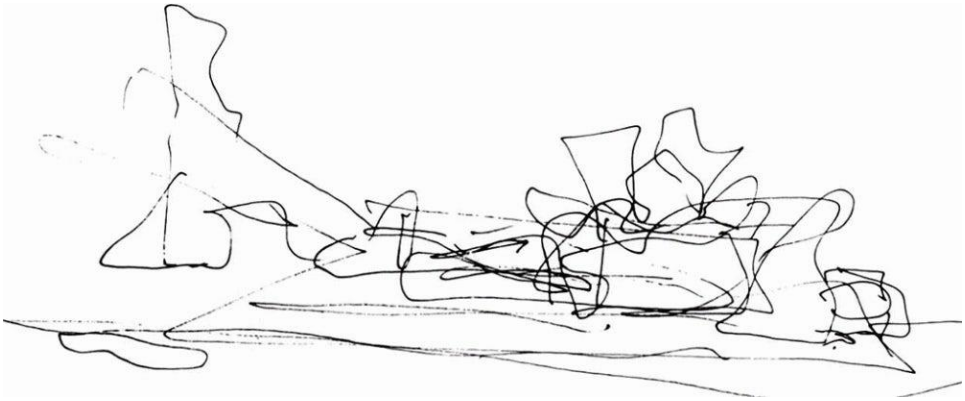


Figure 33: Sketch by Frank Gehry (Keskeys, 2019)

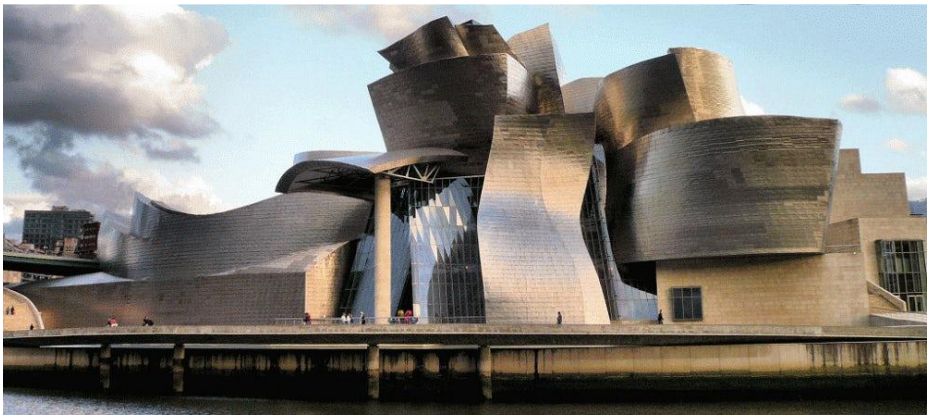


Figure 34: Guggenheim Museum, Bilbao (Keskeys, 2019)

Frank O. Gehry’s sketch adequately accentuates his creative ideas. Gehry mentioned his sketches as “scribble” and underlined the fact that it will not be meaningful for someone else except him. It is clear that from the initial part the original idea was kept. The sketch exactly resonates with the finalised building. The motion is thought

to have a relation with water and fish which resembles Bilbao's river (Keskeys, 2019).

However, there was a problem with the construction of the vivid forms. CATIA (Computer Aided Three-dimensional Interactive Application) was the software applied to make the construction of the building possible. Originally, in those days CATIA was a tool that was in use for different domains such as aircraft and automobile production. The technology helped for the generation of complex structural elements also benefited architectural drawings. Architects from his studio developed an answer for the requirements via this software (Śliwa, 2019). Frank Gehry does not use the computer for these processes (Keskeys, 2019) so it will not be incorrect to mention that he uses traditional ways such as hand modelling and sketching. The architectural entity's free-form structure, the non-Euclidian complex form can be categorised as a blob and folded (Bagneris, Motro, Maurin, & Pauli, 2008; ŚLIWA, 2019; Majeed, Al-Alwan, & Oukaili, 2021). Fold in architecture is characterised by dynamism, continuous surface creation and interchanges between 2D-3D.

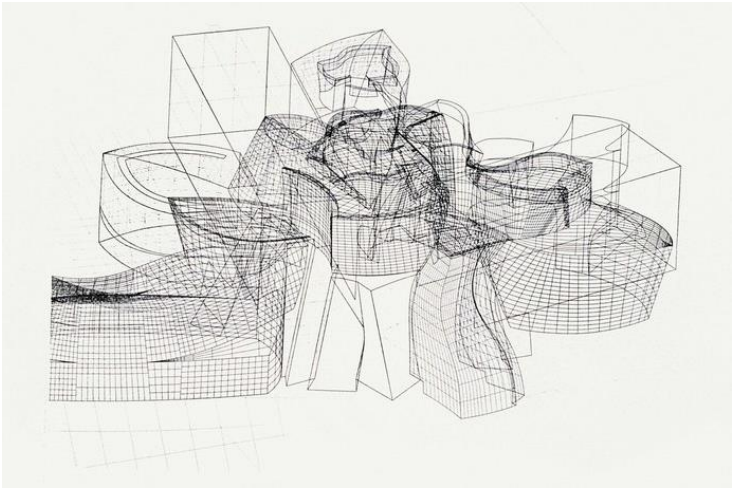


Figure 35: Structural representation of Guggenheim Museum, Bilbao('Let's Settle This: CAD or Hand Drawing? | Baubible', n.d.)

The use of digital components was crucial since panels were cut with a Computer Numerical Control (CNC) router and the drawings produced by CATIA were making the manufacturing to be possible. The building was designed and thought of by physical models in addition to the sketches and parametric design tools (Mendelsohn, 2017).

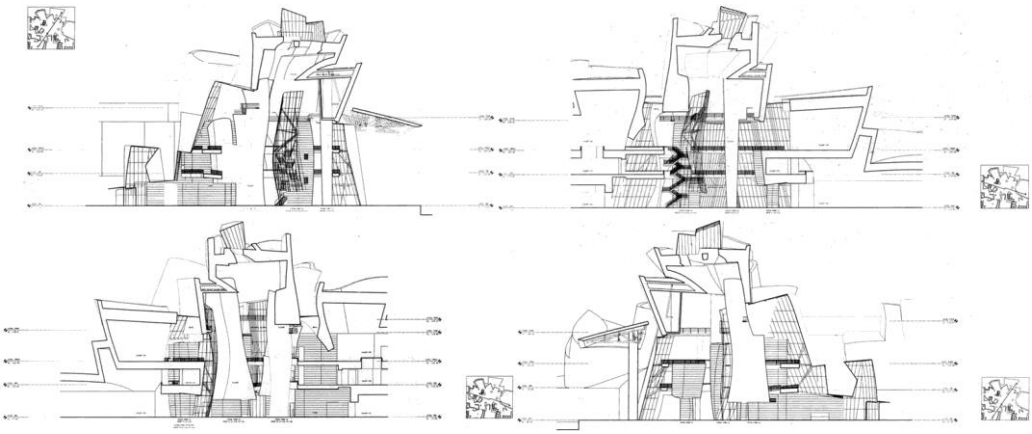


Figure 36: Sections of Guggenheim Museum, Bilbao (Pagnotta, 2021)

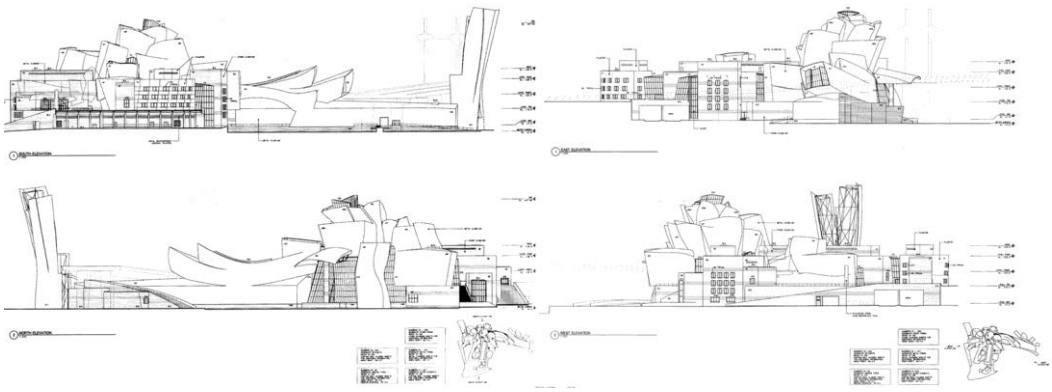


Figure 37: Elevations of Guggenheim Museum, Bilbao (Pagnotta, 2021)

The main load-bearing structures are the walls and ceiling the metal rods formed the grids together with triangles. CATIA was the one that determined the bars location and quantity of them (Pagnotta, 2021). Figures 36 and 37 show the complex sections that were being able to be drawn by the software.

When it comes to the designs of Frank O. Gehry it is important to explain what is the CATIA and his views upon this software. Nowadays, the software approach is known as parametric design. In the 1970s it was the start of architectural software but none of them was in line with CATIA's features. Probably, one of the reasons it was dedicated to other industries such as aviation. It appeared in the market in 1977 by Dassault, a French aircraft manufacturer (Tubielewicz-Michalczuk, 2019; Chang, 2015).

He explained the benefits with these words;

> "I think it's a revolution. I'm 81 and I've committed a good hunk of my life. Do change the industry in a way that architecture can do what it's supposed to do which is to design buildings within budgets on time and schedules and to maintain those in the world." ('CATIA | Customer | Frank Gehry Testimony | Key role of CATIA for his architecture creations', 2011).

Those words by himself underline the importance to achieve his dreams and building them. However, traditional and parametric creativity is still a topic that is discussed by scholars. It reveals the importance of a parametric design.

Almost every building by Gehry Partners, LLP becomes an iconic figure. Especially, Guggenheim Museum, Bilbao is self-explanatory of this matter. The building has a net income of 300 million every year ('CATIA | Customer | Frank Gehry Testimony | Key role of CATIA for his architecture creations', 2011).

Table 6: Phases which adopted the use of parametric design tools, by author

Guggenheim Museum, Bilbao: The phases where the parametric design was advantageous	
Initial Idea:	Conventional methods
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

The architect stated the emotion he faced with these words;

> "In Bilbao, the first time I saw those curves in the rain, glowing warmly, I cried. Once I learned that the metal could express an emotion, I looked for other ways of doing that. I'm trying to capture a feeling" (Davidson, 2020).

Table 7: Assessment by author (based on Gero, 2014)

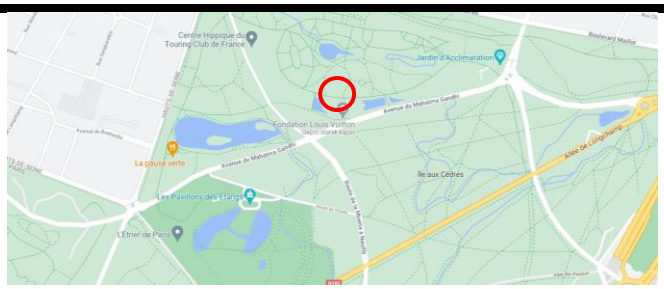
Novelty		**Usefulness**		**Aesthetics**	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

As Table 7 represents the role of parametric tools showed itself especially achieving the technical, functional quality otherwise it would have not been constructed. Aesthetics attractiveness is approved by even the term "Bilbao Effect". His sketch shows a well-expressed design, the complex design appeared by the CATIA and this original idea matched with an innovative approach. However, Table 6 reveals the

generation was initiated by traditional techniques and mostly intuitive manner as was sketched.

4.2.1.2 Fondation Louis Vuitton (2014)

Table 8: Information of Fondation Louis Vuitton, by author (based on Keskeys, 2019)

Project: Fondation Louis Vuitton	
Location: France, Paris	 Source: URL 2
Year (Constructed):	2014
Location:	Paris, France
Project Type:	Commissioned
Awards received:	HQE (Haute Qualité Environmentale) certification AIA BIM Excellence Award (2012)

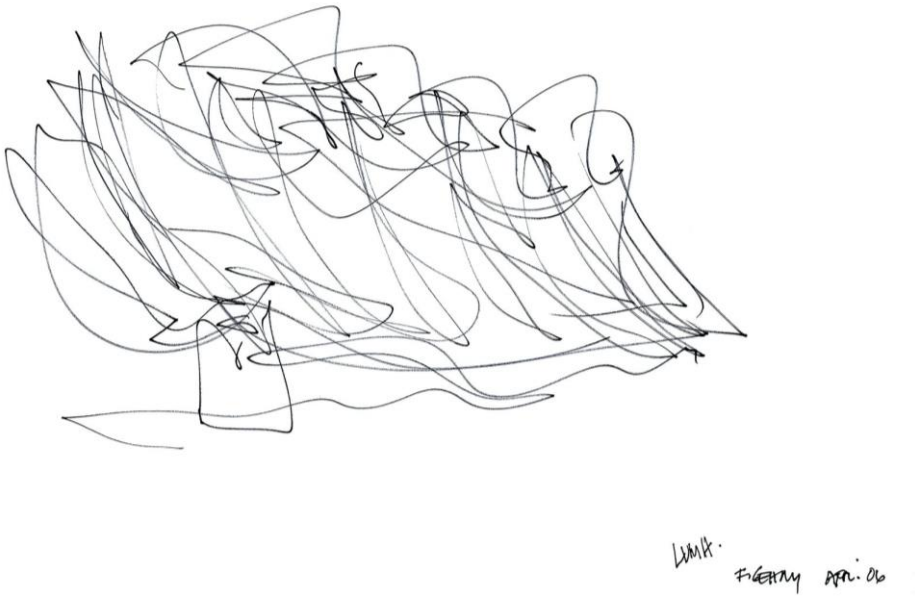


Figure 38: Sketch of Fondation Louis Vuitton (Keskeys, 2019)

Figure 39: Fondation Louis Vuitton (Keskeys, 2019)

The initial sketch by Frank O. Gehry highlights the significance of sketching. The abstract idea evolved in a manner that the final outcome resonates with the sketch well. The glass panels are mentioned as “sails” and in total the building is visually depicted as in motion (Aguilar, 2021). This motion can be observed in Figure 40. The panels are positioned specifically to give the visual of a ship in sail (Zara, 2017).

Figure 40: Fondation Louis Vuitton silhouette of sailing motion (Aguilar, 2021)

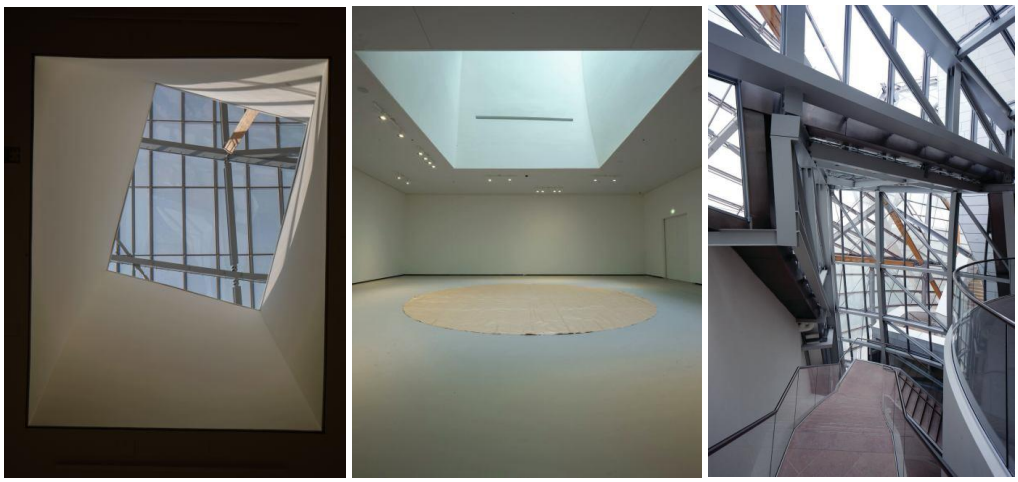


Figure 41: Interior of Fondation Louis Vuitton (Giovannini, 2014)

The Louis Vuitton Fondation welcomes with galleries (Figure 41) in different sizes and forms (‘Louis Vuitton Foundation | STUDIOS Architecture’, n.d.). A question directed to Frank Gehry by the interviewer was about the height limitation of the building. Especially was asking how he managed to design galleries higher than the height of two storeys. He explained the situation was an outcome of the glass enclosure (Giovannini, 2014).

It has been mentioned that the project was a catalyser for the digitalisation of designs and construction from a global aspect. Designing models, engineering and defining parameters for a common web-hosted 3D digital model needed more than 400 people. The façade design which consists of panels that are more than 3600 and made of glass are all designed using mathematical arrangements and assembled by industrial robots. In addition, panels made of concrete were again for the façade designed in the same way. All of these technical designs happened via the common 3D model (Figures 44 and 45). For this common model, software was developed to be able to work on the design (Aguilar, 2021).

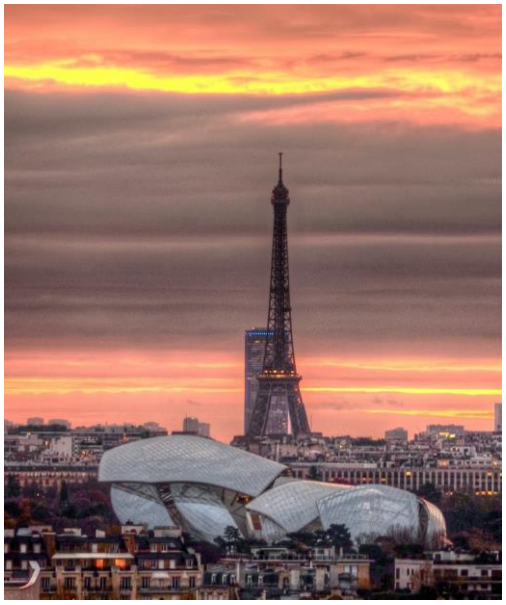


Figure 42: Appearance of Fondation Louis Vuitton (Daley, 2018)

Frank Gehry explained how he was commissioned for the design of Louis Vuitton's building. The chairman and CEO of Louis Vuitton demanded a museum for himself. He stated that the design was complex because of the Beaux-Arts approach. He clarified this by this sentence; ". I start and I just work intuitively along the way. I don't have a prearranged destination, which is complicated for the French because the Beaux-Arts way is that you fix on the model and then that's it." He continued by

stating his work style is not in that predetermined manner. Additionally, added they managed to corporate both kinds of disciplines (Giovannini, 2014). This situation also marks the importance and influence of cultural and educational background.

In terms of sustainability, the design of the roof enabled the collection of rainwater (Aguilar, 2021). The building is a combination of new and old ideas. This is achieved by; 19th-century garden architecture and redevelopment of Grand Palais or structures like; Joseph Paxton's Crystal Palace. Gehry mentioned it may not be similar to those buildings but the idea came from them (Zara, 2017; McGuigan, 2016).

Figure 43: Illustrating the complexity (Aguilar, 2021)

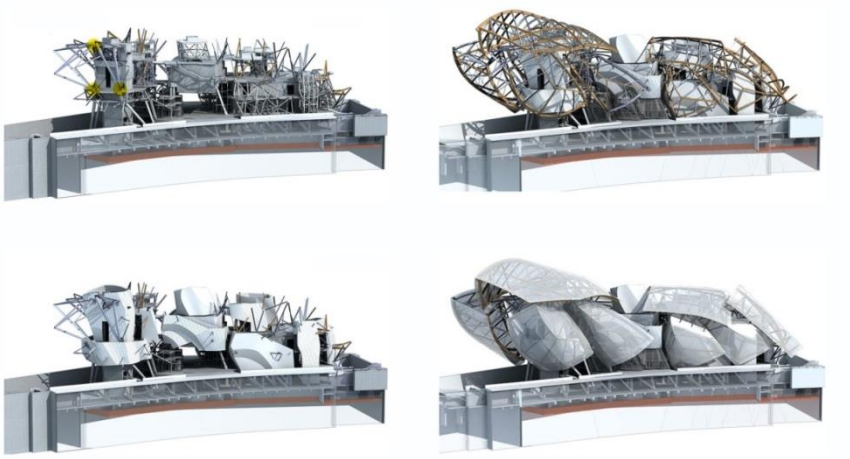


Figure 44: Structural formation of Fondation Louis Vuitton (Studios, n.d.)

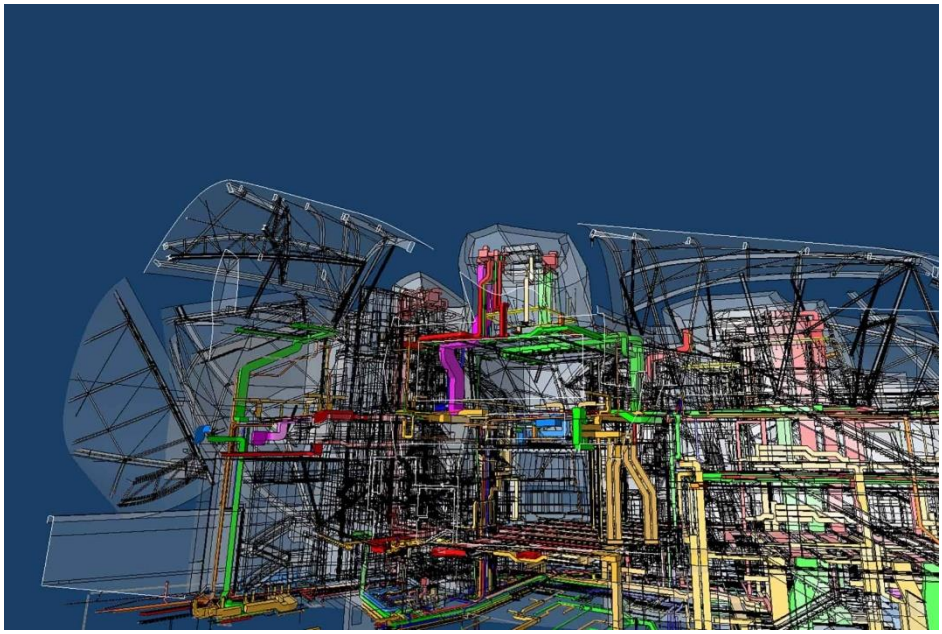


Figure 45: Avant-garde and technically ingenious, the project could not have been carried out without 3D modelling and Full BIM (Studios, n.d.)

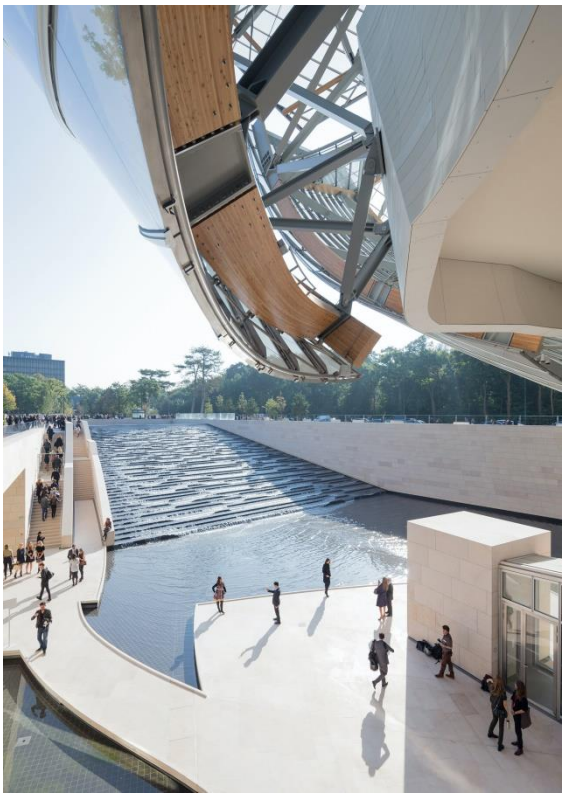


Figure 46: View on the reflecting pool on the east side (Studios, n.d.)

The volume is surrounded by glass which earned the name of the iceberg. The building emerges from a pool also houses a terrace (‘Louis Vuitton Foundation | STUDIOS Architecture’, n.d.) that allows interaction with the landscape (Figure 46).

Table 9: Phases which adopted the use of parametric design tools, by author

Fondation Louis Vuitton: The phases where the parametric design was advantageous	
Initial Idea:	Conventional methods
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Table 10: Assessment by author (based on Gero, 2014)

Novelty		Usefulness		Aesthetics	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

The legislative height limit is extended by a creative decision on the material used. Integration with landscape and urban environment is well achieved. The idea resembles the sketches which give a clue of the ideation and is expressed well. Without the parametric design, usefulness would have not been achieved as functional and technical qualities analysed in detail as Table 9 and 10 depict.

4.2.2 Jean Nouvel

He was born in 1945, Fumel in France (‘Jean Nouvel’, n.d.). When he was a child he wanted to become a painter, even he was thinking of turning back to the “pure” art, however, then he realised that architecture is a form of expression as well (Casciani, 2016). He studied architecture at Ecole Nationale Supérieure des Beaux-Arts, in Paris.

In 1970 he was the architect of the Biennale de Paris. He had received many awards, for instance; in 1980 he was awarded a silver medal from the Académie d’Architecture, in 1987 with “Grand Prix d’Architecture”, “Equerre d’Argent” by the furniture designs. Moreover, The RIBA Royal Gold Medal, The Pritzker Prize, The Imperial Prize of Japan, The Aga Khan Award, and The Wolf Foundation Arts Prize are some of them (Cué, 2015). In addition, his work is exhibited in museums like; Exposeum Museum of Modern Art and the Centre Pompidou, Paris and Museo Nacional Centro de Arte Reina Sofía, Madrid (‘Jean Nouvel’, n.d.). During the years

in the Ecole Nationale Supérieure des Beaux-Arts he was assisting Claude Parent and afterwards Paul Virilio who was a cultural theorist and urbanist (‘Jean Nouvel’, n.d.).

Jean Nouvel describes projects as an adventure. He explained that he does not have a predetermined idea when he starts.

> “I always begin with a hope that the place, the experience, and the people with whom I am going to find myself at that moment are all going to contribute something completely unique. This sort of precision and nonconformity serve as an attack on the concept of cloning. Along these lines, there is something that has made the situation even worse—the development of information technology. Nowadays, the guidelines for creating any kind of project are readily available. As a result, you can design a building in a few hours based upon these predetermined criteria. It doesn't matter if they're residences, offices, or shopping malls. You select from what already exists, adjust a few elements, and just like that, it's done. Unfortunately, there isn't any gray area. There isn't enough thought, planning, or love in the designs that come about like that. They're automated and don't have any soul” (Cué, 2015).

In an interview, Jean Nouvel was directed a question about computers and their effects on architectural design. He answered by referring to his own experience and mentions computer has a role to open a mind. Additionally, without them he states it would have not been possible to build some of the buildings for example he gave reference from Louvre, Abu Dhabi and mentioned he had to design such a building years ago it would have taken centuries to achieve it (‘Jean Nouvel: "With new technology you can lie just as well,. . .’, 2010).

Jean Nouvel mentioned that he talks about architecture and discuss them with his friends and highlights for each of the projects upon the necessities he finds the right consultant (Massimo mini| designboom, 2014).

He intends to “create something unique” he is not fond of repetition of the same architectural vocabulary (Massimo mini| designboom, 2014). Frank Gehry stated as “He tries things and not everything works. There’s a mixture of things that are extraordinary, things that are experiments, things that don’t come off aesthetically. But Jean is willing to jump in and take on things and try. That’s a great quality.” (Famous Architects, 2015). He thinks that architecture should be linked with the past and geography (‘Jean Nouvel: "With new technology you can lie just as well,. . .’, 2010). As an architect he does not draw he prefers to express his ideas verbally, sometimes scribble (‘Jean Nouvel: A Talk on Architecture & Design’, 2020). When he was working in Parent and assisting Virilio he stated in 2010 that he learned how things were working (Casciani, 2016).

Table 11: Relevant data coding and correlating by the use of the interviews

Effects of Nature and Nurture	**Facts Identified and Correlated**
Educational and Cultural Background	• Beaux-Arts (‘Jean Nouvel’, n.d.) • Wanted to be a painter as Gardner suggest these are different forms of a creative intellectual mind (Casciani, 2016) • Sees architecture as an art (Casciani, 2016) • Collaboration with other people for the creation. Social context is in charge Sternberg (2006)
Gender and Age	• The studies carried out reveal that there is not a correlation between creativity and gender. (Kaufmann, 2006) • No relevant data referring to the age
Intuitive Actions	• Verbal approach preferred • Scrawls • “Architectures of light” (Massimo mini I designboom, 2014) The influencing architectural qualities can be observed in his

	designs • Inspiration occurs (explained in section 4.2.2.2)
Learned attitudes and Behaviours	• Mentioned without computers many of his buildings would not be built('Jean Nouvel: "With new technology you can lie just as well,. . .', 2010) • Computers open an individual's mind • Brainstorms, Arguments and analysis • Motivation is induced by hope and excitement.
Importance of Expertise	• When he was working in Parent and assisting Virilio he stated in an interview, in 2010 that he learned how things were working (Casciani, 2016)

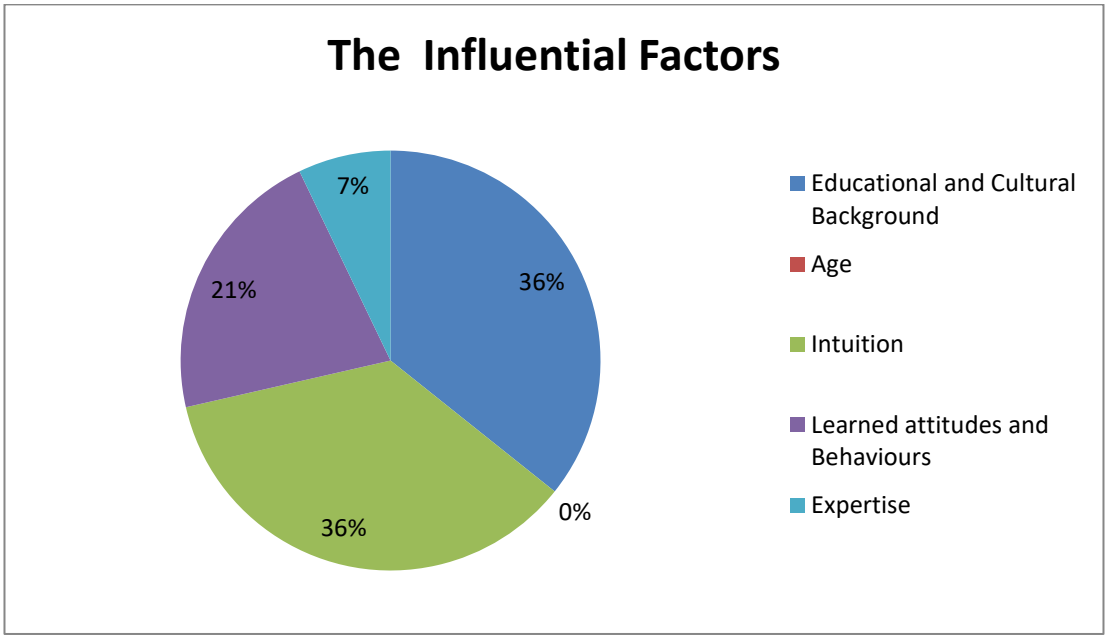
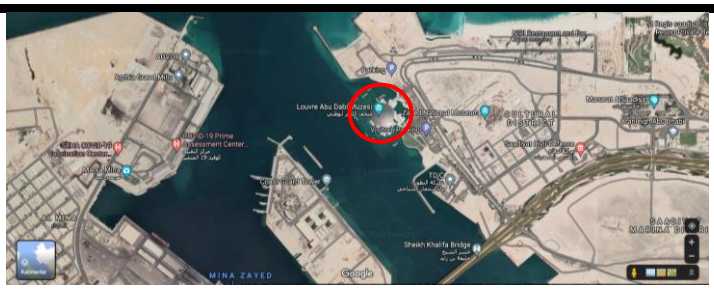


Figure 47: Presentation of factors derived from the table, by author

4.2.2.1 Louvre, Abu Dhabi (2017)

Table 12: Information of Louvre, Abu Dhabi by author (based on Hasan, 2017)

Project: Louvre, Abu Dhabi	
Location: Abu Dhabi	 Source: URL 3
Year (Constructed):	2017
Project Type:	Commissioned
Area:	97000 m²
Awards received:	Identity Design Award (2015) European Steel Design Award (2017) Identity Design Award (2017)

For this project, Jean Nouvel was inspired by the culture of Arabic architecture. Louvre Abu Dhabi is one of the complex projects in terms of engineering, this project received many awards in the field of design and sustainability. The most

striking part of the design is the dome and the light effect it causes (‘Louvre Abu Dhabi | Ateliers Jean Nouvel, BuroHappold Engineering Ltd, Louvre Abu Dhabi’, n.d.).

Jean Nouvel described the choice of the dome by these words;

> “This micro-city requires a micro-climate that would give the visitor a feeling of entering a different world. The building is covered with a large dome, a form common to all civilizations. This one is made of a web of different patterns interlaced into a translucent ceiling which lets a diffuse, magical light come through in the best tradition of great Arabian architecture.” (Imbert et al., n.d.).

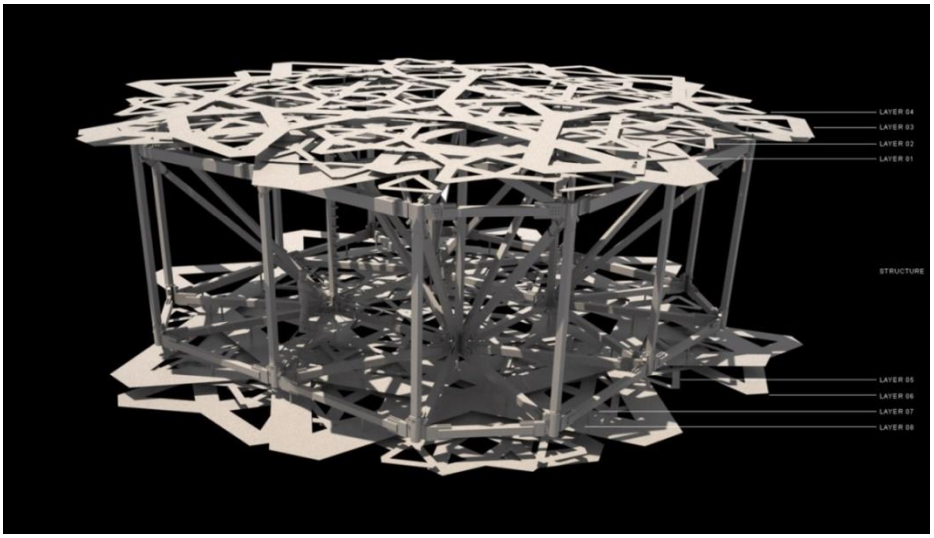


Figure 48: Representation of the clad (Hernández, 2021)

The dome consists of eight layers and is formed by geometric design (‘Louvre Abu Dhabi | Ateliers Jean Nouvel, BuroHappold Engineering Ltd, Louvre Abu Dhabi’, n.d.). Eight layers formed the dome which has aluminium and steel clad that Figure 46 shows and the layering of dome can be observed in Figure 48. The outer part is from steel and the inner parts are aluminium. Both the clad types are positioned by a frame made of steel, which keeps them apart by five meters in height. 7,850 stars can

be seen at night time from interior and exterior(‘Louvre Abu Dhabi | Ateliers Jean Nouvel, BuroHappold Engineering Ltd, Louvre Abu Dhabi’, n.d.).

Zhang (2017) mentioned that designers try to set a harmony between the modern and the traditional. The parametric design of the dome came out of a single pattern (Zhang, 2017) which repeated. The pattern evolution and configuration can be observed in Figures 47 and 49. The patterns created, repeated in a variety of ways as the figure represents rotation and appropriate scaling was in charge as well (Imbert et al., n.d.).The patterns created can be observed from the interior (Figure 50).

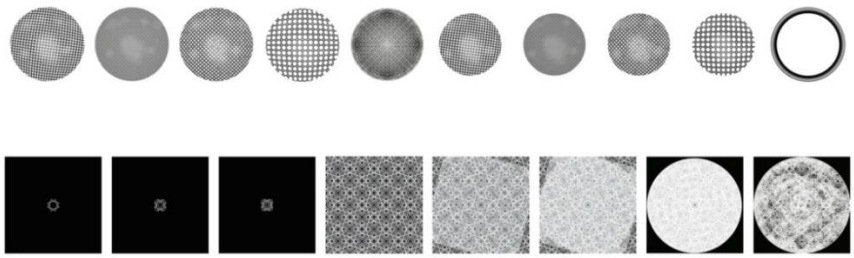


Figure 49: Geometrical pattern creation (Hernández, 2021)

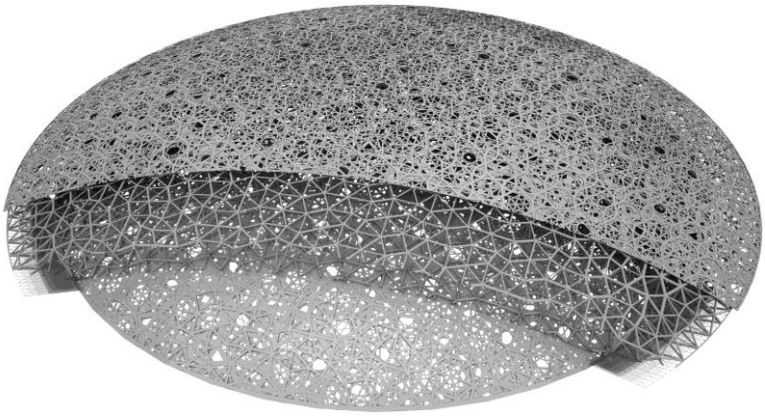


Figure 50: The dome (Hernández, 2021)

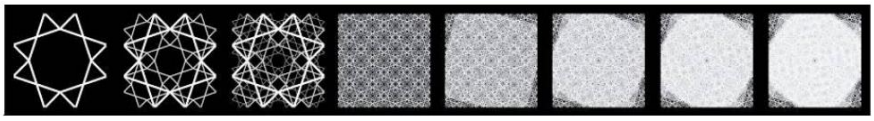


Figure 51: The configuration of the pattern (Imbert et al., n.d.)

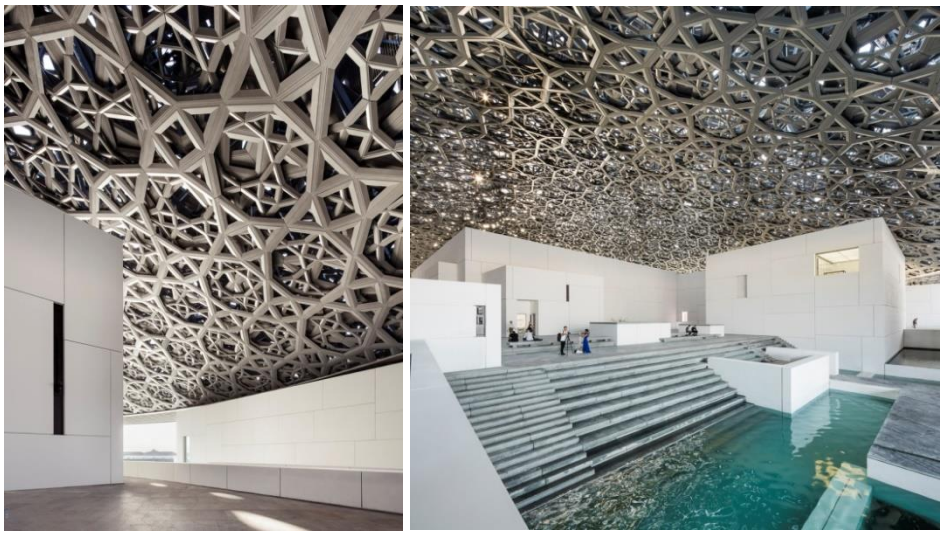


Figure 52: Interior view (Hernández, 2021)

Figure 53: “Rain of light” (Cornachio, 2021)

The dome acts as a filter for the light (Imbert et al., n.d.) which can be seen in Figure 51. The aluminium starts have different scales because the parametric modelling tools and maps for controlling the luminosity like luminance maps used. These illustrated the optimum conditions for the light that each part of the museum will need. The luminosity and sun exposure were essential factors to be controlled as the artworks will not be resistant to those conditions (Cornachio, 2021).

Nouvel described as, “it conveys the consciousness of time, of eternity. The dome is a cosmic object, not unlike a sundial, tracing the path of the sun.” (Cornachio, 2021). The “rain of light” effect (Abourezk, 2018) achieved by the dome and space which has the materials of stone, steel and glass led various paths for the light which in turn caused gradient (Zhang, 2017). Luminance maps were necessary for the process of lighting. The temperature and lighting levels which will differ at certain points in the museum are determined in this way. The light intention map focused on particular spaces like; plazas, galleries, other buildings and water (Zhang, 2017).

During the design process, the necessity of parametric modelling arose for the fabrication of the design. Multiple software use was in charge the ones that benefited from the mentioned situation was; Gehry Technologies which enabled the infrastructure management and created a relation between the dome and the architect, engineer and consultants. Digital Project Software and SVN also a model repository which was web-based. These all allowed the collaborative work, content distribution and training (Imbert et al., n.d.).

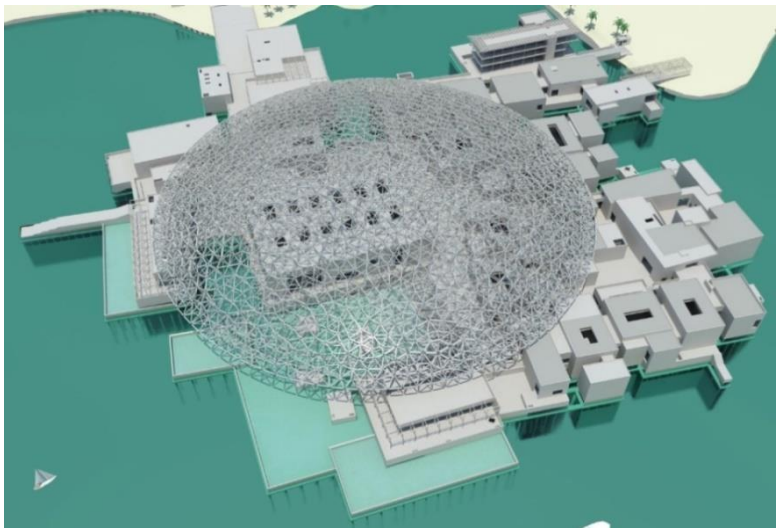


Figure 54: Louvre, Abu Dhabi (Hernández, 2021)

Table 13: Phases which adopted the use of parametric design tools, by author

Louvre, Abu Dhabi: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occurred
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Table 14: Assessment by author (based on Gero, 2014)

Novelty		**Usefulness**		**Aesthetics**	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

Identity Design Award (2015), European Steel Design Award (2017) and Identity Design Award (2017) are awards that illustrate the success of the projects. Without the parametric design facilities, it would not be built (Table 13). The facts written in Table 14 are predominantly achieved by parametric design tools. Parametric architecture became highly creative according to the factors listed in Table 14.

4.2.2.2 National Museum of Qatar (2019)

Table 15: Information of National Museum of Qatar, by author (based on González, 2019)

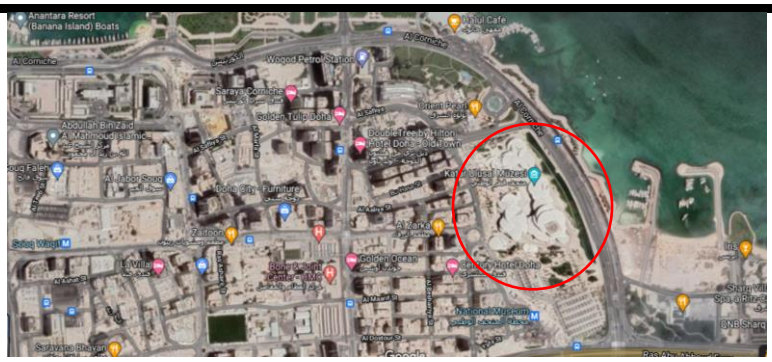
Project: National Museum of Qatar	
Location: Doha, Qatar	 Source: URL 4
Year (Constructed):	2019
Project Type:	Commissioned
Area:	52000 m²
Awards received:	LEED Gold BIM Award

Figure 55: Desert rose (‘Katar Ulusal Müzesi / Ateliers Jean Nouvel’, 2019)

Figure 56: Desert rose applied to layout (‘Katar Ulusal Müzesi / Ateliers Jean Nouvel’, 2019)

Figure 57: Desert rose layout application observed (‘Katar Ulusal Müzesi / Ateliers Jean Nouvel’, 2019)

Figure 58: National Museum of Qatar (González, 2019)

Desert rose which is formed by mineral was the main inspiration point of the project which the form type arose from this rose which can be seen in Figures 55, 56, 57 and 58(‘Katar Ulusal Müzesi / Ateliers Jean Nouvel’, 2019; ‘Qatar’s National Museum by Jean Nouvel becomes the new Desert Rose’, 2018; Broome, 2019). The building is built near the palace of Sheikh Abdullah bin Jassim Al Thani which the place serves as a landmark (‘Qatar National Museum | Ateliers Jean Nouvel, Werner Sobek’, n.d.).

Jean Nouvel was more attracted by the opportunities of the form that can offer he mentioned as “When you have a random system, you can adapt it and also adapt the contents” (Broome, 2019). “This building is at the cutting edge of technology, like Qatar itself. As a result, it is a total object: an experience that is at once architectural, spatial, and sensory” (‘Qatar’s desert rose’, 2019).

Broome (2019) mentioned that the design was aiming to show the conflict between Qatar’s past and today’s. Jean Nouvel stated that for a national museum “monumental approach” is necessary (Broome, 2019).

Figure 59: Structural application (‘Katar Ulusal Müzesi / Ateliers Jean Nouvel’, 2019)

Hafid Rakem who was the manager of the project said that the thought was basic but to conduct. There are 539 disks and 30 of them vary in size since this was a challenging parametric tool were benefited (Figure 59). For example; Gehry Technologies’ software-enabled design communication with different disciplines. Especially, in terms of structure and form, the design was complex because as form generates from the structure even a single change was affecting the structure. Therefore, the usage of analysis software for structure in addition to modelling was important (Broome, 2019).

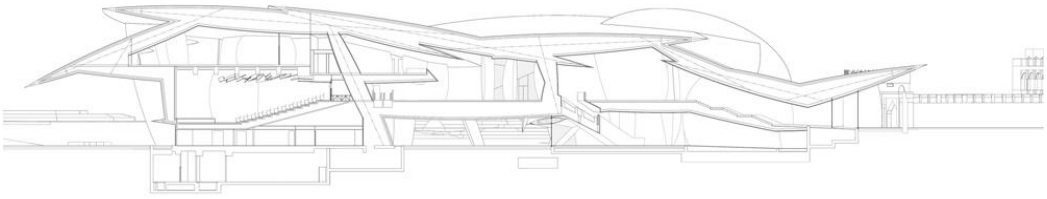


Figure 60: Section of the museum (‘Katar Ulusal Müzesi / Ateliers Jean Nouvel’, 2019)

The complexity of the exterior part showed itself in the interior of the building as well (‘Louvre Abu Dhabi | Ateliers Jean Nouvel, BuroHappold Engineering Ltd, Louvre Abu Dhabi’, n.d.) which increased the quality of space.

Table 16: Phases which adopted the use of parametric design tools, by author

National Museum of Qatar: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occurred
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Table 17: Assessment, by author (based on Gero, 2014)

Novelty		**Usefulness**		**Aesthetics**	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

A biomimetic analogy was adopted for the generation of the building but the first inspiration occurred which is an intuitive feeling (Table 16). The design was complex and was in need of different disciplines and parametric design tools. In terms of aesthetics has a unique structure that supplemented the initial idea by means of functional and spatial arrangement. The spatial effect can be observed in Figure 60.

4.2.3 Zaha Hadid

Zaha Hadid was born in 1950, Baghdad, Iraq and died in 2016. She wanted to study architecture since she was a child. She had the chance to observe her aunt's house construction and the architect was her father's friend. She was seeing the architectural models and drawings which the architect was bringing and she stated it may have triggered a thing in her (Stevens, 2017). Afterwards, she mentioned; "From a young age I came to know that those who are fully engaged can do anything. I wanted to become an architect, so I had to concentrate only on architecture. To succeed you need to be very focused" ('Zaha Hadid', 2012).

She studied architecture at Architectural Associated in 1972 and graduated in 1977. Hadid was the partner of the Office for Metropolitan Architecture. She was teaching at the most prestigious institutions ('Zaha Hadid', 2017). She received the most prestigious architecture award known as the Pritzker Prize and the outstanding fact is that she was the first woman to be awarded the Pritzker (Rajendran, 2021). Before the architectural study, she studied mathematics. She started to be highly recognized by the establishment of Zaha Hadid Architects with her partner Patrik Schumacher (Stevens, 2017). Additionally, her mathematics background can be the reason of this thought as Zaha Hadid's famous quote states; "There are 360 degrees. Why stick to one?" (Rajendran, 2021), clearly depicts her design philosophy. She was keen on fragmentation, abstraction and explosion. She was interested in deconstructing the repetitiveness (Stevens, 2017). She was original in the approach she had towards the problem solution. Usually, she was integrating technology with her novel ideas and she was one of the pioneers to use 3D in the design process (Rajendran, 2021). Stevens (2017) who conducted the interview she said that she does not use a

computer, however, she sketches and often she does it multiple times for the same research. Hadid described architecture as an extremely difficult profession, whoever wants to have an easy life are not suitable for this field (‘Zaha Hadid’, 2012).

Technological developments and new manufacturing strategies became an inspiration point for them. She stated the significance of collaboration in an interview and research by these words; “the current state of architecture and design requires extensive collaboration and an investigative attitude and we continue to research and develop new technologies” (Stevens, 2017). Erich Mendelsohn, Mies van der Rohe, Le Corbusier are some of the architects who affected her (Stevens, 2017). In addition, Kazimir Malevich’s paintings influenced her (Santibañez, 2020). One of Kazimir Malevich’s paintings is illustrated in Figure 61. Her designs were recognised almost ten years later (Rajendran, 2021). Zaha Hadid was also taking part in the field of product, fashion and jewellery design (Rajendran, 2021).

Figure 61: Kazimir Malevich’s painting (Taylor-Foster, 2017)

Table 18: Relevant data coding and correlating by the use of the interviews

Effects of Nature and Nurture	Facts Identified and Correlated
Educational and Cultural Background	• Studied mathematics, domain knowledge perhaps can be the reason behind his iconic buildings (Torrance, 1966) Mathematics influenced her philosophy, which can be understood by her reference to 360 degrees. (Rajendran, 2021) • Wanted to be an architect from childhood ('Zaha Hadid', 2012) • ZHA is a collaborative environment • Fully concentrated on architecture, her aim to be an architect from an early age showed her determination ('Zaha Hadid', 2012)
Gender and Age	• The studies carried out reveal that there is not a correlation between creativity and gender (Kaufmann, 2006)
Intuitive Actions	• Inspired by Kazimir Malevich's paintings (Santibañez, 2020) • Had paintings and drawings • Sketched enormously • Erich Mendelsohn, Mies van der Rohe and Le Corbusier are some of her favourite architects (Stevens, 2017)
Learned attitudes and Behaviours	• Do not use a computer, her firm was a pioneer in 3D technologies (Stevens, 2017) • Paintings and drawings • Sketched • Research and develop new technologies
Importance of Expertise	• Worked in many places before setting up her own firm

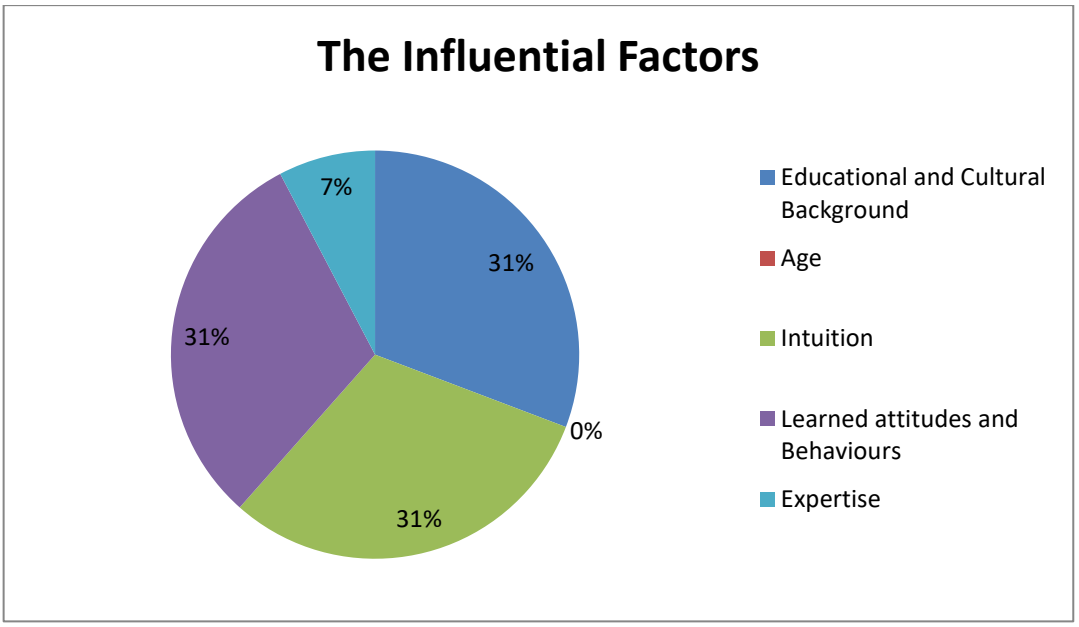


Figure 62: Presentation of factors derived from the table, by author

4.2.3.1 Heydar Aliyev Centre (2013)

Table 19: Information of Heydar Aliyev Centre, by author (based on RIBA, n.d.)

Project: Heydar Aliyev Centre	
Location: Baku, Azerbaijan	 Source: URL 5

Year (Constructed):	2013
Project Type:	Competition in 2007
Area:	101801 m²
Awards received:	RIBA Award for International Excellence

The most striking part of the building is its fluid interaction with the surrounding (Figure 63). “Undulations, bifurcations, folds, and inflections” transforms the architectural entity into a landscape which helps to direct the visitors. By the forms achieved it is not only a building also an urban plaza (Hernández, 2021b).

Figure 63: Undulating elements (Hernández, 2021b)

Figure 64: Interior (Giovannini, 2013b)

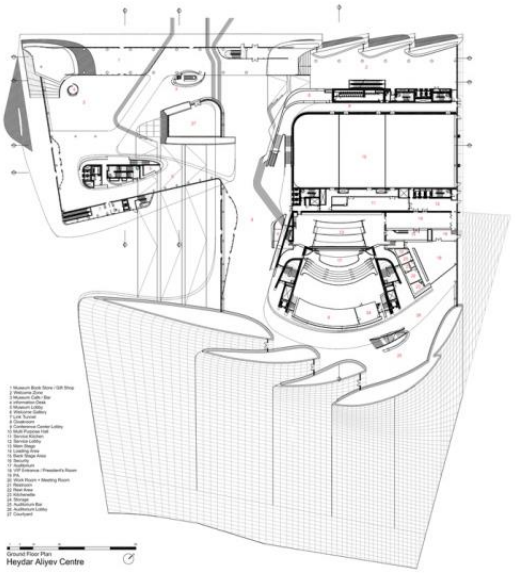


Figure 65: Ground Floor Plan (Hernández, 2021b)

Heydar Aliyev Centre takes place in Baku, Azerbaijan. For this centre Zaha Hadid stated; “This was an incredibly ambitious project and for me, It was always my dream to design and build the theoretical project and that was the closest thing to achieving that”. Saffet Kaya Bekiroglu was the project architect and stated this project reflected the soft and romantic side of Azeri culture (Fairs, 2014).

Zaha Hadid Architects as his colleague Frank Gehry was benefiting from the CATIA. In the design of the centre, CATIA allowed the creation of folds looking similar to wave and achieved a continuous topographical arrangement (Tubielewicz-Michalczuk, 2019).

The interview of Dezeen conducted by Marcus Fairs (2014) directed questions about the role of parametric design during the design process. The project architect underlined the collaboration by these words "I mean we, as a team, are multi-tasking…" and by the term multi-tasking he opened up the subject more by saying they are benefiting from different mediums such as physical models, computers and sketches. However, computing is just for the control of numbers and decreasing the level of uncertainties. The parametric software was to produce the skin and making it accurate and efficient. Marcus Fairs (2014) continued his question by referring to the role of computers and humans in the process. The answer was "A computer is just a tool so we're the ones who push the buttons, we're the ones who provide the data, we're the ones who actually drive it." This sentence explains clearly the role of parametric design tools in the design of the project (Fairs, 2014). Hadid said;

> "We wanted to take the plaza and shape it into an architectural environment, to create a continuous flow between inside and outside, to create a certain infinity, you don't know where it all starts and ends" (Giovannini, 2013b).

"Each program has a different look because of its required height: The tall one at the back is the library, with its many floors, and the rise to the side accommodates the conference center, with the auditorium's fly tower." (Giovannini, 2013b).

Figure 66: Heydar Aliyev Centre (Hernández, 2021b)

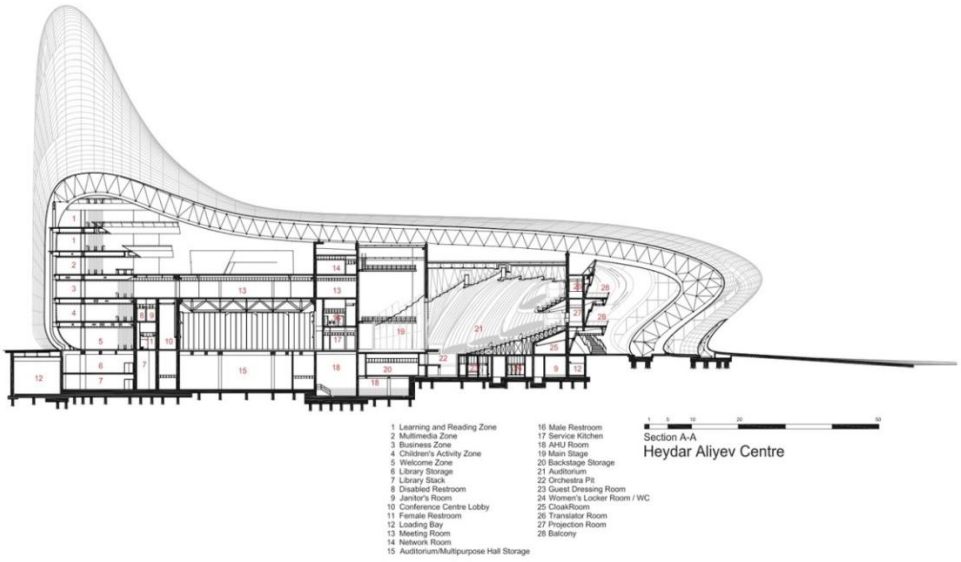


Figure 67: Section (Hernández, 2021b)

The design of Heydar Aliyev Centre consists of two kinds of the structural system which are reinforced concrete and other kind is space frame structure (Özsavaş Akçay & Tarboush, 2019). This issue can be observed by Figure 67.

Table 20: Phases which adopted the use of parametric design tools, by author

Heydar Aliyev Centre: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration from the past
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

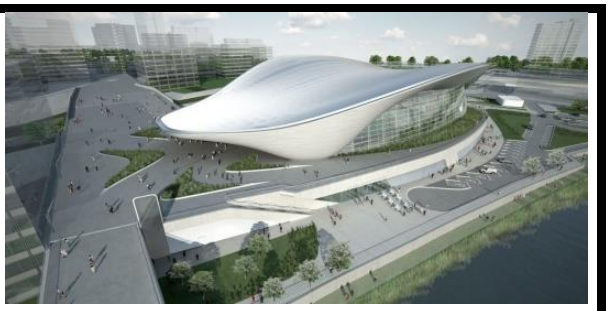
Table 21: Assessment, by author (based on Gero, 2014)

Novelty		**Usefulness**		**Aesthetics**	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

RIBA Award for International Excellence was given for the project therefore it resembles concrete proof of the expression, complexity and expressiveness (Table 21). An innovative approach was in charge as the form's design benefited by parametric design however it was underlined that it served just as a tool. Functional quality, integration and technical parts are interlinked.

4.2.3.2 London Aquatics Centre (2011)

Table 22: London Aquatics Centre, by author (based on 'London Aquatics Centre | Zaha Hadid Architects', 2021)

Project: London Aquatics Centre	
Location: London, UK	 Source: URL 6
Year (Constructed):	2011
Project Type:	Architectural competition
Area:	15950 m²
Awards received:	Silver Medal International IOC/IAKS Awards Winner of competition

London Aquatics Centre was designed by Zaha Hadid in 2004 ('London Aquatics Centre | Zaha Hadid Architects', 2021). The inspiration for the conceptual approach was the motion of water therefore fluidity was enhanced by the chosen geometries.

The roof form comes from a parabolic structure that has a double-curvature geometry (‘London Aquatics Centre | Zaha Hadid Architects’, 2021).

Figure 68: London Aquatics Centre (‘London Aquatics Centre | Zaha Hadid Architects’, 2021)

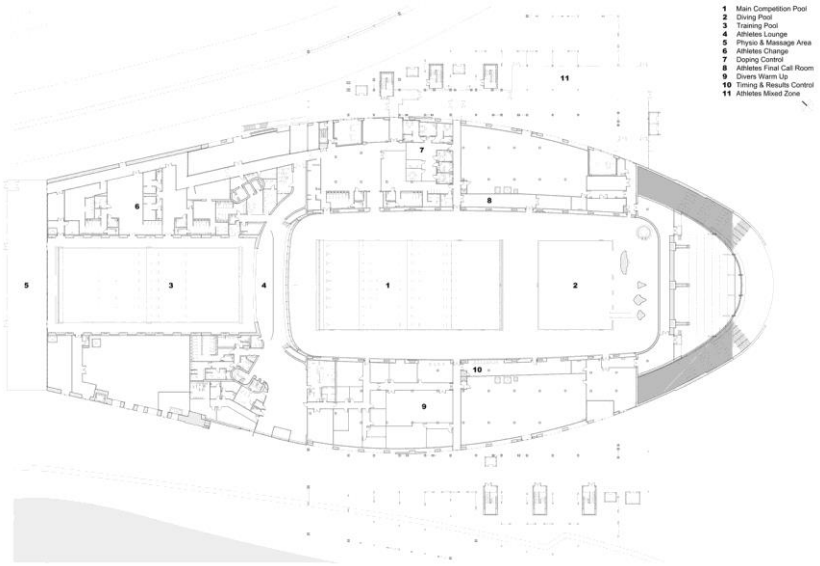


Figure 69: Ground Floor Plan (Jett, 2011)

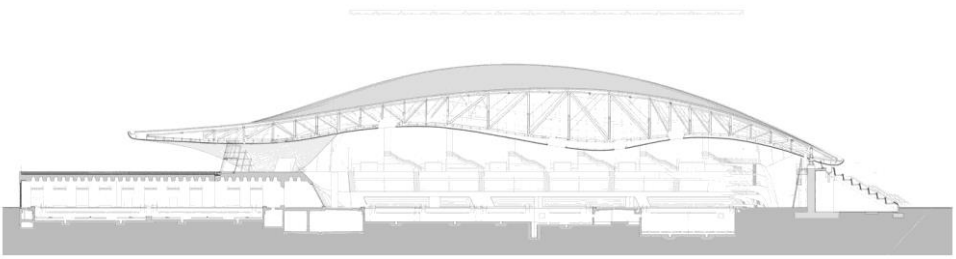


Figure 70: Section revealing the structure (Jett, 2011)

Figure 71: Roof arises from the ground as wave (Jett, 2011; ‘London Aquatics Centre | Zaha Hadid Architects’, 2021)

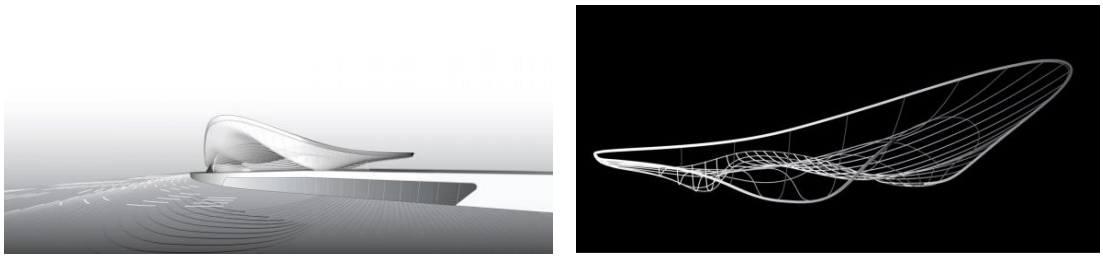


Figure 72: Roof structure (‘London Aquatics Centre | Zaha Hadid Architects’, 2021)

Table 23: Phases which adopted the use of parametric design tools, by author

London Aquatics Centre: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occured
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Table 24: Assessment, by author (based on Gero, 2014)

Novelty		Usefulness		Aesthetics	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

The overall design is complementary with all the parts employing the structure, plan and concurrently by the form. To achieve fluidity a complex engineering design was adopted for the roof. The first inspiration of the fluid motion can be noticed thus the design is well expressed.

4.2.4 Bjarke Ingels

To begin with, he was born in 1974, Copenhagen. In one of his interviews he has been asked; “did you want to be an architect during your childhood?.” He answered this as a “No”. He mentioned that he always wanted to be a cartoonist, novelist even in the documentary named ‘Abstract’ his parents tell about that they were the ones to mention about studying architecture. In an interview, he mentioned that he was ‘good’ at drawing (Designboom, 2012; Delany, n.d.; Inaba, 2013). Bjarke Ingels started to work at OMA , in 2001. After this with Julien De Smedt who was also working at OMA, they started PLOT in Copenhagen. After slowing down the actions at PLOT they founded BIG (Robathan, 2017).

In 2012, he explained that he reads wired magazine to observe the influence of technology in different parts of life such as arts and design also architecture (Designboom, 2012). In 2012, when he was asked about his working process he answers as;

> "I just spend all my time trying to help develop the ideas. In a way when you start studying architecture, you draw with a crayon then you have to learn how to draw with a hard line, like a rotring ink pen and you think you lose something cause you can't do all the different shades you could do with crayon, but, I mean … you can choose. You have a certain new position, and you can choose the line weights and you can use raster and stuff like that. then you learn the computer, and everybody says, you use a lot of the feeling with a computer (laughs). you actually have a lot of new tools, and things you can measure and change perspective and blah, blah blah.. and then eventually, you need like three dimensional softwares. When you start working with people there are certain things you can't do anymore, but you acquire some new possibilities, that are even bigger. So in a way, as an architect I've evolved to the point where now I don't draw with a crayon, I draw with people and in my case, but it almost goes for everyone in the office, my ability to find the right person for the right job (you know, if you try to get, a violin to sound like a trumpet, it's going to sound really weird) it's a new way of finding the potential of the crayon or the rotring." (Designboom, 2012).

In BIG's monograph "Yes is More" written, During the interview of Klat magazine he said this was a tribute for some of the "heroes" which includes; Mies van der Rohe, Philip Johnson, Robert Venturi and Rem Koolhas. "The ideas that our ancestors have developed are a pretty good point to start from before you begin to stack bricks on top of one another." He underlines the fact that he does not believe in beginning from scratch (Inaba, 2013). Moreover, he thinks as turning fiction into real fact (Rosenfield, 2014).

Bjarke Ingel's view upon software based application;

> "We don't have the time to let the vernacular evolve over centuries. We have to make it evolve quicker, and happily we have the tools to do so. With software applications like Grasshopper, you script the parametric engine that will allow you to discover very quickly the optimum typology, overhang, orientation of a building or whatever. As a result, we have a new vernacular vocabulary that reflects the different climate zones." (Delany, n.d.b)

Model-making in BIG is very important in terms of the design process (FMG Fabbrica Marmi e Graniti, 2019). Moreover, as the firm includes many people from different backgrounds everything gets questioned (Zumtobel, 2015).

Table 25: Relevant data coding and correlating by the use of the interviews

Effects of Nature and Nurture	**Facts Identified and Correlated**
Educational and Cultural Background	• Before studying architecture wanted to be a cartoonist. • People with different backgrounds, locating the right person to the right job. Culture is linked with the collective part and as it is common it can be observed within the people who belong to the same social class. The collective level includes the common one. (Gautam & Blessing, 2009).
Gender and Age	• The studies carried out reveal that there is not a correlation between creativity and the gender (Kaufmann, 2006)
Intuitive Actions	• Architects which he favoured Mies van der Rohe, Philip Johnson, Philip Johnson, Robert Venturi and Rem Koolhas are some of them (Inaba, 2013) • "For me, architecture is the means, not the end. It's a means of making different life forms possible."(Delany, n.d.)
Learned attitudes and Behaviours	• Mentioned technology had an impact on architecture, Fiction and reality can crossover now and new possibilities might give rise to more emotionally rich architectural edifices (Hakak et. al, 2014). These also Ingels' view about architecture.
Importance of Expertise	• Locating people according to their areas of expertise in order to have an effective collaborative environment.

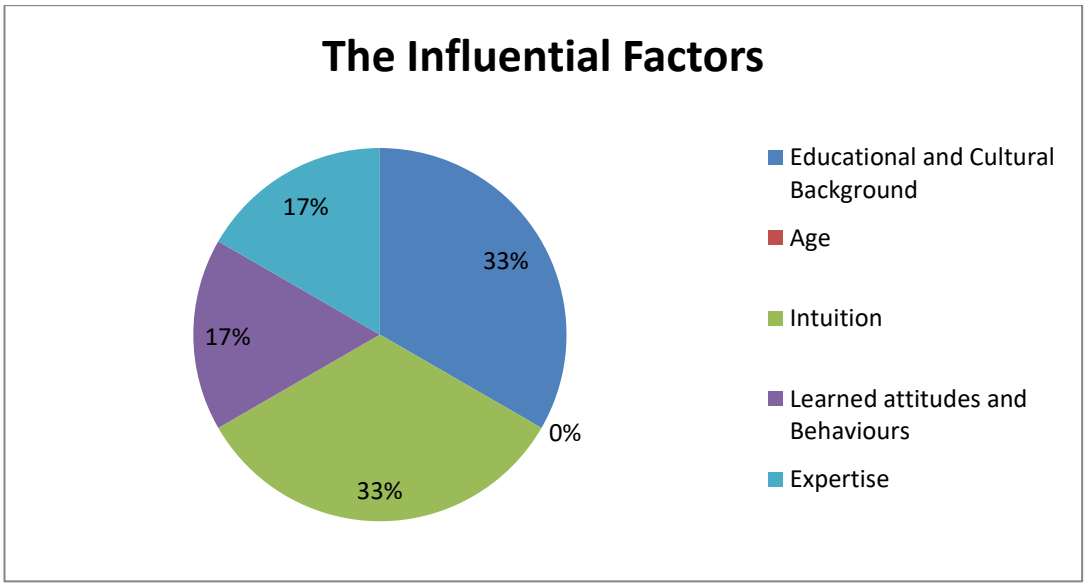
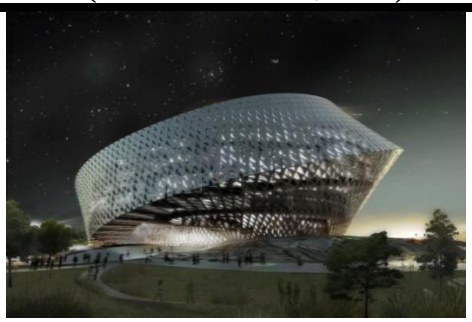


Figure 73: Presentation of factors derived from the table, developed by author

4.2.4.1 Astana National Library (-)

Table 26: Astana National Library, by author (based on Basulto, 2009)

Project: Astana National Library	
Location:	Astana, Kazakhstan
Year (Constructed):	Not constructed
Project Type:	Competition- International design competition for Kazakhstan's new National Library in Astana
Area:	33.000 m^2
Awards received:	Winner of the design competition

BIG won the international competition in 2009 which was dedicated to the National Library which was to be built in Kazakhstan, Astana (Basulto, 2009; Arslan Selçuk & Başkol, 2020). Unfortunately, this building could not be built because of conflicts (Wainwright, 2017).

Bjarke Ingels explained the design by these words;

> "the circle, the rotunda, the arch and the yurt are merged into the form of a Moebius strip. The clarity of the circle, the courtyard of the rotunda, the gateway of the arch and the soft silhouette of the yurt are combined to create a new national monument appearing local and universal, contemporary and timeless, unique and archetypal at the same time" (Basulto, 2009).

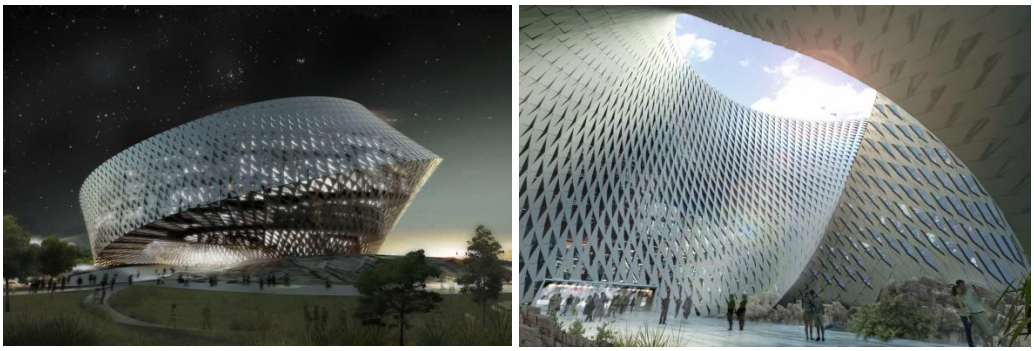


Figure 74: Astana National Library (Basulto, 2009)

BIG has a design attitude of concentrating on simulations. They used parametric modelling for forming a durable structure and the structure at the end becomes a design generated by the environmental conditions (Arslan Selçuk & Başkol, 2020). The analysis of the design both in conceptual and tectonics terms distinguish the significance of digital design (Arslan Selçuk & Başkol, 2020). The form depicts Möbius strip by the structures that are locked in to each other (Basulto, 2009).

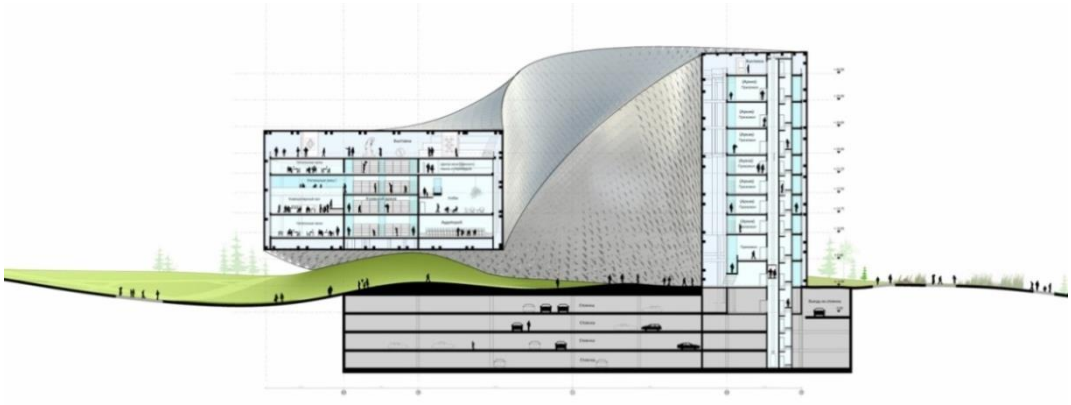


Figure 75: Section of Astana National Library (ANL), (Basulto, 2009)

The section in Figure 75 illustrates how form and function are linked to each other (Basulto, 2009). The horizontal part having the functional layout in a horizontal manner whereas the other part comes higher and narrower continues with a vertical arrangement (Figures 76 and 77).

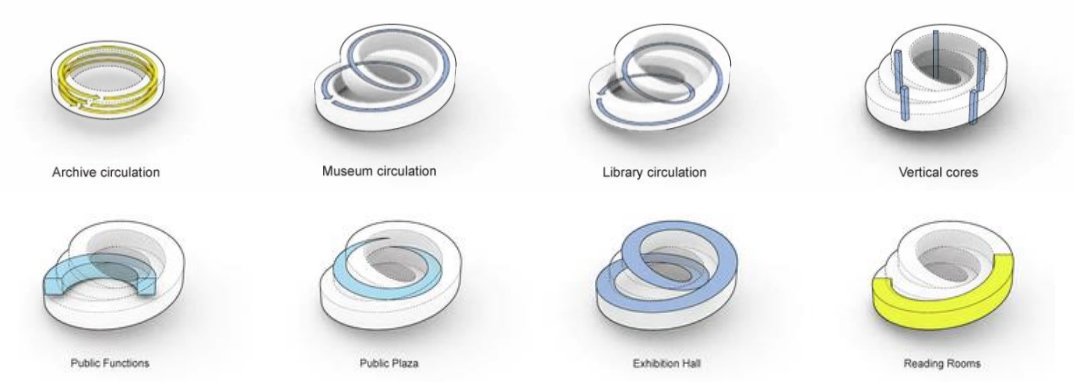


Figure 76: Circulation and functional arrangement of the library (Basulto, 2009)

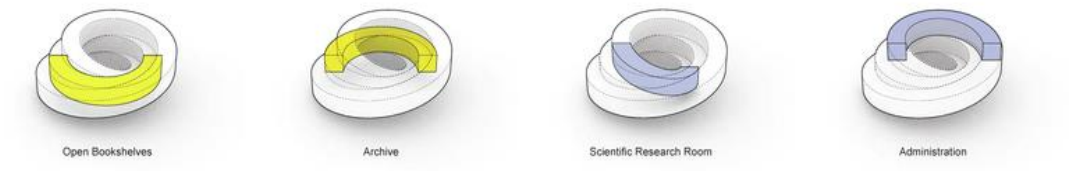


Figure 77: Functional arrangement of the library (Basulto, 2009)

A conceptual approach created in a computer environment. Parameters are defined and used effectively to form a topological relation (Arslan Selçuk & Başkol, 2020).

Astana National Library was not only important in architectural terms, however, as a symbol for the future of the nation. This issue has a historical background since Astana became the capital in 1997 as the nation was separated From the Soviet Union which occurred in 1991. The library will be not only a centre for cultural facilities or political representation but also it will be a base for the future (Branco, 2017).

By the information from Ramboll UK's engineers (see Branco, 2017) the software for the generation of this design was the Grasshopper plug-in which is for Rhino. It is mentioned that they were in need of using a program for their concept formation in 3D (Branco, 2017). With the help of digital tools, many subjects were generated such as; Non-Euclidean geometry, dynamic and kinetic space, robotics, performative, parametric and genetic algorithms (Arslan Selçuk & Başkol, 2020). According to the information the use of algorithm was influential in this design. The form is non-standard and the Mobius strip has folding in a continuous manner. The units become whole; the roof becomes a wall, the wall becomes a roof, Figures 74 and 75 show this situation. The parametric design enabled the calculation of solar exposure which will show its effect on the facade. This in turn showed its impact on the form and arrangement of material density (Arslan Selçuk & Başkol, 2020).

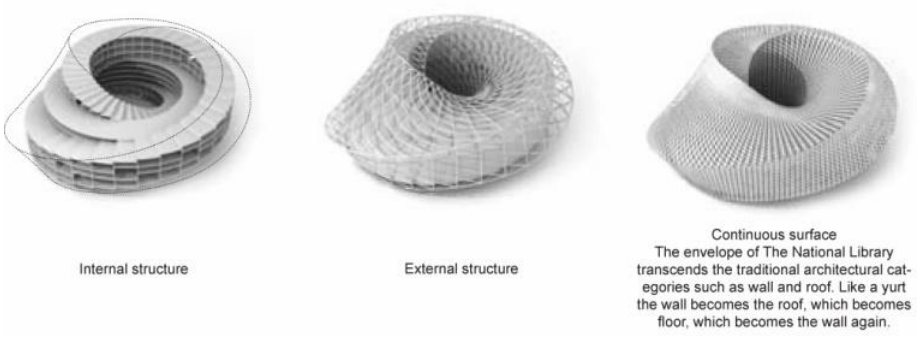


Figure 78: Structure development (Basulto, 2009)

Table 27: Phases which adopted the use of parametric design tools, by author

Astana National Library: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occurred
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	Would have used

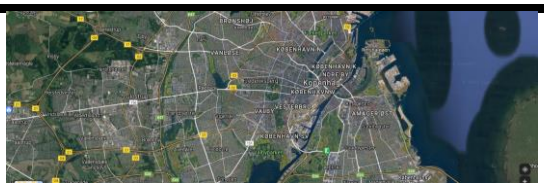
Table 28: Assessment, by author (based on Gero, 2014)

Novelty		**Usefulness**		**Aesthetics**	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

By the renderings, it illustrates well their philosophy behind the design. This project is not built, however, it can be understood how well integrated and a novel project it was.

4.2.4.2 Amager Bakke (Copenhill) (2019)

Table 29: Information of Copenhill, by author (based on Archello, n.d.;'Amager Bakke Waste-to-Energy Plant Rooftop Park by SLA – aasarchitecture', 2018)

Project: Amager Bakke (COPENHILL)	
Location: Copenhagen	 Source: URL 7
Year (Constructed):	2019
Project Type:	International Competition
Area:	16,000 m^2
Awards received:	3 A+ Awards The Popular Choice Award (Factories and Warehousres|Jury| Architecture, Photography and Video category) Winner for the year 2020 in architectural design (Design Educates Awards, 2020)

Amager Bakke is also known as CopenHill is an energy plant and location is in the industrial part of the city. However, the previous building was not only a plant that turns waste into energy it became a place for extreme sports activities which included; Rock climbing, go-kart racing, etc. The old one was an important landmark that was in need of being renewed. The new plant design aimed to strengthen its relationship with the city (Archello, n.d.). It establishes Amager Resource Center as an innovator on an urban scale, redefining the relationship between the waste plant and the city (Archello, n.d.).

The idea appeared by thinking as the Copenhagen is a cold place but there is no mountain in the close environment to ski (FMG Fabbrica Marmi e Graniti, 2019). About this project, Bjarke Ingels stated “change public perceptions of what a public utility should be” (Archello, n.d). BIG worked with Danish Landscape Architects SLA. They were especially responsible from the rooftop (Archello, n.d; ‘Amager Bakke Waste-to-Energy Plant Rooftop Park by SLA – aasarchitecture’, 2018). The communication of the work happened via a 3D model. The related professions had the chance to follow the necessities (Archello, n.d.). Bricks which made of aluminium cover the façade illustrated in Figure 79.

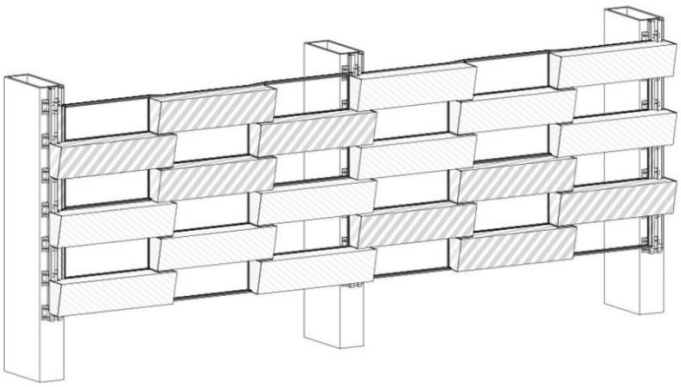


Figure 79: Panels of the building (Baldwin, 2020)

Figure 80: The green roof (Lynch, 2018)

Figure 81: Construction and completed view (Baldwin, 2020; Lynch, 2018)

Table 30: Phases which adopted the use of parametric design tools, by author

Amager Bakke (COPENHILL): The phases where the parametric design was advantageous	
Initial Idea:	The idea initiated by the existing environment
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Table 31: Assessment, by author (based on Gero, 2014)

Novelty		Usefulness		Aesthetics	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

It is a project which classified as the best design in 2020 by the declaration of the winner of the year (Design Educates Awards, 2020). The reason behind the awards mainly lies in the thought of intersecting the public of Copenhagen with the waste-to-energy plant (Baldwin, 2020).

4.2.5 Melike Altınışık

Firstly, Melike Altınışık was born in 1980, Turkey. She is the founder of MAA-Melike Altınısık Achitects. According to the official website of her firm, she is "an award-winning architect, designer and an educator". Moreover, it is mentioned that she is a determined person to develop an innovative approach towards architecture, urbanism and design (Hassanzadeh, 2020b; Mimmel, 2020).

She has been invited as a critic, guest lecturer, speaker and jury member. Some of the institutions she has been to are; "AA (Architectural Association, London), SAC (Staedelschule of Architecture, Frankfurt), LAU (Lebanese American University, Beirut), ITU (Istanbul Technical University) BU (Bilgi University, Istanbul). Melike Altınısık's designs awarded with many prestigious design awards such as; Europe 40 under 40, FEIDAD Design Award 07′ and Swiss Art Award (Hassanzadeh, 2020b; Mimmel, 2020). In one of her interviews, she had been asked to describe her journey from the beginning until MAA. Melike Altınısık mentioned that during the

presentations especially if there are students she underlines the importance of the four cornerstones in her life. The first one is Istanbul Technical University where she completed her undergraduate study in the field of Architecture and graduated as the first ranked student. Then she went to Architectural Association Design Research Laboratory (AADRL) for her postgraduate education while explaining her journey she highlights the fact that the renowned 'Star architects' had passed from its education. Zaha Hadid Architects (ZHA) was the office she started to work; she describes ZHA as a place that receives the best clients, the most creative people who work there, being at the centre of the knowledge. She felt that opening a new gate, to turn over a new leaf… She came back to Istanbul and had the urge to start something and create her own path with her own rights and faults. She ends the talk by stating how MAA's adventure had started (Kaya & Doğan, 2020).

"The academic study I have gained at London based AADRL (Architectural Association Design Research Lab) helped me to learn how to use this principle in practice" (Doshi, 2020). Melike Altınışık stated that she learned to say 'we' in ZHA, this means to be a team. Being a team not because of any obligation but making it a part of production is a nice element. She mentioned these were the fundamental blocks for her while starting the MAA (Kaya, & Doğan, 2020b). Melike Altınışık explains her design processes as when a new project has been received or a competition an understanding should be developed for a balance between the needs of the clients and users. She mentions the importance of research during the interview; "Research is the key point, research related with existing projects." Each project brings a new problem (Parametric-Architecture, 2020).

According to her clients usually prefer them because of their visionary and innovative approach.

> "I have been always interested in architectural technology and engineering and nature. How to combine these has been always in the centre of my interest." And "I could describe myself as a curious person in general who is obsessed with nature, technology, and architectural thinking. My style sits where nature, architecture, and technology intersect each other. The ultimate goal here is to create a dialogue between them" (Doshi, 2020; Parametric-Architecture, 2020).

> "Architecture and Design is my lifestyle cannot separate my personal life from my career. I continue thinking, designing, sketching in my private life as well because they will blended together and I don't think that its architecture is not only about building itself. When your lifestyle and the way how you also lets say even read something or lets say even the way how you cook like all together you can use your creativity (Parametric-Architecture, 2020).

Table 32: Relevant data coding and correlating by the use of the interviews

Effects of Nature and Nurture	**Facts Identified and Correlated**
Educational and Cultural Background	• AADRL, ZHA affected her innovative and collaborative approach (Kaya & Doğan, 2020) • Each person in MAA has a certain skill that complements each other • Interested in; engineering part, architectural technology and nature (curiosity) (Parametric-Architecture, 2020). • ITU and AADRL were mentioned as a cornerstone by her explanations (Kaya & Doğan, 2020)
Gender and Age	• The studies carried out reveal that there is not a correlation between creativity and gender (Kaufmann, 2006)
Intuitive Actions	• Interested in painting and drawing (Parametric-Architecture, 2020) • Sketches (Parametric-Architecture, 2020)

Intuitive Actions	• Interest in certain fields fuels related intuitive actions • Influential people for her; Oscar Niemeyer, Frei Otto and Christopher Alexander are some of them (Parametric-Architecture, 2020)
Learned attitudes and Behaviours	• Interested in painting and drawing • MAA use technological advancements • Besides traditional sketching afterwards uses parametric software • Mentions architecture is her lifestyle by means of certain actions • "Urge" (Kaya & Doğan, 2020). highlights the motivation she feels • Importance of research
Importance of Expertise	• Always mentioned AARDL and ZHA were important places for her to learn (Kaya & Doğan, 2020)

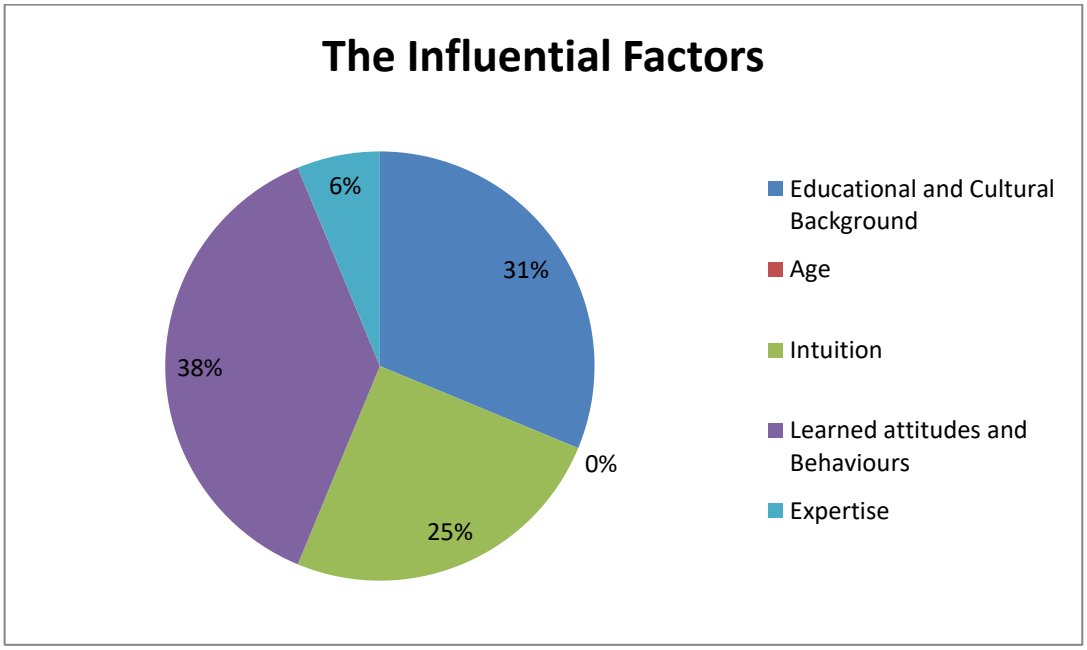


Figure 82: Presentation of factors derived from the table, by author

4.2.5.1 Robot Science Museum (expected in 2022)

Table 33: Information of Robot Science Museum, by author (based on Walsh, 2019)

Project: Robot Science Museum	
Location: Seoul, South Korea	 Source: URL 8
Year (Constructed):	To be completed in 2022
Project Type:	Competition- an international competition for the Robot Science Museum by Seoul
Area:	6500m^2
Awards received:	Winner of competition

MAA (Melike Altınışık Architects) became the winner of the Robot Science Museum competition. The construction is expected to be finished in the year 2022. The project will take place in South Korea, Seoul. The main theme of the museum is to provide education on robotics also to promote robots for the public interest (Walsh, 2019).

The design approach is shaped by the main principles of robotics, which are; "technology, science and innovation" (Walsh, 2019). Therefore, it was aimed to use fabrication technology and robotic construction for such an innovative project. The metal façade of the museum was to be constructed by robots, BIM is going to be used for directing to assemble. Another group of robots will be responsible for the 3D printing of the concrete materials. Thus, robots will take place in construction, service and exhibition (Walsh, 2019; Block, 2019). The museum will house the latest technological facilities for instance; robotic technologies, AI, VR, AR and holograms will be a part (Walsh, 2019) (Figure 84).

Melike Altınışık explained Robotic Science Museum by these words;

> "The new Robot Science Museum (RSM) which plays a catalytic role in advancing and promoting science, technology, and innovation throughout society is not only going to exhibit robots but actually from design, manufacturing to construction and services robots will be in charge. In other words, RSM will start its 'first exhibition' with 'its own construction' by robots on site" (Walsh, 2019).

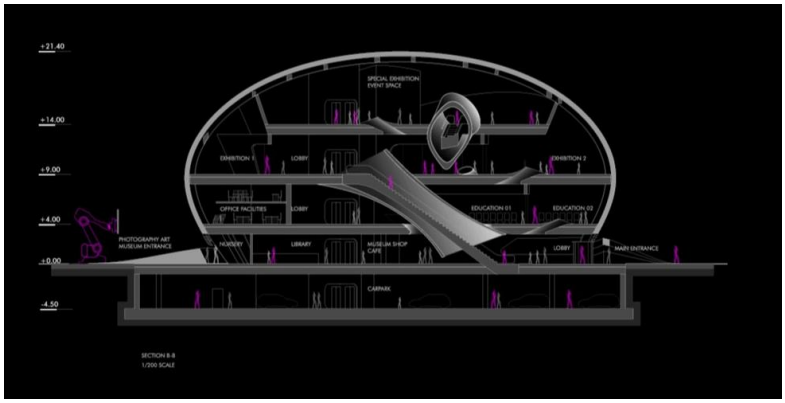


Figure 83: Section of the museum (Walsh, 2019)

Figure 84: Interior of the museum (Walsh, 2019)

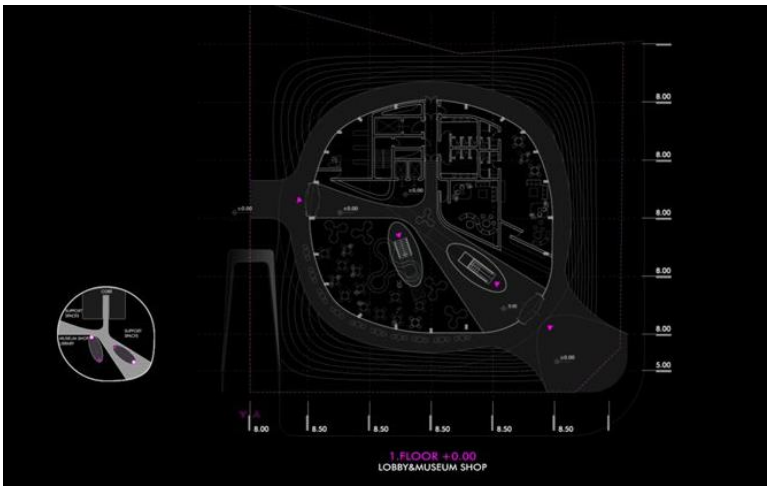


Figure 85: Plan of the museum (Walsh, 2019)

“The main design character of the museum to create its own universe for the robots and their visitors, a sphere-like non-directional, fluid, and natural form is preferred instead of rigid geometry and orthogonal forms” (Doshi, 2020). Melike Altınışık mentioned the importance of BIM by explaining that they will develop it for the definition of the construction methodology. The idea is to allow the interchange of information during the construction process in between the BIM system and the robots also the architecture model (Doshi, 2020).

Table 34: Phases which adopted the use of parametric design tools, by author

Robot Science Museum: The phases where the parametric design was advantageous	
Initial Idea:	Idea generation by competition theme
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Table 35: Assessment by author (based on Gero, 2014)

Novelty		**Usefulness**		**Aesthetics**	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

The conceptual idea behind the design was innovative from the beginning. According to the renders and drawings, this project is rich in terms of the expression of the idea.

4.2.5.2 Istanbul Camlica TV and Radio Tower (2020)

Table 36: Information of Istanbul Camlica TV and Radio Tower, by author (based on Ranjit, 2021)

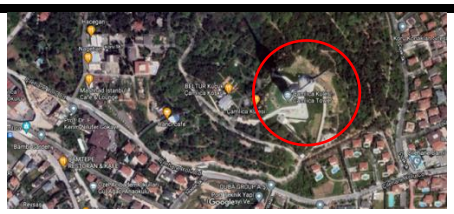
Project: Istanbul Camlica TV and Radio Tower	
Location: Istanbul, Turkey	 Source: URL 9
Year (Constructed):	2020
Project Type:	Competition- Telecommunications Tower for the Ministry of Transportation and Communication
Area:	29000m^2
Awards received:	Competition Winner

Figure 86: During the construction phase (Block, 2019b)

The tower's height is about 369 meters and the architect said that this project was not only complex by its design process but the technical part is also complex (Block, 2019b). For the construction of the tower "Liftin-Up" is designed and a total of eight stages of the lifting-up process is programmed (Figure 86) (Doshi, 2020b).

Figure 87: The pattern derived from environmental analysis (Shah, 2021)

The environmental data were analysed by the studio such as the wind patterns (Figure 87) to be ensured about the stability also in terms of aesthetic as well. From each angle, different points can be observed which gives the effect of motion (Shah, 2021). Figure 88 represents the interior shares the same characteristics as the exterior a similar motion effect is achieved (Shah, 2021).

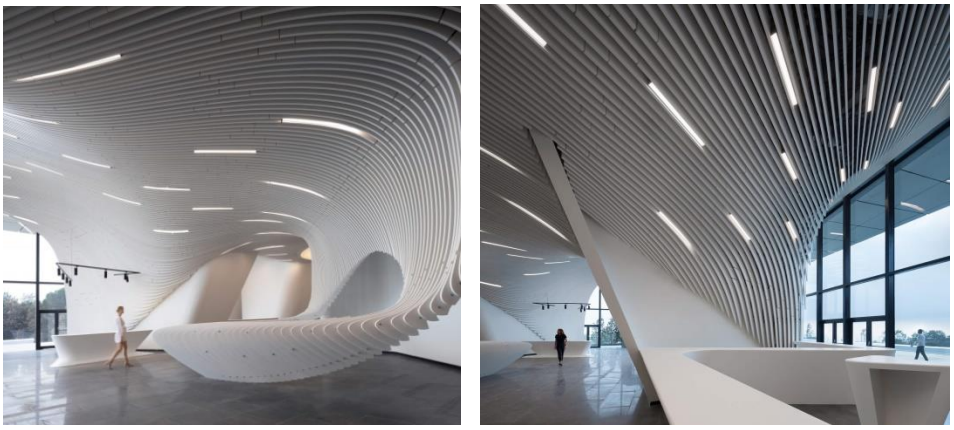


Figure 88: Interior of the tower (Shah, 2021)

Table 37: Phases which adopted use of parametric design tools, by author

Istanbul Camlica TV and Radio Tower: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occurred
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Table 38: Assessment, by author (based on Gero, 2014)

Novelty		**Usefulness**		**Aesthetics**	
Originality	✓	Technical Quality	✓	Attractiveness	✓
Innovation	✓	Functional Quality	✓	Expressiveness	✓
		Integration Capacity	✓	Complexity	✓

The parametric design expressed the ideology behind the idea in terms of aesthetics. Novelty by innovation by radical engineering also “frozen sound waves” (Shah, 2021) is unique. In addition, the creation of public spaces is integrated with a high level of technical and functional quality. A unique engineering system searched to be able to construct the structure successfully (Parametric-Architecture, 2020). Moreover, Melike Altınışık mentioned by the BIM model many disciplines were able to work together. Also, MAA used coding to make the model’s façade change by itself according to the changed parameters (Bursa MimarTV, 2020).

The parametric approach has many benefits for the generation of alternatives, time management, budget calculations and many more. In addition, some of the cases revealed that even it has the potential to affect the aesthetic of design by adopting different techniques such as in Çamlıca Tower the environmental data was used for the façade generation. On the other hand, these kinds of ideas do not generate just by software individuals are the ones who think and try to seek a solution but it is certain that some of the projects would not be constructed without the digital tools, therefore, an expression of a creative idea is linked with this technology.

4.3 Comparison of Findings

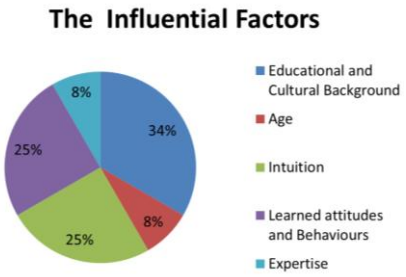


Figure 89: Frank Gehry's analysis by percentage

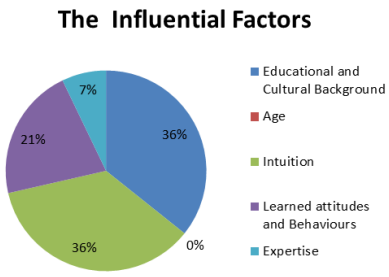


Figure 90: Jean Nouvel's analysis by percentage

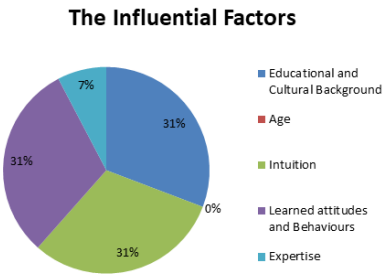


Figure 91: Zaha Hadid's analysis by percentage

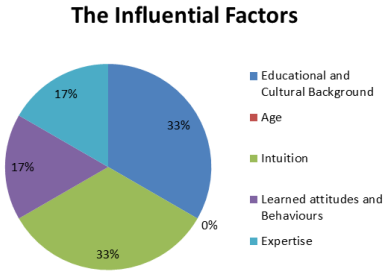


Figure 92: Bjarke Ingel's analysis by percentage

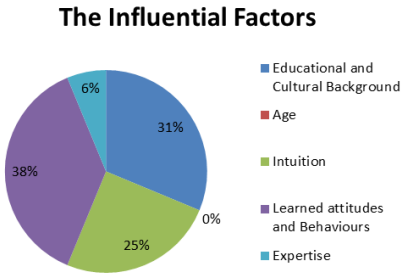


Figure 93: Melike Altınışık's analysis by percentage

Table 39: Comparison of projects' phases which adopted the use of parametric design tools, by author

Guggenheim Museum, Bilbao: The phases where the parametric design was advantageous	
Initial Idea:	Conventional methods
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Fondation Louis Vuitton: The phases where the parametric design was advantageous	
Initial Idea:	Conventional methods
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Louvre, Abu Dhabi: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occured
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

National Museum of Qatar: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occured
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Heydar Aliyev Centre: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration from the past
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

London Aquatics Centre: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occured
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Astana National Library: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occurred
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	Would have used

Amager Bakke (COPENHILL): The phases where the parametric design was advantageous	
Initial Idea:	The idea initiated by the existing environment
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Robot Science Museum: The phases where the parametric design was advantageous	
Initial Idea:	Idea generation by competition theme
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Istanbul Camlica TV and Radio Tower: The phases where the parametric design was advantageous	
Initial Idea:	Inspiration occurred
Design Utilization (complex form):	✓
Structural Analysis:	✓
Manufacture:	✓

Figures 89, 90, 91, 92 and 93 show that the most abundant factors observed are background, intuition and learned behaviours. It has been referred to in Chapters 2 and 3 how these factors are correlated with each other. Therefore, the close percentages of intuition, learned behaviours, cultural and educational background supported the theoretical background. As Table 39 illustrates initial idea generation occurred by traditional methods and inspiration whereas later stages benefited the

parametric design tools. This suggests that the starting points can be different in terms of initial idea generation as each project changes, however, they are similar in terms of the techniques used.

Chapter 5

CONCLUSION

The research revealed the uniqueness of each people and how an individual is affected by multiple factors and continues to be affected by nurturing creative skills. According to the necessities of the 21st century, it is essential to follow the technological developments. Parametric design is a notion which rises. However, parametric design techniques are not new in architecture architects like; Gaudi was using the parametric thinking methodology in an analogous manner such as; "string length, anchor point location, birdshot weight" (Peteinarelis & Yiannoudes, n.d.) Additionally, how an architectural edifice can appear without considering the parameters?

By the appearance of CAD-CAM products, analogous parametric thinking turned to digital. The main questions were; 'What are the factors affecting creativity?' and 'How does parametric design affect the creative product and the creative person?' In respect of these questions through the content analysis of the architects' thoughts which they mentioned in interviews their ideology and attitudes towards a design were analysed to be able to understand their creative mind relation with parametric design advancements. Moreover, the 4P model by Rhodes (1961) (Abraham, 2015) was applied as qualitative data to observe which of the factors were the most influential for a creative human being. In addition, the case studies analysed by the role of parametric design during their design phases. Technological developments

embraced from the oldest to the youngest architects. Most of the architects thought and think without the digital design methods it would not be possible to see most of the buildings which they designed. Parametric design methods are correlated with the increase of creative products and thinking but as most of the architects stated it is just a tool for the architects.

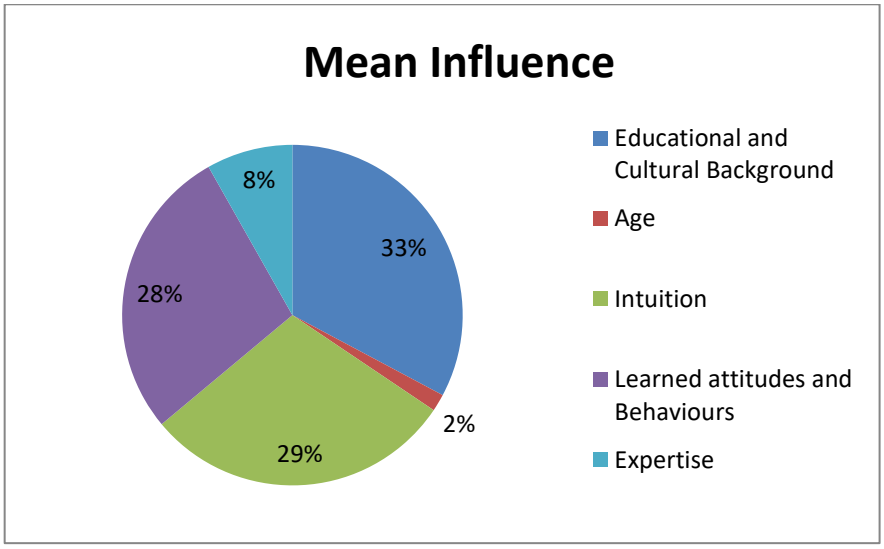


Figure 94: Mean calculation of all the factors, by author

Figure 94 shows the greatest impact among them is due to educational and cultural background. Intuitive actions, learned attitudes and behaviours are the factors that have a high influence as well. Age was the least influential factor and expertise was the moderate one. The parametric design falls in the main part of the nurture of the skills which can be categorised as learned attitudes and behaviours. A high correlation rate of learned attitudes also gives the idea that parametric design is also influential. It is categorised by other sub-categories as expertise, intuition and educational background, however, all of these categories can be enhanced after learning. Through the process, it can affect their creative behaviour. The analysis shows that the age generally was not the most influential aspect from their point of

view, however, again through the analysis it is clear that by younger generations the interaction with the parametric tools by themselves became more abundant. Besides, as Figure 94 illustrates a person's background; it is the most influential fact as it is a large subject that encompasses many variables such as thinking manner, consciousness, etc.

The 4P model (Table 40) consists of four factors person, process, product and press. They are all connected to each other as a person needs to pass through the process to produce an original product also the environment which is referred to as press, affects the process.

Table 40: Representation of the factors 4P model, by author (based on Abraham, 2015)

Person	Educational and Cultural Background, Intuition, Expertise
Press	Educational and Cultural Background, Attitudes and Behaviours
Process	Sketch, Parametric tools, Models, Analysis, Brain-storm, Verbal expressions (Intuitive and Learned actions)
Product	According to the table which had the standards of CAT it is creative

In conclusion, as Table 40 and Figure 94 represent the parametric design supports creative design outcomes, however, the creativeness of the idea comes from the architect. Parametric design tools can only be the creative supporters of the main creativity within a person. Parametric design has the potential to nurture creative skills via parametric design environment but it is more effective in terms of manufacturing, structural analysis, cost and time efficiency and more. Parametric design is a successful way to express creative ideas. However, the creative ideas do

not come from the software it occurs with many parameters as listed in Table 40. The parametric design approach is just a parameter of the creative design to be able to express and implement the creative idea.

Future studies could be conducted in a manner to study each factor separately. Moreover, the number of architects could be increased and implementing a detailed analysis of the subject has the potential to benefit the architectural education system.

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