SKETCH AS THE AGENT OF THE “CREATIVE GENIUS” PARADIGM “DEATH OF DRAWING” DEBATE IN THE FRAMEWORK OF THE NEW DIGITAL SKETCHING TECHNOLOGIES

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SKETCH AS THE AGENT OF THE "CREATIVE GENIUS" PARADIGM DEATH OF DRAWING DISCUSSIONS IN THE FRAMEWORK OF THE NEW DIGITAL SKETCHING TECHNOLOGIES

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ABSTRACT

SKETCH AS THE AGENT OF THE "CREATIVE GENIUS" PARADIGM DEATH OF DRAWING DISCUSSIONS IN THE FRAMEWORK OF THE NEW DIGITAL SKETCHING TECHNOLOGIES

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Sketching as the first step in architectural design is explored in this study in the light of the digital invasion to the realm of architecture. The question of whether freehand sketching is dead or going through a revival is studied along with researching new definitions of "sketching" and "drawing", in addition, contemporary digital tools and methods of sketch production are explored. The main scope is concerned with the analysis of the digital technologies regarding its capacity in facilitating the sketching process, starting from the 1960s until today, and that includes digital cameras, computers and digital tablets. After the analysis of the discussions on this issue in the academic and professional publications, this thesis aims to understand the current state of affairs regarding the usage of the digital sketching technologies in the production of architecture with an empirical research. A survey is prepared to understand digital sketching production in architectural offices in Ankara and the most commonly used programs and applications accordingly, to elaborate on the architects' evaluations and expectations of this medium. Thoughts and debates regarding digital sketching production are discussed and a conclusion is driven as a result.

Keywords: freehand sketching, manual, digital, computer, creativity

ÖZ

"YARATICI DAHİ" PARADİGMASI OLARAK ESKİZ YENİ DİJİTAL ESKİZ TEKNOLOJİLERİ ÇERÇEVESİNDE ÇİZİM ÖLÜMÜ TARTIŞMALARI

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Bu çalışmada, mimarlık üretiminin en temel adımlarından olan eskiz yapımı, günümüzdeki mimarlık üzerinde dijital akının ışığı altında ele alınmıştır. Serbest el çizim döneminin sona ermiş olması veya yeniden canlaması sorusu üzerinde çalışılır iken, "eskiz" ve "çizim" terimlerinin çağdaş tanımları araştırılmıştır, bununla beraber, eskiz yapımındaki yeni dijital araç ve metodlar irdelenmiştir. Bu çalışmada eskiz aşamasının kolaylaştırılması amaçlı geliştirilmiş olan teknolojik araçlar tartışılmıştır. Çalışmanın zaman çizelgesi 1960'lı yıllardan başlayıp günümüze uzanmakta olup, dijital kameraları, bilgisayarları ve dijital tabletleri kapsamaktadır. Tartışmalar ve analizler akademik ve profesyonel yayınlar alanlarda sunulur iken, bu çalışma mimarlık üretimindeki dijital eskiz teknolojilerinde gelinen noktayı ampirik araştıma yöntemi ile anlamayı hedeflemektedir. Ankara'daki mimarlık ofislerinin dijital eskiz üretimi hakkında bir anket hazırlanmıştır, bu anket yolu ile en çok tercih edilen araçlar, program ve uygulamalar tesbit edilip, mimarların bu konudaki değerlendirme ve beklentileri anlatılmıştır. Dijital imaj üretimi konusundaki düşünce ve tartışmalar yolu ile çıkan sonuç bölümü ile bu çalışma sonlanmaktadır.

Anahtar Kelimeler: serbest el eskizi, manuel, dijital, bilgisayar, yaratıcılık

To Baghdad, Ankara and Vienna

Places I lived, loved and sketched..

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CHAPTER 1

INTRODUCTION

This study aims at covering the scope of creative architectural design production by means of sketching methods under the reign of digital tools. No two architects disagree that sketching has the power of symbolizing a personal signature or a pattern of creativity associated with designers in general, and architects in particular, in other words, an agent of the "creative genius" paradigm. However, as it is not possible to discuss sketching in the realm of architecture nowadays without questioning the impact of the digital invasion to every aspect of everyday life including architectural practice, the study discusses architectural freehand sketching in the framework of two contradictory positions; whether technology led to the "**death**" of sketches and hand drawings, as architect David Ross Scheer suggests in his book[1], or on the contrary, hand drawings are witnessing a "**renaissance**"[2] via technological means as landscape architect Dr. James Richards is promoting. To put differently, the study investigates how various digital tools such as the mouse and monitor, the digital pen and tablet PC[3], and the digital camera, can affect sketching process during the early design phase. This affect can take the form of either a complete elimination of the traditional role of the pen and paper, hence, leading to the "death" of freehand sketching by turning this creative personal touch into a drawing devoid of feelings, or it can take a secondary role leading to enforcing the position sketching plays in producing, personalizing, and sharing the architectural

[1] Scheer, D. R. (2014). *The Death of Drawing: Architecture in the Age of Simulation*. Routledge, Abingdon, UK

[2] Richards, J. (2011). *Freehand Renaissance: Concept Sketching for a Digital Age*. ASLA 2011 Annual Meeting and Expo. San Diego, California

[3] PC stands for personal computers.

concepts, which can lead to a revival in the sketching practice. Finnish architect and Professor Juhani Pallasmaa remarks:

> "[A]t the same time that we acknowledge the benefits of the computer and associated digital technologies, we need to identify the ways in which they differ from previous instruments of design. We must consider the limitations and problems that they may pose, for instance, in the mental and sensuous aspects of the work of the architect."[4]

1.1 Problem Definition

The argument raised by this study regarding the early phases of design is that the involvement of the computer as the **primary** sketching and drawing tool is a problematic issue. This involvement can take two forms; first, a direct form concerning the "tool" in which the pencil is simply replaced with the mouse, consequently leading to the loss of the architect's personal signature touch brought by freehand sketching, and second, an indirect form concerning the "outcome", where the restriction of certain software knowledge and computer skills leads the architect to settle with specific geometries. Both ways will only lead to limiting the boundaries of creative design production which will be broadly discussed throughout this study.

1.2 Aim of the Thesis

Advanced technology nowadays provides possibilities to produce freehand sketches in a variety of methods; three-dimensional or two-dimensional, and precise or free of measurements, in addition to the ability to animate, archive, or share the sketched material in a click of a button. As a result, this study aims **first** at forming a new definition of "sketching" in the framework of the current-day digital advancements; a definition that covers all forms of "sketching" regardless of the

[4] Pallasmaa, J. (2009). *The Thinking Hand: Existential and Embodied Wisdom in Architecture*. AD Primers. John Wiley & Sons Ltd. UK. p. 95

means or the final products. **Second**, it investigates ways to eliminate the tension between the paper and the screen by searching for middle-ground solutions offered by today's tablet PC technology which can lead to raising the levels of creative thinking. **Third**, it attempts at setting a guideline for architecture students and professional practitioners who tend to improve their sketching skills paralleled with the knowledge of the technological developments in the field; this guideline is formed by sharing expert architects opinions about traditional and digital tools of sketching, which is meant to raise an awareness regarding the limitations and the advantages of each sketching tool. This study does not aim, however, at advocating for a certain form of architectural representation over the others as much as it aims at investigating the methods that best serve creative architectural design interests in a digitalized world.

1.3 Significance and Boundary of the Thesis

This area of research concerning computer influence on freehand sketching is not new, and has been handled among architects and academicians for more than half a century. While this study sheds light on the discussions trying to diagnose the problems associated with the digital involvement in design; it looks for solutions that rely on today's contemporary technology of digital pens and tablet PCs, although these tools are, again, not new and have been available even before the emergence of personal computers, however, it has been obvious that only recently these digital pens succeeded in mimicking their traditional peers, which raised a necessity to reconsidering the subject.

This reconsideration is concerned with the discussions among experts in the fields of architecture and computer science. Other relevant experts' thoughts, such as neuroscientists and psychologists, have not been within the main focus. While this study presents world-wide opinions in the field, it regards the sketching practices of Turkish architects and compares the digital impact on their sketching with examples from other countries to better understand Turkey's current state of affairs regarding

the matter. The emphasis will be made more about sketching in professional practice rather than in architectural education on the grounds that students still have the freedom to present their projects fully drawn by hand, unlike professional architectural design studios where computers became inevitable tools of representation.

1.4 Methodology and Structure of the Thesis

The methodology of the thesis is a critical evaluation of primary research data collected through personal communications, interviews, and surveys, in addition to the secondary research data collected through literature (books, academic publications, and websites). In certain very recent topics, especially within the last couple of years, web references have been cited more frequently to compensate for the lack of related academic publications. As for the structure of the thesis; after the introduction to the thesis in **chapter 1**, the study will start in **chapter 2** with theoretical discussions of architectural sketching in the digital age; an overview that will cover the "new" definition of sketching, its functions and types and lastly, where does it stand in today's architectural education. **Chapter 3** will go over a brief history of the technological tools that influenced the architectural design process, focusing on their impact on both the traditional tools and the way of thinking. As for the timeline covered by the chapter, the range of the last six decades will be elaborated starting from the 1960s with the invention of the *Sketchpad*, followed by the introduction of personal computers and digital cameras and their widespread use in offices and households accompanied by the developments of a variety of sketching programs, until today when digital means of production became almost unavoidable. While theoretical discussions take place in each chapter, **chapter 4** will be about sketching in the practical field; opinions of a selection of both international as well as Ankara-based architects who run their own practices will be explored and a survey regarding their sketch habits will be explained to note whether digital tools play any role in enforcing/weakening their sketching production in the early stages of design. **Chapter 5** will summarize the final conclusions of the study.

CHAPTER 2

ARCHITECTURAL SKETCHING IN THE DIGITAL AGE: AN OVERVIEW

Throughout over half a millennium in the history of the profession ever since the Renaissance[5], freehand sketching stood for the milestone of the architectural design production; it represented the first step towards bridging the gap between imagination and reality. Thoughts needed to be transformed into a communicable form, and sketching was one of the most intuitive methods to do so. When it comes to the relation between these two processes (thinking and sketching); architect and Professor Dr. Aydan Balamir makes a distinction such that sketching (an outcome of a "hand-eye-brain" coordination) yields into two activities; "thinking via drawing" or "drawing via thinking"[6]. Although seemingly interchangeable, they, in fact, bear differences as Balamir elaborates. She quotes Professor Dr. Necati İnceoğlu that sketches mostly take the form of graphic soliloquy; a conversation in which statements and words are translated into lines. "Thinking via drawing" resembles thinking via mumbling. The process of "thinking via drawing" is about the exploration of images that are not yet formed in the imagination and are meant to appear on the surface through sketching. The opposite of this process; "drawing via thinking" is likewise possible. This time, an image that is already formed in the imagination (whether finite or blurred) is to be transferred to a visual medium and further developed via sketching. Another possible interpretation for the second term

[5] Goldschmidt G. (2017). *Manual Sketching: Why Is It Still Relevant?* In Ammon, S. and Capdevila-Werning, R. (Eds.) (2017). *The Active Image: Architecture and Engineering in the Age of Modeling*. Springer International Publishing. Switzerland. p. 86

[6] These expressions are implemented by Professor Dr. Necati İnceoğlu as his book title: İnceoğlu, N. (2012). *Eskizler: Çizerek Düşünme Düşünerek Çizme (Sketches: Thinking via Drawing, Drawing via Thinking)*. Istanbul, Nemli Yayıncılık.

is “drawing the thought”. In fact, both of “drawing via thinking” and “drawing the thought” must be considered variations of “thinking via drawing”.[7]

Apart from these variations of the activity regarding “thinking via drawing” or “drawing via thinking”, another “different” activity is also a matter of discussion. Balamir explains that while “thinking via drawing” and “drawing via thinking” are two very natural activities, the opposite “drawing without thinking” is very well likely. This term as Balamir indicates, applying for a sketch done without much thinking, whether created by hand or an advanced computer program, and apart from its seemingly negative meaning, explains one other way of search; a tool for the subconscious mind to open up to the outer world; an automation that is based on coincidence. Computers hold infinite potentiality for this creative coincidental production, and these potentialities, however, are accompanied with negative aspects on the long run[8]. Architect Peter Cook argues that “the ideal way in which an architect can approach the act of drawing is to be unaware that he is actually doing it at all” as drawing is a “spontaneous” way of summarizing instant intentions[9]. This argument can be linked to the processes of “thinking via drawing” and “drawing via thinking”, but not “drawing without thinking”, since “summarizing the instant intentions” suggests the existence of traces of thought. In the case of “drawing without thinking”, architect Edward Cullinan sees the activity in its negative sense and does not believe it is possible to create sketches and derive design solutions without thinking:

> “Some people who are struggling to become architects push pens and pencils up and down the page desperately looking for a solution, hoping that the

[7] Balamir, A. (2012). *Mimarlıkta Çizerek Düşünme, Düşünerek Çizme, Düşünmeden Çizme (Thinking by Drawing, Drawing by Thinking, Drawing without Thinking).* Introductory chapter in: İnceoğlu, N. (2012). *Eskizler: Çizerek Düşünme, Düşünerek Çizme (Sketches: Thinking via Drawing, Drawing via Thinking).* Istanbul, Nemli Yayıncılık. pp. 6-11

[8] *Ibid*.

[9] Cook, P., Sr. (2008). *Drawing: The Motive Force of Architecture*. (1st Ed.). AD Primers. John Wiley & Sons Ltd. UK.. p 9

> drawing will produce the solution or the concept. But it never does... I think that one person or a group of people working together have to have an energetic concept of what it is, that are trying to make in their heads or their imaginations, and that drawings are then, as it were, a test of the concept."[10]

It is important to emphasize that while the ability to sketch and the ability to think and design are two separate, yet, interrelated skills that require enormous amount of practicing; practicing one of them may not guarantee the development of the other in the same speed by default but still forms a crucial asset for the sketcher/ designer. Pallasmaa notes that Santiago Ramon y Cajal, the father of modern neurobiology, persisted that his students must take watercolor sketching lessons assuring that "[i]t is not without reason that all great observers are skillful in sketching"[11]. This statement can be understood as such that practicing sketching leads to enhancing observation skills not only for architects or design oriented disciplines, but for all the fields requiring creative thinking and high skills for problem solving.

Since designers are required to develop their own form of non-verbal communication based on translating brain thoughts into drawings; the development of CAD[12] and BIM[13] software aimed at simplifying the connection between the brain and the hand, if any, by enabling to skip "freehand" sketching phase on paper and expedite the working drawings production. It is possible to witness architectural practices nowadays starting design creation directly on the screen, however, Italian architect Paolo Belardi quotes from architect and Professor Fernando Tavora that it is not possible to sketch in computers for those who cannot sketch on paper to begin with: "Only if you're able to draw in a traditional way you can also properly draw

[10] Robbins, E. (1994). *Why Architects Draw.* Cambridge, Ma: The MIT Press. p.58

[11] Pallasmaa, J. (2009). *Op. Cit*. p. 90

[12] CAD mostly stands for Computer Aided Design. The term also expands to Computer Aided Drawing and Computer Aided Drafting.

[13] BIM: Building Information modeling; a form of modeling based on fully erecting buildings in the virtual world in addition to calculating the estimated cost and construction duration.

using a computer"[14]. In other words, those who can mumble on the screen with a plastic mouse are only those who can mumble using pen and paper.

Today the new smart technologies both in hardware and software is promising potentiality to bring back freehand sketching to architecture by encouraging the use of pens rather than plastic mice in the early stages of designing. "Bringing back" here does not indicate that sketching ever left architectural practice in the first place but rather it is an implication of a decrease in use. However, Professor of English and Art History William J. T. Mitchell[15] states that drawing not only never left architecture, but today, it is taking an even more powerful stand:

> "Architecture in its most archaic imaging was always more about drawing than building, and this drawing was from the first "digital" in both senses of the word—i. e., a question of the fingers, of counting and measuring, and of a binary operation that divides the light from the darkness, inside from outside, the one from the zero. Even though everyone now claims (prematurely, in my view) to know that painting is dead, drawing has clearly never been more virulently alive, penetrating every aspect of the production of real spaces"[16].

Gabriela Goldschmidt, architect and author of "*Linkography: Unfolding the Design Process*", assumes that the recent possibility to replace the pen and paper (though not yet perfect) is gradually narrowing the gap between manual and digital sketching. This situation is leading many designers towards a form of "paperless" architecture, which in return alerts those intrigued by freehand sketching into debates regarding whether manual sketching is indispensable for architects, or on the other

[14] Belardi, P. (2014). *Why Architects Still Draw*. (Z. Nowac, Trans.). Cambridge, MA: MIT Press. pp.36-37

[15] William J. T. Mitchell has numerous publications on media theory and visual culture. Not to be confused with architect William J. Mitchell the former dean of MIT's School of Architecture and Planning whose texts are also quoted in this study.

[16] Mitchell, W. J. T. (2007). *Back to the Drawing Board: Architecture, Sculpture, and the Digital image.* In: The Beat & the Impossible. Architecture and the digitate BM, University of the Bauhaus. Weimar. pp.13-20

hand, it is possible (and probably necessary) to replace it with the digital[17]. Goldschmidt herself, while supporting computational design, her argument is in favor of manual sketching in the "front edge conceptual search phase" which does not contradict the implementation of the digital tools later[18].

Peter Cook argues that drawing is not just a tool but an "extension of one's head"[19], for this reason, it could turn into a very powerful tool as in the example Belardi explains of Italian High Renaissance[20] artist Michelangelo, who demanded his sketches to be destroyed after his passing. A possible reason is that Michelangelo worried his sketches would get misinterpreted and thus generate different concepts he would not have approved has he still been alive:

> "Michelangelo Buonarroti ordered the destruction of all of his preparatory drawings after his death, demonstrating with great intellectual honesty the temporary (and therefore private) nature of sketching: not just the quick draft of a well-defined thought, but rather the more effective representation of the draft of thought. Sketching, both because of its small dimensions and indeterminacy on paper as well as its independence from any code, is able to continuously regenerate itself, always offering new suggestions- sometimes ones that prove surprising even to their author."[21]

If smart technology holds promises towards encouraging the use of pen-like tools, it would be crucially important for the users to be aware of the differences as mentioned earlier. For example, in the previous quote, some of the terms Belardi

[17] Goldschmidt is referring here to a 2012 symposium held by Professors Victor Argan and George Knight at Yale School of Architecture entitled "*Is Drawing Dead?*" motivated by the concerns about the vanishment of sketches.

[18] Goldschmidt G. (2017). *Op. Cit*. p. 86.

[19] Stott, R. (2016). *Peter Cook on How Drawing Enables Architects to Learn, Communicate and Experiment*. [Video file]. Retrieved 15.10.2017 from: https://www.archdaily.com/802591/peter-cook-on-how-drawing-enables-architects-to-learn-communicate-and-experiment?ad_medium=widget&ad_name=navigation-next

[20] Italian High Renaissance period spans the late 15th to the early 16th century and is known for the highest achievements in the art of post-medieval Europe. Leonardo Da Vinci and Raphael are among other well-known artists of the period.

[21] Belardi, P. (2014) *Op. Cit*. (Z. Nowac, Trans.). pp.29-30

uses to describe Michelangelo sketches such as “small dimensions” and “indeterminacy” are most likely to be lost if sketches were produced using digital tools, taking into account that digital sketches can be scale-less and clearly precise.

2.1 “Re” Defining Architectural Sketching

The study will attempt to form a new definition of “sketching” in architecture based on the previous definitions of some architectural theoreticians experienced in the area; a definition that can encompass all forms of “sketching” disregarding the method or the outcome. As the name suggests, sketching (in contrast with working drawing) brings to mind the ability to freely and quickly draw with a single tool (being a pen, a brush, a finger or a computer mouse) with direct or indirect interaction with the drawing surface. As defined by Merriam-Webster online dictionary; a “sketch” is a “rough drawing representing the chief features of an object or scene and often made as a preliminary study”[22], a “drawing”, according to the same source, is “the art or technique of representing an object or outlining a figure, plan, or sketch by means of lines”[23]. Pallasmaa remarks that the other meaning of the term “to draw” which is “to pull”; refers to the inherent quality of the act of drawing to bring out the mental images and emotions embodied in one’s thoughts[24]. It can be derived from these definitions that every “sketch” is a form of “drawing” but not vice versa, although it is common to use these terms interchangeably. Belardi defines sketching in his lecture for architecture students as “a quick, readily available, dense, self-generative, and, above all, extraordinarily communicative notational system”[25].

[22] Sketch, (2016). In *Merriam-Webster.com*. Retrieved 18.11.2016 from: http://www.merriam-webster.com/dictionary/sketch.

[23] Drawing (2016). In *Merriam-Webster.com*. Retrieved 18.11.2016 from: http://www.merriam-webster.com/dictionary/drawing.

[24] Pallasmaa, J. (2009). *Op. Cit*. p. 92

[25] Belardi, P. (2014). *Op. Cit*. (Z. Nowac, Trans.). p.32

Other sources state that "sketches are quickly made depictions that facilitate visual thinking. In this way, sketches may include everything from doodles to roughly drawn circuit diagrams to an architect's quick isometric projection"[26]. Architect and Professor Dr. Celal Abdi Güzer describes a sketch as the innocent or naïve form of the product. He argues that a sketch represents the product not solely in terms of what it will be but also what it will not be; it represents the possible alternatives, the selected and the non-selected, the emphasized and the ignored. In a sense a sketch represents "incompleteness", it holds the uncertainty, the hopes and the innocence of the "incomplete"[27]. A similar description is suggested by architect Brian Edwards:

> "Whether a sketch is of a design proposal or an existing reality, the element of removal or abstraction is one of the characteristics of such drawings. It is better to capture the essence rather than seek an exhaustive realism. Designers need to know what to leave suggested rather than explicitly recorded. The principles and truth that such drawings seek to communicate can be hidden by too much detail or graphic bombardment. A good drawing is one that leaves room for imaginative interpretation."[28]

Güzer adds that a sketch may tell more about architecture than the finite product and in this case, it may become more "real" than the real product itself. Renowned architect, theorist, and educator Peter Eisenman makes a similar point stating that "[t]he 'real architecture' only exists in the drawings. The 'real building' exists outside the drawings. The difference here is that 'architecture' and 'building' are not the same"[29]. İnceoğlu classifies sketches as the tangible outcome of the act of visualizing specific sections of the design phase and design thinking. As a result,

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[26] Johnson, G., Gross, M. D., Hong, J. and Yi-Leon Do, E. (2009). *Computational Support for Sketching in Design: A Review*. Now Publishers Inc., Foundations and Trends(r) in Human-Computer Interaction (Book 5). Breda, Netherlands. p. 3

[27] Güzer, C. A. (2011). *Çizgi ile Düşünmek, Çizgide Düşünmek (Thinking via Lines, Thinking within Lines)* Exhibition Catalogue. Architects' Association 1927. Ankara, Turkey

[28] Edwards, B. (2008) *Understanding Architecture through Drawing*. The Cromwell Press. Trowbridge. Wiltshire. p.3

[29] Ansari, I. (2013). *Interview: Peter Eisenman*. The Architectural Review. Retrieved 11.12.2017 from: https://www.architectural-review.com/rethink/interview-peter-eisenman/8646893.article

İnceoğlu asserts that it is not possible to separate designing phase from sketching phase[30]. An interpretation of this statement can be that any design production passes through sketching production regardless of the tools and methods of sketching. By examining the previously mentioned architects' definitions along with the dictionary definition, it is possible to define sketches according to these five points:

- **Speed:** Quick, readily available
- **Phase:** Preliminary study, design phase
- **Type:** Doodles, diagrams, orthographic, paraline or perspective drawings.
- **Characteristic:** Abstract, rough, dense, innocent, naïve, incomplete, uncertain, instantaneous, spontaneous
- **Capabilities:** Self-generative, communicative, facilitates visual thinking and recording, leaves room for interpretation.

A final definition can be derived accordingly:

> **"A Sketch is the quick and readily available drawing that is produced as a preliminary study of an object or an idea in the design phase. It can take the form of doodles, diagrams or isometric projections. It holds characteristics of abstractness, roughness, density, innocence, naïveté, incompleteness and uncertainty. It bears capabilities of generating ideas, facilitating visual thinking, leaving room for interpretation and communicating with others"**.

This definition can apply to both hand sketched doodles and digitally sketched concepts using computers. Kendra Schank Smith, author of "*Architects' Drawings; A Selection of Sketches by World Famous Architects Through History*", argues that "sketching" value lies in its capability to facilitate design process regardless of the media:

[30] İnceoğlu, N. (2012) *Op. Cit.* p. 5

> "Sketches may also comprise three-dimensional actions preliminary to architecture, such as the fast 'sketch' model, or be conceived of digitally as a wire-frame massing in the computer. In such ways, **the intention takes precedence over the media**. How sketches act to assist design thinking designates their value."[31]

Some architects argue that an important feature of a sketch is the "imprecision", and as a result, they reject classifying digital models as sketches as it will be discussed in the coming chapters. Moreover, in this era, "sketching" does not necessarily refer to "freehand sketching", and "freehand sketching" no longer covers both the process and the end result at the same time. To clarify; a sketch made by a conventional pen on a conventional paper is a "freehand sketch" in both the process and the end result. However, some software within a tablet PC avail the sketchers with precise measurements even though their sketch method is "freehand", in this case, the end technical drawing result **does not lose** the above-mentioned features of a sketch. A sketch made by mouse on a computer screen, on the other hand, may not be classified as an act of "freehand sketching"; meanwhile, the end result can still be a "freehand sketch". A possible reason for mouse drawing not being "freehand" sketching/drawing can be related to the fact that in "freehand" sketching/drawing, fingers are in control of the drawing tool and its tip movement, while in the case of the mouse, it is the palm (and not the fingers) that is in charge of the pointer movement, hence, making the free sketching/drawing process more restricted and more difficult (Figures 1 and 2).

An important remark here is that both cases (precise sketching using a digital pen and freehand sketching using a computer mouse) require a lot of practice and training. Since every new program necessitates the designers to familiarize themselves with the interface and shortcuts; it would be difficult for a designer skillful in sketching to reach the required results when being introduced to any software for the first time.

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[31] Smith, K. S. (2005). *Architects' Drawings; A Selection of Sketches by World Famous Architects Through History*. Architectural Press, Elsevier. p.2

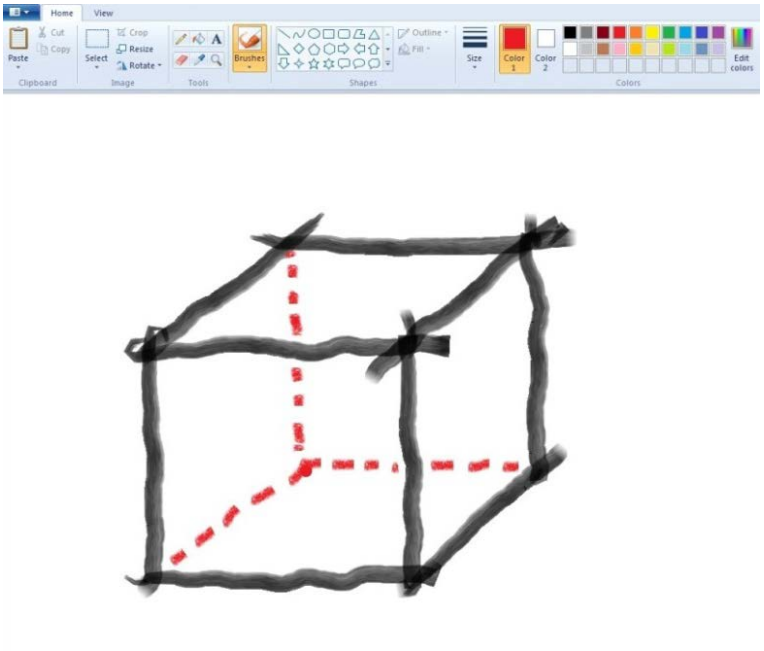

Figure 1: A freehand sketch produced by mouse on computer screen
Source: Author

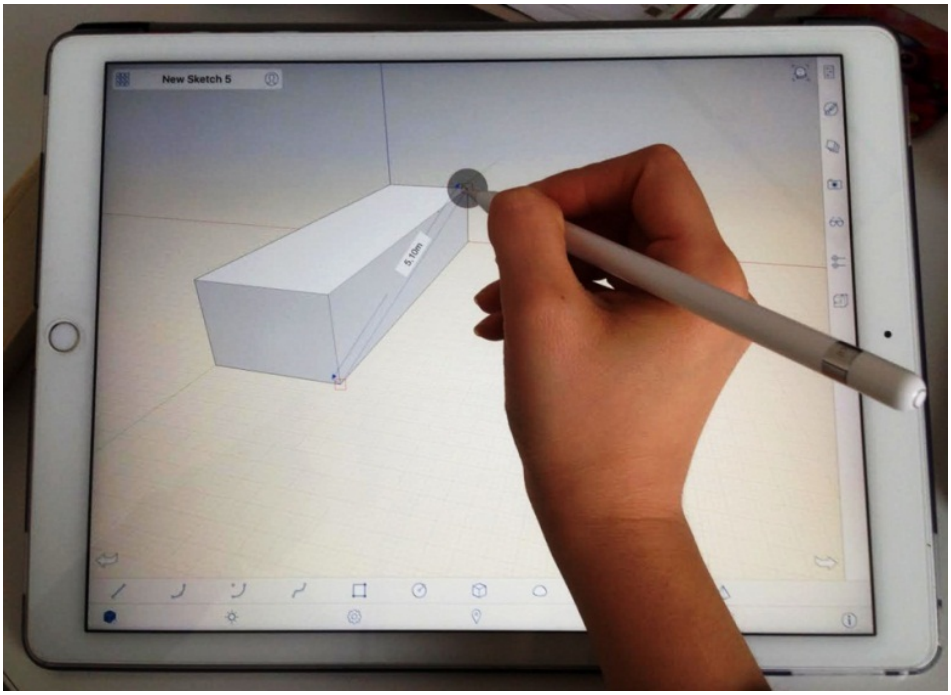

Figure 2: A precise sketch produced by digital pen on tablet screen (*iPad Pro, Apple Pencil + Autodesk FormIt*)
Source: Author

2.2 Functions of Sketching

When scrutinized, the sketch as the trademark or the indication of the designer unfolds in two crucial functions for both nascent and experienced architects. The first function can be summarized as such that practicing freehand sketching while examining and recording significant pieces of architecture yielded in teaching architects valuable lessons about the profession. It was the means to attain higher levels of understanding of history, forms and proportions, material quality and the relation between the human body and the physical space. As for the second function; it was the main method for translating the architects' imagination into forms, spaces, and relations. These two roles, as the most prolific illustrator of architectural publications Francis D. K. Ching[32] puts it, are strongly related:

> "Drawing, like the ancient Roman god Janus, has two faces. One looks to the past, at what already exists, when we draw on location from direct observation... The other face of the drawing looks to the future, what does not yet exist except in our mind's eye. This is what we do when we design… The things we learn about our environment when we draw on location help us as we imagine, draw and design the future."[33]

This method used to be a dominant part of architectural education and professional practice until two technological advances with about a century apart impacted "freehand" architectural sketching in a way that can be classified as negative. The first technological advance being the camera reduced the need to log books and the urge to sketch on site, meaning the reduction of the production of **sketching as observation and analysis**, and the second being the computer with its ability to produce precise sketches with faster adaptability to working drawings affected the production of **sketching as designing**. The two functions of sketching;

[32] Ching has numerous books illustrated with his distinctive drawing style including but not limited to Architecture: Form, Space, and Order, Architectural Graphics, Design Drawing, Drawing: A Creative Process, Interior Design Illustrated, Sketches from Japan and A Visual Dictionary of Architecture. Many of which have been translated to a variety of languages including Turkish.

[33] Ching, F. D. K. (2013) *Forward* in Richards, J. (2013) *Freehand Drawing & Discovery: Urban Sketching and Concept Drawing For Designers.* John Wiley & Sons, Inc. Hoboken. New Jersey.

observation and design, are the two main pillars the importance of sketching strives on. Edwards summarizes the significance of sketching and its functions in few lines:

> "The act of drawing is an important starting point for the intellectual process we call 'design'. To be able to draw a chair or a building is a prerequisite for anyone wishing to design such things. Drawing has two functions for the designer – it allows him or her to record and to analyze existing examples, and the sketch provides the medium with which to test the appearance of some imagined object."[34]

Whether the sketch is for observation or for designing purpose, in both cases it could serve a third function; that is **sketching as a tool for communication** and transferring thoughts among architects, to put differently; a tool for presentation. Whether the influence of digital tools on the previously mentioned two functions is a matter of debate, it can be stated that they serve a positive role in empowering and facilitating this last function in particular more than the others.

2.2.1 Sketching as Observation and Analysis

In terms of documenting already existing architecture, the invention of photography which changed the way in which architecture was perceived, represents the first change concerning architectural freehand sketching. This 19th century invention[35] which was then laborious in capturing images and transferring them on the printed medium became an effortless tool after it became digitized. This invention provided faster ways to capture the scenes (whether printed or in digital

[34] Edwards, B. (2008). *Op. Cit.* p.1

[35] It is referred here to the first camera able to produce printed photograph image in the mid-19th century by French inventor Joseph Nicephore Niepce (1765-1833) who was interested in lithography (a form of stone printing), yet, lacking drawing skills, thus, sought to invent a machine that would produce automatic imagery. Before that, *Camera Obscura* which translates to "dark chamber" was used as photography machine. It was simply a darkened box with a pinhole in which a convex lens or an aperture was placed in order to reflect an external image to a screen inside. Italian artist Leonardo Da Vinci provided a detailed description of this device which he used in his perspective drawing studies. Sources: Encyclopedia Brittanica (n.d.) *Joseph Niepce French inventor*. Retrieved from: https://www.britannica.com/biography/Nicephore-Niepce

format) rather than hand-drawn scenes of architecture, and the more time progressed, the more architectural photography became abundant as portable cameras became available to the traveling architects, not to mention that today the cellular phones with their high-resolution cameras replaced the need to carry portable cameras as well.

These camera captured images either compensated for the need to sketch or, in the best case scenario, provided the appropriate material as drawing-object in substitution to observing the real work outdoors. A photograph could be helpful in sketching either as a source to look at and redraw or as a base that can be directly traced over using transparent layers; the first can be associated more with sketching as observation while the second can be more about sketching as designing. Although this activity enables access to architecture photography without the necessity to travel, observe the architecture in person and sketch while facing site exigencies, it simplifies the drawing process by framing the scene, locking the perspectives as well as horizon lines and vanishing points, and transferring the content of the frame from three-dimensional active scene into two-dimensional static one. This results in a simpler understanding of ratio and proportions; as the object to be drawn had to be zoomed out, in the expense of losing features such as the sense of scale and the physical and sensual interaction with the spatial qualities of architecture. In sketching from reality, the slightest movement by the person sketching yields in changing the level of the horizon line and location of the vanishing points, thus, requiring a lot more skill and practice. While both methods of sketching; from reality or from photographs, act as an important source for learning, it can be said that the first is an active way of learning and personally engaging with the drawing object while the second is a form of less active learning and minor or indirect engagement with the object. Many architects started to feel the gap left by abandoning freehand sketching and sought to bring the sketching ritual back into their practices. Edwards notes:

> "It is said that in our modern world we now produce more photographs than bricks. Photographs are not always the most appropriate medium for expressing this visual concern. There are times, and subjects, which lend themselves to graphic analysis, rather than pictorial description"[36]

Edwards' statement can be elaborated in the way that photographs provide a full record of the scene, while in sketching; the process is not as much an effort on mimicking the object, but rather a challenge to get engaged in a dialog with it. This requires omitting some details while accentuating some others, in other words, "graphically analyzing" the built environment and deriving one's own reactions and conclusions accordingly, which is a form of "hand-eye-brain" coordination procedure discussed earlier. As Edwards puts it:

> "Drawing an object, building or townscape forces you to engage more directly in the subject than as a mere photographer, the search to record shape, proportion, detail, and color requires greater effort and more skilled observation than that needed to press the shutter of a camera. The discriminatory eye encouraged through sketching has value to the potential designer and tourist alike for it engages the observer in an important dialogue with his or her subject".[37]

Pallasmaa makes a similar argument assuring that he can vividly remember each one of the hundreds of sketches he made during his travels, whereas he struggles to recall the spaces he photographed due to the weaker embodied recording of shooting a scene in comparison to hand sketching. In the latter case, the architect argues that sketching yields in three variant sets of images; the drawing on the paper, the image recorded in the cerebral memory, and the muscular memory of the activity itself[38]. Among the architects who sought to produce traveler hand-sketches in the digital photography era, is Jacob Brillhart, architect and author of "*Voyage Le Corbusier: Drawing on the Road*"[39], who explains his experience in following the

[36] Edwards. B (2008) *Op. Cit.* p.9

[37] *Ibid*. p.16

[38] Pallasmaa, J. (2009). *Op. Cit.* p. 92

[39] Brillhart, J. (2016) *Voyage Le Corbusier: Drawing on the Road*. W. W. Norton. New York.

steps of Le Corbusier in his journey to the east by using the latter's sketchbook as a guideline as follows: "Revisiting history while understanding architecture spatially, I realized how observation and experience, translated through drawing, inevitably informs design".[40] (Figure 3) shows a sample of Brillhart's sketchbook page showing his and Le Corbusier's recordings of Istanbul during the journey, where the point of reference for these sketches was not always Le Corbusier's sketches but sometimes the photographs he took. Carrying a camera, which Le Corbusier referred to as "a tool for idlers, who use a machine to do their seeing for them"[41], did not discourage the latter from making on-site sketches, which accumulated in return into forming the basis for his manifesto in his 1930 book "*Towards a New Architecture*"[42]. Another travel sketch of Turkey is made by Richards, which he considers to be a very special sketch he made over two pages and in 10 minutes observing Uçhisar village from a distance, watercolors were applied at a later stage[43] (Figure 4).

[40] Brillhart, J. (2011). *Drawing towards a More Creative Architecture: Mediating between the Digital and the Analog*. Presented at the Association of Collegiate Schools of Architecture (ACSA) 99th Annual Conference. Montreal. p.1.

[41] Jenkins, E. (2013). *Drawn to Design: Analyzing Architecture Through Freehand Drawing*. Birkhäuser Verlag. Basel, Switzerland. p. 38

[42] Brillhart Architecture (n.d.). *Voyage Le Corbusier*. Retrieved 15.11.2017 from: http://brillhartarchitecture.com/academic/voyage-le-corbusier/. Originally the French title of the book is "Towards Architecture" (Vers une Architecture), implying that there are essentials of architecture pertaining similarly to different periods.

[43] Richards, J. (Interview) (2012). *Eskizlerle Kendinizi Keşfedin (Discover Yourself Through Sketching).* Peyzaj Life Magazine. Issue 9. Istanbul. p.40

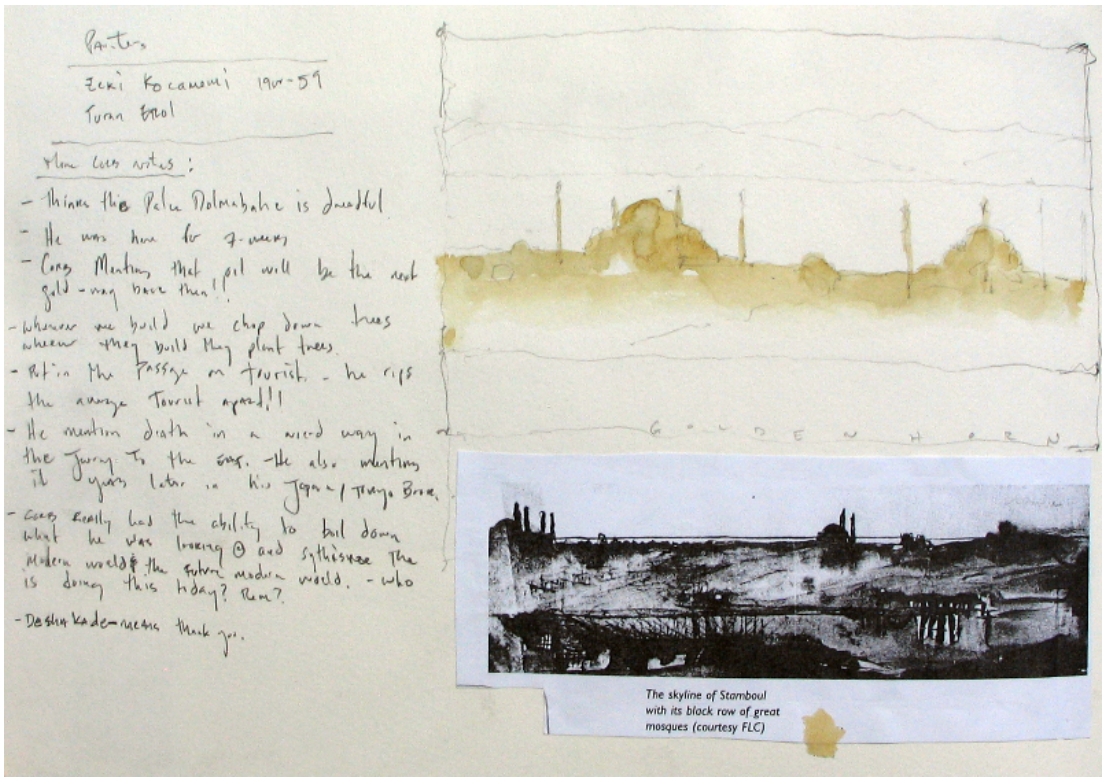

Figure 3: Jacob Brillhart Sketchbook showing Istanbul skyline drawn by Brillhart (above) and Le Corbusier (below)

Source: Brillhart Architecture. Retrieved 15.11.2017 from: http://brillhartarchitecture.com/middle-east/

Figure 4: Uçhisar Village Sketch by James Richards

Source: Richards, J. (Interview) (2012). *Eskizlerle Kendinizi Keşfedin (Discover Yourself Through Sketching)*. Peyzaj Life Magazine. Issue 9. pp. 38-39

2.2.2 Sketching as Designing

When it comes to freehand sketching as the first stride in the architectural design process, the introduction of computer-based digital tools diminished the pencil role in sketching in favor of more rapid design solutions in terms of time and cost. The intention of providing working drawings and blueprints to maximize productivity and minimize manpower resulted in the possibility to reduce the time, if not totally skip, the initial hand sketching phase and start from precise drawings in the first place both in orthogonal sets as well as three-dimensional forms. Goldschmidt argues:

> "In recent years, powerful computer programs have made it possible to not only abandon manual drafting in favor of CAD (Computer-Aided-Design) drafting, but also to model and perceive spaces and forms of even the most intricate geometries. The commonplace use of the new digital tools has increasingly devaluated manual sketching, including in the preliminary stages of desgining."[44]

Scheer's concern is mostly about drawing (or sketching) being replaced by BIM and computational design means, while hand drawing is about representing ideas in forms; BIM technology is about simulating experience and predicting building behavior according to actual coordinates and various weather conditions. One of the results of this shift is, as the book suggests; blurring the distinction between the preliminary phases of design and sketching on one hand, and the working drawings and construction on the other. Although suggesting "death" for hand drawing, Scheer himself while raising the question of "whether drawing will remain an integral part of architectural work or shall be replaced by digital tools", he still finds hope in those tools asserting that they might either retain conventional drawing in some way or replicate drawing experience by digital means in the end[45]. This "death" of drawing (or pencil to be specific) was also raised on one of the covers of Italian architecture and design magazine "*Domus"* in the 1990s by artist

[44] Goldschmidt G. (2017). *Op. Cit.* p. 77

[45] Scheer, D. R. (2014). *Op. Cit*. p.100

Alan Fletcher (Figure 5). Fletcher's poster brings to mind the photograph taken of architect Frank Lloyd Wright's colored pencils left at his desk following his death in 1959 (Figure 6). Sir Peter Cook argues that Wright's drawings of "Broadacre City" and "Living City" projects, owed their natural expression to the rough strokes of the colored pencil which he referred to as being "a fairly direct product of the soil"[46], this is similar to Steven Holl's preference for watercolors which demonstrate natural light flow in space through water's natural flow on paper; which is a quality missing in a digital tool. These two posters show two contradictory stands relating to architects and hand-drawing; in Frank Lloyd Wright's case, the architect has passed away while his pencils survived, while in Fletcher's poster, the pencils were declared dead as they were abandoned by architects in favor for digital means of drawing. Belardi gladly declares that this "death" never happened the way Fletcher anticipated:

> "That cover, now part of the history of drawing, in addition to swarming with colored pencils (each different from the next, and all of them worn down), featured the headline "Technological Graveyard" and the subtitle "The arrival of the computer will render the pencil as useless as the stylus." "Ceci tuera cela" ("This will kill that; the printed book will destroy the building"), Victor Hugo would have said. But just as the paper page didn't destroy the stone building, the plastic mouse hasn't killed the wooden pencil."[47]

[46] Cook, P., Sr. (2008). *Op. Cit*. p 10

[47] Belardi, P. (2014). *Op Cit*. pp.2-3

Figure 5: Technological Cemetery by Alan Fletcher
Source: Alan Fletcher Electronic Archive. Retrieved 25.12.2016 from: http://www.alanfletcherarchive.com/sites/default/files/max_box_9-4_016_d.jpg

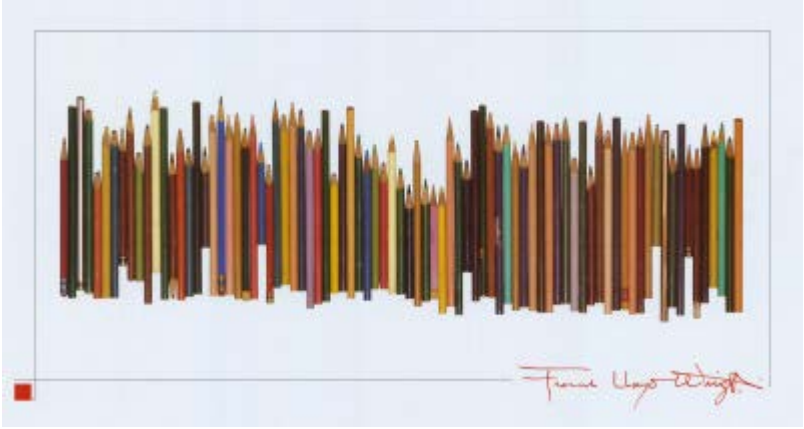

Figure 6: *Pencils from the Architect's Desk*. Collected from the desk of Frank Lloyd Wright, 1959. Photograph by Oskar Munoz.
Source: The Steiner Agency (Advertising and Creative Services). Retrieved 25.12.2016 from: http://www.steinerag.com/flw/Posters/PomCommPosters.htm

In addition to computers, cameras too have their share in influencing sketching during the design phase. Edwards, in collaboration with artist Susan Fahy, has written a full chapter in his book about drawing and photography discussing the advantages of this medium. It is significantly important to layout some of the main points made here since Fahy specializes in "lens-based media"[48]; basically photography. From a photographer's point of view, it is argued that a combination of photography and sketching can be very beneficial in case the architect "can record all the details and at the same time explore the fundamentals of rhythm, structure, proportion, skyline, and texture. It is the latter that are needed as a stimulus to design intervention in the city or landscape"[49]:

> "How light changes the quality of rugged modern materials such as concrete or cast glass, and how this alters the perception of interior space, are subjects that photo-graphic images can reveal more readily than line in the sketchbook...However, when the camera is used in this fashion it is often advantageous to supplement the photographic images with sketched notes – the two mediums being used in a complementary way, taking advantage of the graphic properties of each."[50]

(Figure 7) shows an old example of a photograph used as basis for sketching by French architect Henri Prost that dates back to the first half of the 20th century. The discussion rose by Richards "that in the wake of the freehand renaissance over the past few years, there's very little disagreement anymore over the value of freehand sketching in the design process (though a few academics would still argue the point). The question now, it seems, is where is it going--and how far can we take it?"[51] is highly relevant in this case considering the advancements in technology that

[48] The term 'Lens-Based Media' is used in Fahy's biography at University of Wolverhampton webpage: http://www.wlv.ac.uk/research/institutes-and-centres/cadre---centre-for-art-design-research-and-expe/art-philosophy-and-social-practice/su-fahy/

[49] Edwards, B. (2008) *Op. Cit*. p.80

[50] *Ibid.* p. 81

[51] Richards, J. (Author's Communication via e-mail, Oct. 1, 2016)

allow the same device to act as a digital camera and a drawing surface at the same time.

Figure 7: Photograph of Sultan Ahmet Mosque in Istanbul with sketches and notes by French architect Henri Prost.
Source: Bilsel, C. and Pinon, P., (Eds.) (2010). *From the Imperial capital to the Republican modern city: Henri Prost's planning of Istanbul (1936-1951).* Istanbul Research Institute. p.281

2.2.3 Sketching as a Communication Tool

One other function of a sketch is that it is a medium to present and share ideas between the designers, craftsmen, clients, and every other person involved. While this study focuses on the issues and problems related to architectural freehand sketching during the design phase in the recent years where “digital” is “inevitable”, it will discuss the role of communication tools in simplifying all kinds of data-transfer including sketches. Smart technology plays a vital role in this process as instead of producing a CAD drawings with computer-mouse, or scanning hand-made drawings, smart technologies enable users to freely sketch and share these sketches in a short time regardless of the sketch being produced directly on the smart device or by pen and paper and then digitally photographed. As Richards put it; “We’re

witnessing a pendulum swing from almost exclusive use of digital imagery to a new found appreciation for the immediacy and freshness of hand drawing"[52], and this immediate and fresh drawing can travel to the furthest points in a matter of seconds. The most important assets of these smart devices could be their small sizes, ease of use, and portability which make them a lot more fast and efficient in transferring data in comparison to personal computers, thus, encouraging users to depend more on the pen rather than on the computer-mouse.

2.3 Types of Sketching

Painters classify sketches according to the sketch outcome such as *croquis*, *pochade*, and *portraiture*. *Croquis* is a rough draft or line-based sketch made by the artist in few minutes, usually made of live models, *pochade* is a sketch created in colors using *pochade* boxes which are compact portable boxes where artists carry their brushes and palettes, and *portraiture* is a sketch of facial characters[53]. These studies are mostly informing the forthcoming usually large size oil paintings. Sketches are also the medium for other artists including sculptors, cartoonists, fashion designers, stage set designers, and movie makers.

In this study, as it is mostly concerned with sketching medium in architecture, sketching will be classified as **manual**, **digital** or **hybrid** (or mixed media). Manual sketches here refer to sketches produced without any software involvement[54], while digital sketches refer to sketches produced with the help of certain software. Both of these types could be combined into a form of "hybrid sketch". A hybrid sketch can combine any medium from "photographs, digital images, freehand sketching,

[52] Richards, J. (2011). *Op. Cit.* p.1

[53] Encyclopedia Britannica (n.d.) Retrieved 15.11.2017 from: https://www.britannica.com/art/sketch-art#ref165057

[54] If manual sketches were scanned or photographed and then transferred to the digital medium, they will still be classified as manual unless further manipulation takes place on screen; in which case they become hybrid.

drafting, computer models, physical models, watercolors, oil paints, and more, and are often enhanced through computer manipulation, though not always"[55]. Peter Cook mentions this hybridization method in the works of American architect Perry Kulper who, while does not draw digitally, is interested in the combination of both hand-drawn and digital forms of representation:

> "I (Kulper) am interested in the roles and affordances of both and how design might leverage, or harness the capacities of digital and manual means, producing hybrid visualization and perhaps hybrid architecture, 'other architecture', or divergent spatiality that we can't quite imagine, or 'represent' yet."[56]

The hybrid technique carries the potential to pave the way towards more free and more creative self-expression in design for both architecture candidates and professional practitioners. James Richards is among the strong supporters of the method of merging analog with digital means in order to maximize the benefits of both. His work is largely based on "the rejection of the "either/or" mentality relative to the use of analog and digital methods" in addition to "the creative use of both freehand sketching and computer technology for what each does best, and at their appropriate place in the creative process"[57]. Practitioners of architecture also search for new means and medium for sketching. Architects Paul Lewis, Marc Tsurumaki, and David J. Lewis (LTL Architects) and the authors of the book "*Lewis.Tsurumaki.Lewis: Opportunistic Architecture*" talk about their philosophy related to drawing and the use of hybrid media to be specific; their departure point is a debate raised in the 19th century by Honoré de Balzac's[58] short story "*The*

[55] Yost, B. L. (2015). *Sketching in Code: Exploring Hybrid Drawing Techniques*. Presented at FATE: Foundations in Art Theory and Education. Indianapolis, Indiana.

[56] Kulper, P. (n.d.). Quoted in Cook, P., Sr. (2014). *Drawing: The Motive Force of Architecture*. (2nd Ed.). AD Primers. John Wiley & Sons Ltd. The United Kingdom. pp 219-220

[57] Richards, J. (Interview) (2012). *Op. Cit*. p.39

[58] Honoré de Balzac (1799-1850): a French author, novelist, and playwright.

Unknown Masterpiece" in which two styles of painting are to be united; those of Ingres and Delacroix[59]:

> "On Ingres's side are those who argue that art and representation is a demonstration of the intellect and as such should be controlled and conveyed through line, drawing or *disegno*. The supporters of Delacroix argue that the purpose of art is the translation of the world through the effects of paint, engulfing the viewer in the totality of the image through color or *colorito*."[60]

LTL Architects argue that about a century and a half later, the same debate is being witnessed in the discourse of architecture in the fields of technology and representation. Architecture's dependence on line in the attempt to produce the built form rendered it on Ingres's side. Digital technology's invasion and the introduction of advanced rendering software began dragging the discipline to Delacroix color side. As a result, an "unfortunate" and "counterproductive" split between traditional forms of representation being hand sketching hardline constructions on one hand, and digital imagery produced through high-end programs on the other. LTL Architects' approach is a search for "a truly complex form of architectural representation, one that learns from both, steals selectively, and pays little heed to zealots on either side", which requires "an agile exchange between line and color, between drawing and production, between manual and digital means of working in order to circumvent current frames of thinking for the benefit of continuing architectural vitality":

> "Rather than relying on a single technique, rapid computer-generated renderings are overdrawn by hand, with detailed development and design alterations to the initial form emerging in the process. These drawings are then scanned and re-composited with the original rendering and this hybrid image is further digitally manipulated to capitalize on the qualities of both media."[61]

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[59] 19th Century French artists; Ingres was Neoclassical painter while Delacroix was associated with the Romantic style.

[60] LTL Architects (n.d.) *Over Drawing*. Retrieved 25.12.2016 from: http://ltlarchitects.com/over-drawing/

[61] *Ibid*

Brillhart notes a similarity between the approach of LTL Architects (Figure 8), and that of architect Hugh Ferriss[62] in conceiving architectural renderings. According to him, LTL works enable the viewer's mind to access the project through hand drawings; these drawings as Brillhart continuous, are "open, not finished, and frame ideas without delineating every detail"[63]. Looking at Ferriss's illustrations (Figure 9), as there are no traces of hybrid drawing, it can be said that it was not the use of mixed media but rather this "openness", "incompleteness" and "ambiguity" that characterized the works in both approaches. These qualities can also be observed in the works of other architects such as John Hejduk (Figure 10) and Lebbeus Woods[64] who showed interests in "paper architecture" i.e. architecture without building. In fact, Wolf D. Prix from the Austrian-based Coop Himmelb(l)au architecture states that "Lebbeus was the living proof of Derrida's theory that often a small sketch can have more influence on the world than a large building"[65].

[62] Hugh Ferriss (1889-1962) was an American architect and delineator and "the most prominent urban portraitist in the American architecture world of the 1920s and '30s. Working as a delineator for architects such as Cass Gilbert and Raymond Hood, he rendered the evolution of both the real and the ideal metropolis". Source: Museum of Modern Architecture (MoMA). Retrieved 21.09.2107 from: https://www.moma.org/collection/works/83681

[63] Brillhart J. (2011). *Op. Cit.* pp. 1-7

[64] John Hejduk (1929-2000) and Lebbeus Woods (1940-2012) were architects, artists and architectural theorists. Hejduk was mostly associated with the themes of psychology, mythology and later, religion. Woods was known for his dystopian visions set in cities stroke by disasters such as Sarajevo, Zagreb and Havana adopting a sort of a "medical metaphor" aiming at healing buildings damaged by wars or natural catastrophes. Sources: Goodwin, D. (2017). *Spotlight: John Hejduk*. Archdaily. Retrieved 01.02.2018 from: https://www.archdaily.com/770148/spotlight-john-hejduk

Wainwright, O. (2012). *Lebbeus Woods, visionary architect of imaginary worlds, dies in New York*. The Guardian. Retrieved 01.02.2018 from: https://www.theguardian.com/artanddesign/architecture-design-blog/2012/oct/31/lebbeus-woods

[65] Prix, W. D. (2012). *For Lebbeus Woods*. Coop Himmelb(l)au. Retrieved 21.01.2018 from: http://www.coop-himmelblau.at/architecture/news/wolf-d-prix-for-lebbeus-woods/

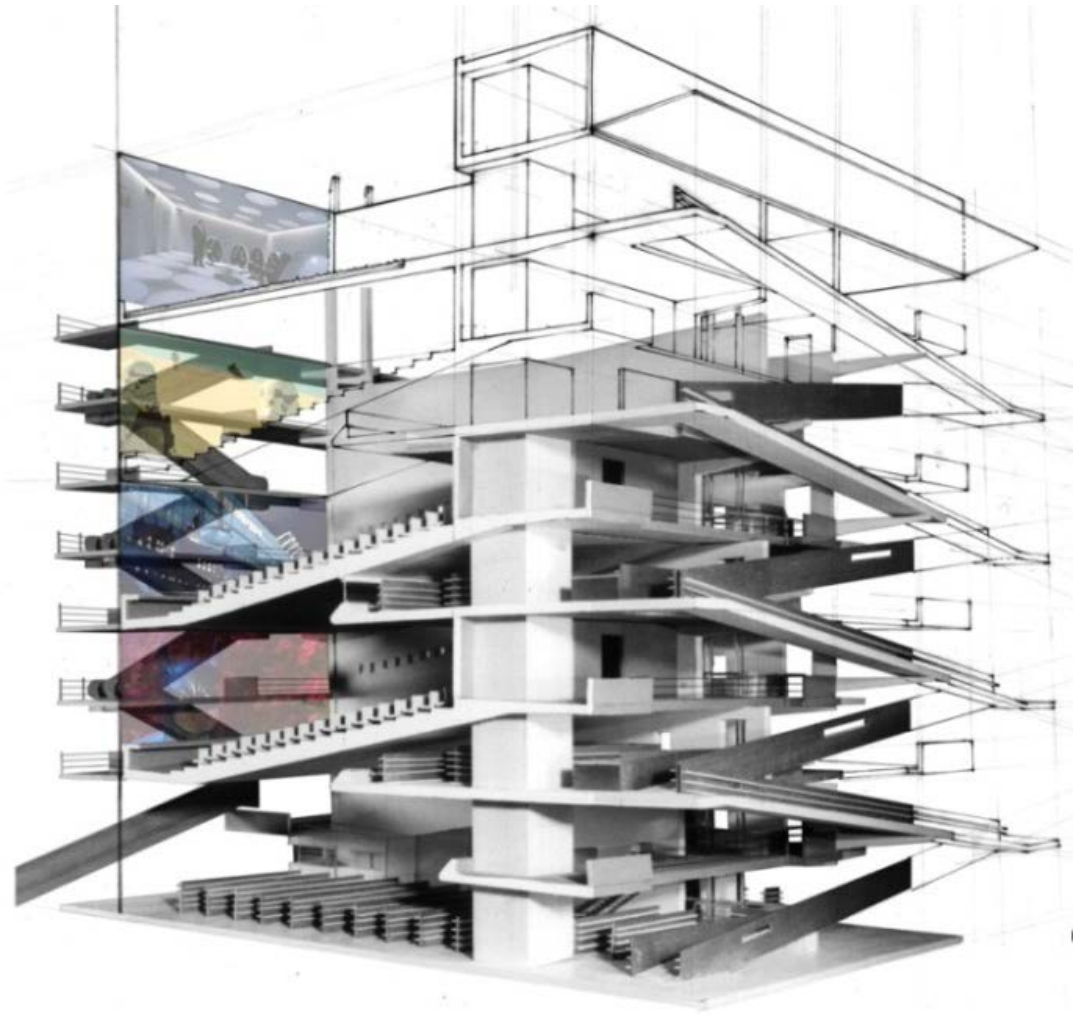

Figure 8: Hybrid drawing composed of printed model photograph, a hand sketch traced over, and a computer image mapped over the scanning
Source: LTL Architects. Retrieved 25.12.2016 from: http://ltlarchitects.com/video-filmplex

Figure 9: Hugh Ferriss – Buildings in the Modeling Project (Aerial perspective) (1924)
Source: Museum of Modern Architecture (MoMA). Retrieved 21.09.2107 from: https://www.moma.org/collection/works/83681

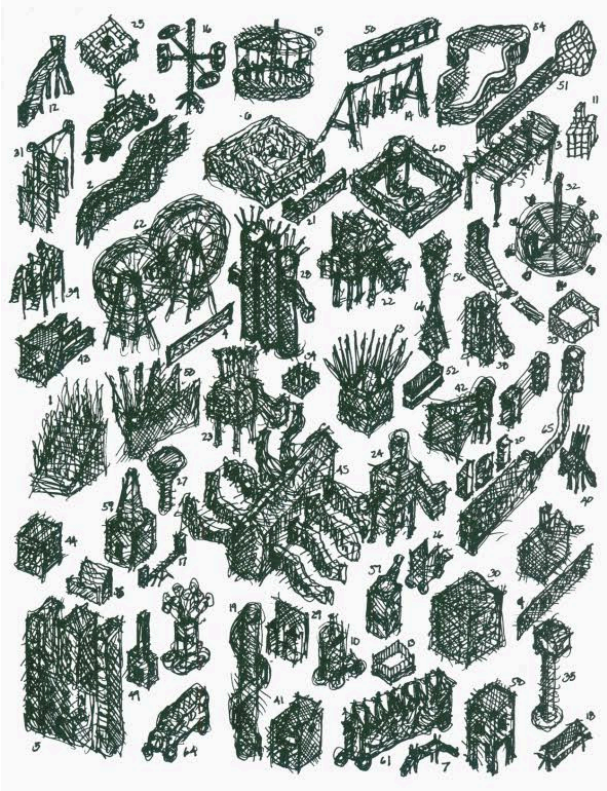

Figure 10: John Hejduk – Victims (1983)
Source: Hedjuk, J. (1986). *Victims.* The Architectural Associaiton. London. UK

2.4 Sketching in Architectural Education

"Thinking via drawing" is a crucial skill to develop in students of architecture as Balamir stresses; this graphic mumbling would teach them not to get satisfied with the first ideas emerging in their minds but to search for further and more variable alternatives[66]. Eisenman remarks that current day architects and architecture students "have lost the essential capacity to think through drawing. They can only think through a computer"[67]. Not only students are losing interest in sketching by hand, but a number of drawing teachers at the schools of architecture no longer desire to teach hand-drawing[68].

Computers became an inevitable part of the architectural production with the many advantages they brought; however, they also brought some major drawbacks especially for architectural candidates who might be in danger of being exposed to the digital form of design "too soon". A possible solution to this problem could be found in engaging digital tools in sketching as well. In case drawing from reality is unavailable and drawing from photographs is insufficient[69], a third option would be drawing from models which are especially beneficial for un-built architecture. It can be said that digital models have the supremacy over physical models (as a basis for sketching) in various aspects such as abundance and the ease of access, the ability to be zoomed and projected on large surfaces and the ability to provide full exterior-interior detailing including sun-shade effects. This form of training prepares

[66] Balamir, A. (n.d.). *Op. Cit*. pp. 6-7

[67] Cited in Ansari, I. (2013). *Op. Cit.*

[68] Architect Steven Holl pointed out that he was unsatisfied with people at the University of Columbia who did not want to continue teaching drawing by hand. Source: Pedersen, M. (2013) *For Steven Holl, Morning Watercolors Are Akin to Meditation*. Metropolis Magazine. Retrieved 15.10.2017 from: http://www.metropolismag.com/architecture/steven-holl-morning-watercolors-meditation/

[69] A new trend in photography is the digital 360-degree videos. These videos are created by stitching multiple still images together. To minimize distortion, video filters use CG method named "cube mapping" in which the frame is divided into 6 images of a cube; two ends and four sides. For further technical details: Moon, M. (2015) *Facebook explains the tech behind its 360-degree videos*. Retrieved 18.12.2016 from: https://www.engadget.com/2015/10/15/facebook-360-degree-video-tech/

architecture students, who plan to take active roles in designing in the professional field, to improve their designs by sketching over photographs of their concrete models or directly on the digital models of their own un-built works.

(Figure 11) shows sketches conceived by the author during the first year class of (ARCH 103-104 Graphic Communication) as part of architectural education curriculum at Middle East Technical University (METU). The sketches of Le Corbusier's buildings were made by observing digital photographs on a display screen for 3 minutes per each photograph, the drawing of Hans Poelzig's model was conceived by observing the concrete model[70] and the overall drawing lasted around 20-30 minutes. Further "imaginary" background and landscape was added later. Since no time restriction was imposed during the model drawing, the result came as a finished drawing rather than a rough sketch as the case in drawing from the photograph. According to Dr. Haluk Zelef, these sketching exercises given in METU aimed at increasing both the cognitive and the motor skills in students; the cognitive skills involved analytic and synthetic aspects targeting left and right brain activities respectively, and the motor skills targeted sketching language, techniques and speed[71]. (Figure 12) shows another sketch conceived by the author during an elective drawing class at Vienna University of Technology conceived on site in approximately 20 minutes. These kinds of exercises tend to raise the levels of students' self-confidence while holding the pen. Students who do not find sufficient confidence in their sketching skills may tend to produce their designs fully digitally, and while presenting their works, they add filters that make the digital model "look as if" it was drawn by hand. This method gives the illusion of imprecision and abstraction much appreciated in this stage, however, it remains a "fake" way of representation. Pallasmaa points out:

[70] The model was displayed in the exhibition entitled "*Hans Poelzig- Architect- Educator- Artist*" at the Center for Contemporary Arts in Ankara in October- November 2008.

[71] Zelef, M. H., Bursa, N., Çakıcı, F. Z. (2011). *Düşüncenin İzi: Mimarlık ve Sanat Eğitiminde Eskiz Geleneği (Trace of Thought: Sketch Tradition in Architecture and Art Education)*. First Art and Design Symposium. Yesterday, Today and Future. Başkent University. Ankara. p. 534

"In comparison to the expressive richness and emotive life of the hand-drawn line, the computer line is a laconic and uniform connection of two points (computer lines can, of course, be articulated to simulate lines drawn by hand, but their essence is the emotionless factuality of mathematicised space)"[72]

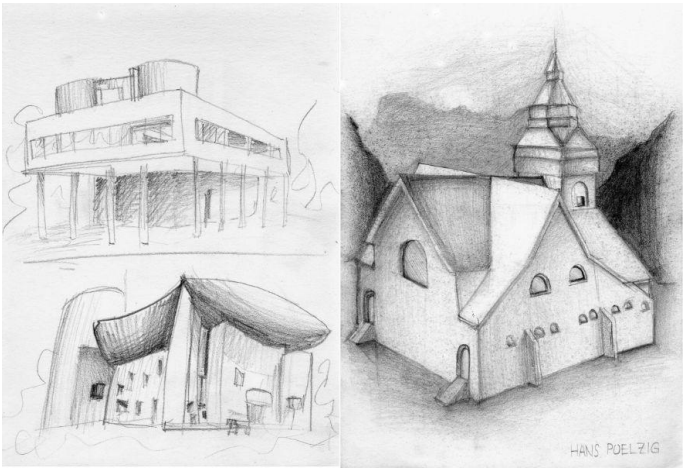

Figure 11: Left; sketches of Le Corbusier's buildings Villa Savoye and Ronchamp Chapel in France, drawn from photographs. Right; drawing of Hans Poelzig's Evangelical Church in Germany, drawn by observing the concrete model.
Source: Author's Sketchbook. (2008). Part of course 103 Graphic Communication. Middle East Technical University. Tutor: Mustafa Haluk Zelef

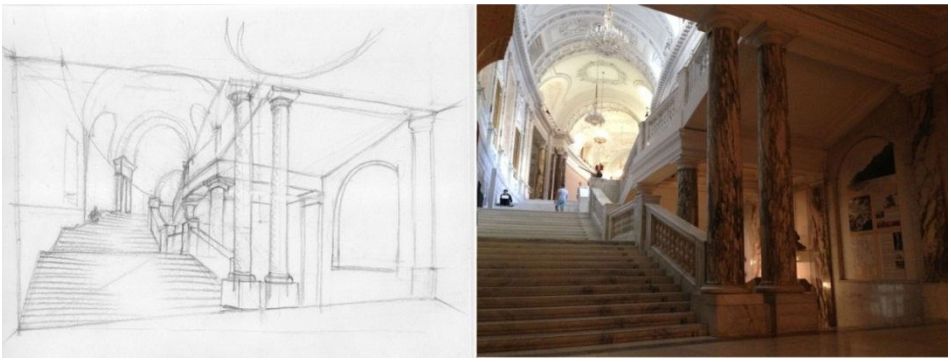

Figure 12: Left; sketch of Ephesus Museum in Vienna conceived on site and right; a photograph of the approximate scene.
Source: Author's Sketchbook. (2016). Part of course 264.125 Freehand Drawing 2. Vienna University of Technology. Tutor: Daniel Von Chamier

[72] Pallasmaa, J. (2009). *Op. Cit.* p. 100

CHAPTER 3

DIGITAL DEVELOPMENTS IN ARCHITECTURE: A BRIEF HISTORY

Table 1: Timeline of some of the major Software and Hardware Developments Affecting Architectural Drawing Divided in 3 Periods
Source: Author

	SOFTWARE	HARDWARE
1963	Sketchpad | Sutherland Sketchpad III | Johnson	
1964		RAND Tablet | RAND
1965		
1966		
1967		
1968	Chiaroscuro | Appel	Dynabook | Kay
1969		
1970		
1971	ADAM | Hanratty	
1972		
1973		
1974		
1975		Altair 8800 | MITS
1976		
1977	CATI | Dassault	
1978		
1979		
1980		
1981	CATIA | IBM	5150 PC | IBM PC Mouse | Xerox
1982	AutoCAD | Autodesk	
1983		
1984	Allplan | Nemetschek Programmsystem GmbH	KoalaPad | Koala WT Series | Wacom
1985	Autocad 3D | Autodesk Vectorworks | Diehl Graphsoft	
1986	MicroStation | Bentley TurboCAD | Vermooten & Oosthuizen	

1987	ProEngineer | PTC ArchiCAD | Graphisoft	
1988		
1989		
1990	3D Studio | Autodesk & Yost Group	
1991		
1992	3DM | Butterworth et al.	
1993		Newton MessagePAD | Apple
1994		
1995	Sculptor | Kurmann	
1996		
1997		
1998	Rhinoceros | Mcneel Maya | Alias Wavefront Digital Clay | Schweikardt & Gross	Microsoft Tablet PC | Microsoft
1999	Autodesk Inventor | Autodesk Teddy | Igarashi, Matsuoka & Taraka	
2000	SketchUp | @last Software Revit | Revit Technology Corporation BodyPaint 3D | Maxon DDDoolz | Achten, de Vries & Jessurun	
2001		
2002		
2003	The Augmented Round Table | Wolfgang Broll	
2004		
2005		
2006		
2007		iPhone | Apple
2008	ILoveSketch | Bae et al.	
2009	Sketch Book | Schneider & Petzold	
2010		iPad | Apple Galaxy Tab | Samsung
2011		
2012		
2013	Digital Project | Gehry Technologies	
2014		
2015		Apple Pencil | Apple
2016		HP Z2 mini | HP Microsoft Surface Studio | Microsoft Smart Writing Set | Moleskine
2017		Dell Canvas | Dell

Although computer aided drawing roots date back to much earlier; to the 1940s when attempts started to develop computer software for military purposes[73], the study covers the period starting with the 1960s when CAD started influencing engineering disciplines related to architecture. This chapter attempts to elaborate the history of the digital influence on hand-drawing by dividing it into three periods. The first period starting from 1963 discusses the first attempts marked by the *Sketchpad*[74] and discusses the debates arose among professional architects as well as academicians concerning computer aided drawing/drafting introduction to engineering and its possible influence on architecture. The second period starting from 1981 corresponds to the beginning of PC era with the introduction of *CATIA*; the first software designed with the discipline of architecture in mind, light will be shed, as well, on other hardware and software developments and the differences between various commercial drawing and sketching software products within this range, in addition, few non-commercial sketching software examples developed for academic research will be discussed. The third period starting from 2007 covers the range of the invasion of smart technology to everyday life aspects with the arrival of the multipurpose telephone *iPhone* along with the impact of some major smart technology advances that followed. Various devices and drawing and sketching applications widely used today will be given as case studies. This division of periods does not indicate that the beginning of one marked the end of the previous but rather the opening of a new era that took architectural freehand sketching into new directions.

[73] Weisberg, D. E. (2008) *The Engineering Design Revolution CAD History* [E-Book]. p7. Retrieved 01.10.2017 from: http://www.cadhistory.net/02%20Brief%20Overview.pdf

[74] Some references point that the Sketchpad was developed in 1962, however Sutherland's dissertation "*Sketchpad, a Man-Machine Graphical Communication System"* was published in 1963.

3.1 1963- Beginnings

The first attempt to use electronic means in sketching was presented in a doctoral dissertation in 1963, when electrical engineer and computer scientist Ivan Sutherland from Massachusetts Institute of Technology (MIT) introduced a software he invented and called "*Sketchpad*" (also known as "Robot Draftsman") (Figure 13), this software attempted to accurately draw, redraw and alter drawings with a "light pen" on a computer display. Drawings could be produced with straight lines and/ or circle arcs and other shapes could be derived from these two basic shapes. As the engineer indicated in his thesis introduction, the intention was basically to play a role in producing electrical, mechanical, scientific, mathematical, and animated drawings.[75] Although not mentioning any potential uses in the field of architecture or spatial design, Sutherland did present examples of artistic drawings showing the capabilities of the new software (Figure 14), however, he admitted that the practicality of these drawings was limited:

> "For drawings where motion of the drawing or analysis of a drawn problem is of value to the user, Sketchpad excels. For highly repetitive drawings or drawings where accuracy is required, Sketchpad is sufficiently faster than conventional techniques to be worthwhile. For drawings which merely communicate with shops, it is probably better to use conventional paper and pencil."[76]

[75] Sutherland I. E. (1963) *Sketchpad, A Man-Machine Graphical Communication System* (Doctoral Dissertation). MIT. pp. 9-10. Retrived from University of Cambridge Computer Laboratoty. https://www.cl.cam.ac.uk/techreports/UCAM-CL-TR-574.pdf

[76] Sutherland, I. E. (1963) *Sketchpad: A Man-Machine Graphical Communication System* - Proceedings of the Spring Joint Computer Conference, Detroit, Michigan. Vol. 23 – Spartan Books p. 341

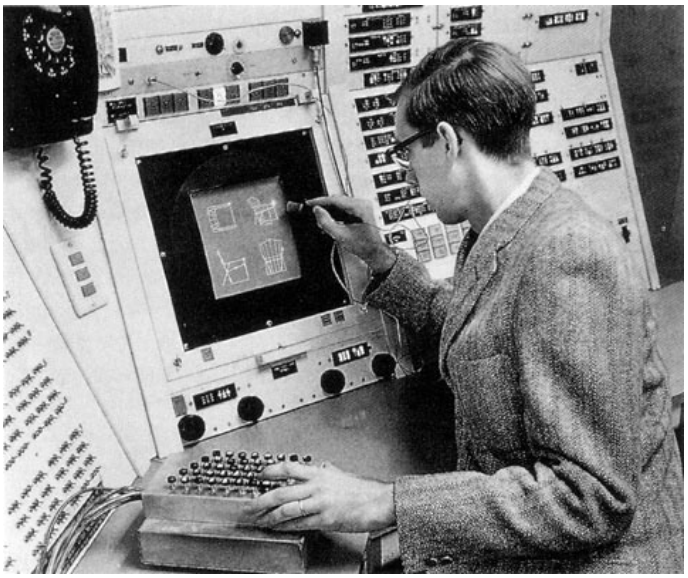

Figure 13: Sutherland Using the Sketchpad in 1962

Source: Sketchpad of Ivan Sutherland. Retrieved 25.12.2016 from: http://history-computer.com/ModernComputer/Software/images/Ivan_Sutherland1962.jpg

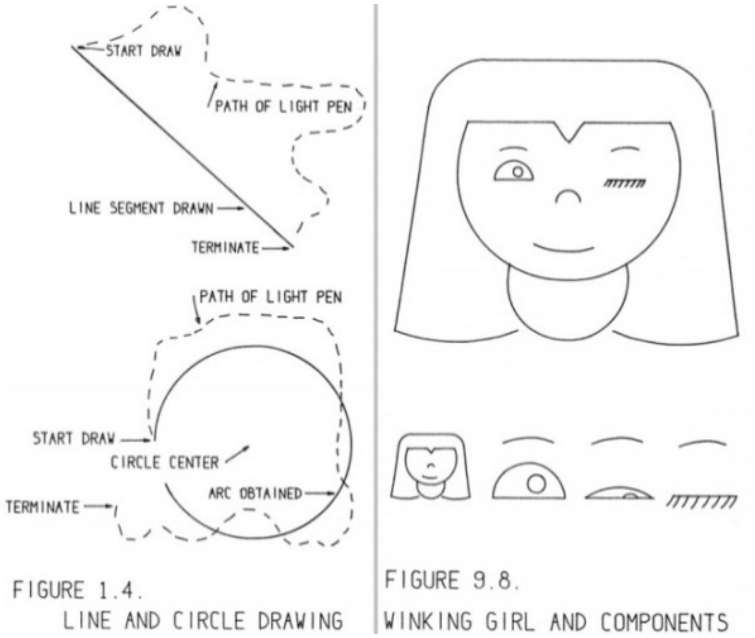

Figure 14: Drawing Examples done by using the Sketchpad

Source: Sutherland I. E. (1963). *Sketchpad, A Man-Machine Graphical Communication System* (Doctoral Dissertation). MIT. pp. 22 and 109. Retrived from University of Cambridge Computer Laboratory. https://www.cl.cam.ac.uk/techreports/UCAM-CL-TR-574.pdf

This invention in itself did not get widely used by architects but paved the way to developing CAD, and here lies its' significance. Professor of architecture Dr. Ömer Akın explains Sutherland's contribution in the invention of CAD as follows:

> "Sutherland is responsible for the invention of the first CAD (computer aided-drafting) system called *Sketchpad*. With its devices of interactivity, and parametric and inheritance-based design concepts, *Sketchpad* was, and still is, nothing short of remarkable."[77]

In his own words, Sutherland explains the method in which his light pen operated as opposed to conventional means; "[c]onventionally, of course, drawing is an active process which leaves a trail of carbon on the paper. With a computer sketch, however, any line segment is straight and can be relocated by moving one or both of its end points"[78]. The advantage of the *Sketchpad* lies, in contrast to the conventional means, in the "ability to store information relating the parts of a drawing to each other"[79], meaning, as explained in Sutherland's text that it is possible for each element to get relocated independently without causing deformation to itself nor to the other elements, as it is apparent in the "winking girl" sketch in (figure 14) were the entire face is constructed by components of straight lines and partial circles drawn and relocated by the light pen, this process can be linked in nowadays software terms to the concept of "layering".

The role of the electronic devices in the production of architectural drawings became a matter of debate among architects. The *Sketchpad* divided architects in two groups; the first group was enthusiastic about the software, and linked the similarities in the process between freehand sketching with a regular pen on paper to sketching with the light pen on the *Sketchpad*, the second group went beyond the physical similarities, and believed that the software (although seemingly working with

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[77] Akın Ö. *Current Trends and Future Directions in CAD*. In Karimi, H. A., & Akinci, B. (2010). *CAD and GIS integration*. (Eds.). Boca Raton: CRC Press. p.4

[78] Sutherland, I. (2003). *Op. Cit*. p. 87

[79] *Ibid*. p. 19

traditional methods) offered new system in drawing with no actual benefits or advantages worth abandoning traditional sketching methods for.[80]

Architect William J. Mitchell (MIT) was one of the architects who had promising ideas about the role the *Sketchpad* could play in the future of architectural design in general and freehand drawing in particular. He states:

> "Beginning with I. E. Sutherland's very important pioneering *Sketchpad* system, an enormous amount of effort has been devoted to development of graphic input techniques which enable a user to sketch on the refreshed CRT[81] using a light-pen… The most natural and general mode of graphic communication for an architect is the rapid and unconstrained freehand sketch."[82]

As a contradictory position, Professor Sanford R. Greenfield was one of the architects who saw in computer-aided design a threat, yet, a predictable part of the development of architectural practice. In his *foreword* to the conference *Architecture and the Computer,* held at the Boston Architectural Center in Massachusetts in 1964, Greenfield states:

> "It is, perhaps, ironic that *SKETCHPAD* and computer graphics, the two tools most readily adaptable to the architect's work, themselves pose the greatest threat to his traditional role. The conference failed to discuss this aspect. … In retrospect, the conference seems to have served at least to alert the profession to an irresistible force which will readily alter the practice of architecture whether we plan for it or not. It is a force that can be controlled and directed to fulfill those values we judge essential, but only if we understand it and its relation to our traditional role."[83]

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[80] Kassem D. (2014). *The Sketchpad Window* (Unpublished Doctoral Dissertation). Virginia Polytechnic Institute and State University. p. 1-2

[81] CRT (Cathode-Ray Tube): "A vacuum tube used as a display screen in a computer monitor or TV. The viewing end of the tube is coated with phosphors, which emit light when struck by electrons". Source: PC Mag Encyclopedia. Retrieved 21.09.2017 from: https://www.pcmag.com/encyclopedia/term/40512/crt

[82] Mitchel, W. J. (1977) *Ibid*. p. 42

[83] Greenfield, S. R. (1964) Quoted in Kassem, D. (2014). *Op Cit.* pp 38-39

When Greenfield made this remark in the mid-1960s; it was a time before architects started using the combination of the mouse and the screen. Yet, the architect saw a threat in the *Sketchpad* which was basically a simulation of the traditional sketching method. The reason behind his concerns can be categorized in two aspects; first, the "limited" type of forms produced by the software and second, the socio-spatial impact of the type of designs in the computer-produced architecture.

The first aspect (the limited type of forms) is concerned with the limited capability of the *Sketchpad* to produce complex shapes and forms since it simplifies every data input into either a straight line or an arc that is part of a perfect circle. Architect Dalal Kassem notes the connection between this simplification and Leon Battista Alberti's fifteenth century text entitled "*On the Art of Building in Ten Books"*, where she quotes: "A line may be either straight or curved: there is no need here to deal with lines that spiral like a snail shell or a whirlpool"[84]. It is worth mentioning that while Alberti's seeking for simplification was rather a conceptual approach, the simplification brought by the *Sketchpad* was due to inadequacy of the available technology of the time. The Stanford Journal of Science, Technology, and Society "*Intersect*" remarks that "[t]his push towards 2-D sketch rendering was a step in the right direction for designers, but it was not technologically advanced enough to justify the complete replacement of analog drawings"[85]. Today, however, it can be said that tablet PC technologies overcame this disadvantage by allowing architects to freely express the forms in their minds with the movement of the digital pen on the tablet surface. Thus, having far more control on the outcome than at the time when the *Sketchpad* was first introduced.

The second aspect (the socio-spatial impact of computer-produced architecture) can be understood by exploring the thoughts of another prominent participant in the 1964 Boston conference; architect Christopher Alexander.

[84] Leon Battista Alberti, *On the Art of Building in Ten Books.* In Kassem, D. (2014). *Ibid*. p. 46

[85] Brown, P. (2009). *CAD: Do Computers Aid the Design Process After All?* Intersect: The Stanford Journal of Science, Technology and Society. Vol.2, No.1. p. 53

Alexander[86] opposed the use of computers as design generators labeling them as "huge army of clerks" that follow specific instructions while unable to think and create on their own[87]. Curiously, in the book "*Pattern: Ornament, Structure, and Behavior*", it is stated that Alexander, who is considered "the father of the Pattern Language movement in computer science"[88], did not reject the use of computers in architectural design but rather criticized the limitations brought by the dependence on the machine:

> "He (Alexander) was vehemently opposed to the popular tendency to ascribe artificial intelligence to computers. In response to the argument, fashionable at the time among developers of computer-aided design, that computers were able to swiftly generate a massive diversity of ground plans or façade variations from every conceivable perspective, Alexander declared[89] soberly, 'At the moment, the computer can, in effect, shows us only alternatives which we have already thought of. This is not a limitation in the computer. It is a limitation in our own ability to conceive, abstractly, large domains of significant alternatives.'"[90]

Civil engineer David E. Weisberg (MIT), who has been involved in the applications of computer technology to engineering design since the 1960s, assures that although the *Sketchpad* was a remarkable advancement, it was not feasible at the

[86] The attack of Alexander emerged from an attempt to create a hypothetical hospital space using computer-generated design based on an input of data. The design subject (the hospital) was chosen as a case study by J. C. R. Licklider (a psychologist and computer scientist) and architect Welden E. Clark in 1962 in their paper entitled *On-Line Man-Computer Communication*, and the role of the computer was to produce partial floor plans based on "anticipated time distribution of patient circulation in the hypothetical hospitals" and as a method, the design was basically created by using punch cards, the lines produced in computer were in the form of dots rather than continuous lines which could be later drawn by the *Sketchpad*. Source: Kassem, D. (2014). *Op Cit*. p 61

[87] Alexander, C. (1964). In Kassem, D. (2014) *Ibid.* pp 40-41

[88] Pattern Language (n.d.) *About Chris*. Retrieved 15.11.2017 from: http://www.patternlanguage.com/ca/ca.html

[89] Alexander, C. (1964). "*A Much Asked Question about Computers and Design*" Speech at "Architecture and the Computer". Proceedings of the First Boston Architectural Centre Conference. Boston, MA

[90] Gleiniger, A. and Vrachliotis, G. (2009). *Pattern: Ornament, Structure, and Behavior*. Birkhäuser Basel p. 29

time; building TX-2 computer that supported the software costed Air Force millions, as a result, "it was not viewed at the time as putting legions of drafters out of work in the near future."[91]

After the *Sketchpad*, the attempts to create computer-aided drawing software and hardware rapidly continued. In the same year, 1963, Timothy E. Johnson proposed *Sketchpad III* as his master thesis in MIT. This proposal was to enable three-dimensional drawings via computers. According to Weisberg, while using *Sketchpad*'s same monitor and light pen, *Sketchpad III* was the first system to present three orthogonal views of a three-dimensional object along with a perspective view that was possible to be shown in a different scale[92] (Figure 15).

Johnson described *Sketchpad III* objects to be in a wire-frame mode, since the problem of surface creation and manipulation was a work in progress at the time. This led to another problem, as he assures; the two-dimensional views of the object in the wire-frame mode failed to convey any depth perception, while the three-dimensional perspective alone was inadequate to present all the correct object information at once. Johnson thus summarizes three reasons for this orthogonal plus perspective layout: first, the three views fully explained a straight line in an object in three-dimensions, second, the simultaneous rotation of the views in 90 degrees increased the depth perception, and lastly, many *Sketchpad III* users felt uneasy sketching in perspective, thus preferred the conventional orthogonal system used by most draftsmen[93]. Two possible reasons linked to this last point could be that users were introduced to a dynamic mode of sketching which can be rotated in different angles, thus, controlling the sketch outcome from a single window became more difficult. Secondly, while sketching in perspective with a pen on paper did not

[91] Weisberg, D. E. (2008) *Op cit*. p 20

[92] Johnson, T. E. (1963) *Sketchpad III, Three Dimensional Graphical Communication with a Digital Computer*. Master Thesis. MIT

[93] *Ibid*. p 2

require precision and accuracy; the sudden move to accuracy and straightness of the lines brought by the software might have intimidated the users, and pushed them towards a safer sketching mode; that is the orthogonal mode. These problems have found solutions in some of the contemporary sketching applications; *Mental Canvas* for instance, which will be explored in the coming sections.

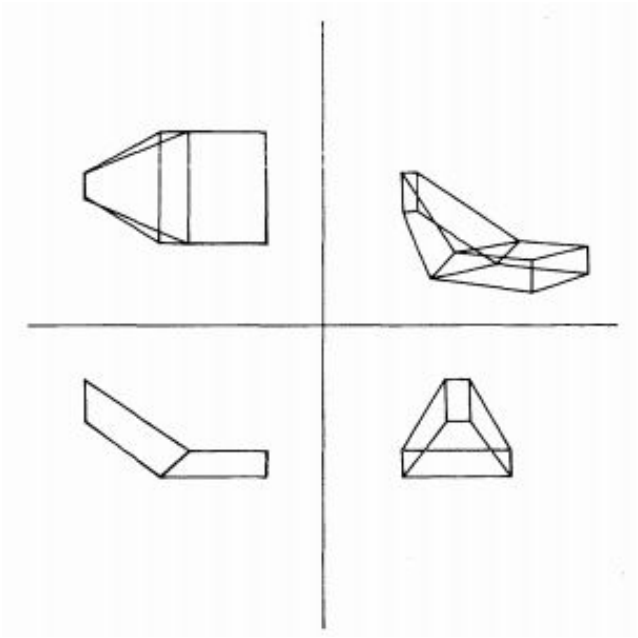

Figure 15: *SketpadIII* typical graphical presentation showing top, front, and side views plus a "3/4" perspective view
Source: Johnson, T. E. (1963) *Sketchpad III, Three Dimensional Graphical Communications with a Digital Computer*. Master Thesis. MIT. p. 348

In 1964, *RAND Corporations* introduced the *RAND Tablet* (Figure 16), which is considered to be the first digital tablet PC with a stylus enabling users to draw two-dimensional graphics: “It was felt that exploration of man’s existent dexterity with a free, pen-like instrument on a horizontal surface, like a pad or paper, would be fruitful”[94]. In this technology, users could sketch on the pad surface and see the

[94] Davis, M. R. and Ellis, T. O. (1964) *The RAND Tablet: A Man-Machine Graphical Communications Device*. FJCC, Spartan Books. p.1

result on the screen, this way, the displayed sketch would not be obscured by the hand or the physical pen, about the fields where the tablet could be beneficial in, it was stated that applications requiring "excellent linearity" and "accuracy" would find it practical[95], which was certainly not the case in architectural sketching.

These two-dimensional wire-frame sketches whether done in the *Sketchpad*, *Sketchpad III* or *RAND Tablet*, lacked surface recognition, which meant as mentioned previously that they could not fully provide a sense of depth usually given by shades and shadows. In 1968, Arthur Appel from *IBM* Research Center tried to overcome these problems by developing a system that simulates shades and shadows effects in a computer-executed plane. The technique known as *chiaroscuro*[96] held promising applications in various aspects including architectural graphic communication:

> "Some applications of computer graphics require a vivid illusion of reality. These include the spatial organization of machine parts, conceptual architectural design, simulation of mechanisms, and industrial design… If techniques for the automatic determination of chiaroscuro with good resolution should prove to be competitive with line drawings, and this is a possibility, machine generated photographs might replace line drawings as the principal mode of graphical communication in engineering and architecture."[97]

Weisberg comments on this quote by saying that although it took about three decades for Appel's expectations to see the light, today, "color shaded images of mechanical products, buildings and process plants are used as the primary means of exchanging design information between relevant parties"[98]. Unlike today's plotting

[95] *Ibid*. pp. 3-21

[96] From Italian: *chiaro*, "light," and *scuro*, "dark", *Chiaroscuro* is a technique employed in the visual arts to represent light and shadow as they define three-dimensional objects. Source: Encyclopedia Britannica. Retrieved 23.10.2017 from: https://www.britannica.com/art/chiaroscuro

[97] Appel, A. (1968) *Some techniques for shading machine renderings of solids.* Proceedings of the 1968 Spring Joint Computer Conference, Atlantic City, N.J. Vol. 32. Thompson Books, p. 37

[98] Weisberg, D. E. (2008) *Op cit*. p 15

technology using pixels, Appel's system used plus signs that varied in sizes and frequencies to indicate shaded and shadowed areas (Figure 17).

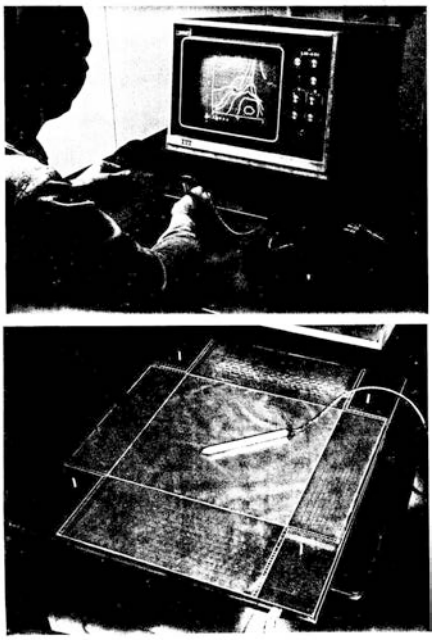

Figure 16: The *RAND* Tablet
Source: Davis, M. R. & Ellis, T. O. (1964) *The RAND Tablet: A Man-Machine Graphical Communications Device.* FJCC, Spartan Books. pp.2-7

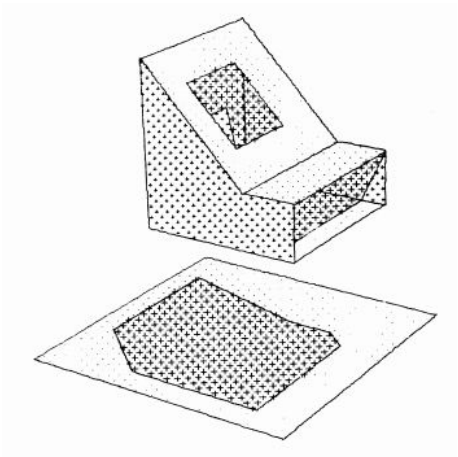

Figure 17: A Shaded Drawing Using Appel's *Chiaroscuro* System
Source: Appel, A. (1968) *Some techniques for shading machine renderings of solids.* Proceedings of the 1968 Spring Joint Computer Conference, Atlantic City, N.J. Vol. 32. Thompson Books, p. 38

Inspired by the *Sketchpad*, computer scientist Alan Kay presented in 1968 what he called the *"Dynabook; A personal computer for children of all ages"*[99], it was a thin portable tablet PC with keyboard rather than a stylus, however, it was never built but laid the foundations to the design of laptop computers. Another significant advancement in CAD software took place in 1972, when computer scientist Patrick J. Hanratty, who is considered to be the father of CAD/CAM[100] systems, introduced *ADAM* (Automated Drafting and Machining) software which the majority of today's commercial drafting software root back to[101]. Soon afterwards, personal computers began emerging starting from the 1975 *MITS Altair 8800* followed by *IMSAI 8080;* these computers were composed of metal cases without monitors or keyboards, and users had to write their own programs to operate the machines[102]. Two years later, in 1977, French aircraft industrialist Marcel Dassault and his team developed *CATI*[103] for their personal use in air craft industry which later developed to become *CATIA*[104]; the first commercial CAD software to be used by architects as well, which would remark the start of the second period in this study.

[99] History of Computers (n.d.) *The Dynabook of Alan Kay.* Retrieved 14.10.2017 from: http://history-computer.com/ModernComputer/Personal/Dynabook.html

[100] CAD/CAM stands for Computer Aided Design and Computer Aided Manufacturing

[101] Autodesk (n.d.) *CAD innovation over the years.* Retrieved 14.10.2017 from: https://www.autodesk.com/campaigns/inspired-by-autocad/cad-innovation

[102] Old Computers (n.d.) *MITS Altair 8800.* Retrieved 14.10.2017 from: http://oldcomputers.net/altair-8800.html

[103] CATI: Conception Assistée Tridimensionnelle Interactive – French for Interactive Aided Three-dimensional Design, it was developed as a surface modeler to assist in designing the Dassault fighter jets. Source: Allford, M. (1977). *History of Innovation 1977 CATIA.* Retrieved 15.10.2017 from: https://aehistory.wordpress.com/1977/01/01/1977-catia/

[104] CATIA: Computer Aided Three-dimensional Interactive Application

3.2 1981- The CAD Flourish

Bryan Lawson, author of the book "*How Designers Think: The Designing Process Demystified*", states that the introduction of the "third generation[105]" of computers around the mid-1960s enabled research into computer-aided design despite the fact that these machines were large and institutionally owned computers that could not be practical for individual design studios. The "fourth generation", Lawson continues, availed computers to be mass-produced for domestic and business purposes accompanied by plotters and printers, nevertheless, he notes that it was not the massive technical advances themselves but rather the extent to which these advances penetrated society that influenced computer aided architectural design[106]. Although fourth generation computers have been available since 1971[107], it can be said that the actual impact of technology on architectural design began in 1981 with three significant events; in hardware terms, the release of the first *IBM* PC (*5150 PC*) affordable by the masses and the development of the first PC mouse by *Xerox*, and in software terms; the introduction of *CATIA* to the market. The following year, 1982, witnessed the foundation of *Autodesk* by computer programmer John Walker which became one of the most leading software companies in architectural design until today.

[105] Lawson states that the first generation of computers (around the mid 1940s) depended on valves and were vast in size and small in capacity, besides, required teams of technicians and engineers to look after. In the second generation (mid 1950s), valves were replaced with transistors, making the machines faster and more compact. Integrated circuit enabled the production of computers on a single device creating the third generation. The fourth generation, came with "chips" and was small enough for microcomputers to be mass-produced.

[106] Lawson, B. (1990) *How Designers Think: The Designing Process Demystified* (2nd Ed.) Butterworth Architecture. London. pp196-199

[107] "The period of fourth generation was from 1971 to present. The fourth generation computers were developed using microprocessor. Intel 4004 chip was the first microprocessor developed in 1971." Source: Computer Basics> Generations of Computers> Fourth Generation. Retrieved 24.10.2017 from:http://www.physics-and-radio-electronics.com/computer-basics/generations-of-computer/fourth-generation.html

In the following section, a list of the most influential CAD software packages in architectural design[108], along with pre-smart age sketching programs, will be elaborated in a chronological order.

3.2.1 WIMP[109] Based Architectural Drawing

WIMP based architectural drawing software can be organized in three main groups: two-dimensional drafting, three-dimensional modeling and BIM (Tables 2, 3 and 4). Choosing the right software among these for the designer depends mainly on five factors:

- The desired outcome.
- The interface complexity and the software learning speed.
- The software compatibility with other software products in importing from, or exporting to other formats.
- The software compatibility with the computer operating system; *Windows*, *Mac*, and *Linux* for example.
- The cost of the software license.

[108] Some other significant CAD software such as *Solidworks*, *Trispective (IRONCAD)*, *Solid Edge* and *Autodesk Inventor* were not added to the list since they have been developed mainly for other disciplines of engineering and not for architectural design studios.

[109] WIMP stands for (windows, icons, menus, and pointers) interface and is a subset of GUI (Graphical User Interface). WIMP-based systems depend on mouse and keyboard while other GUI systems use different types of input such as touchscreen display.

Table 2: Two-dimensional Drafting Software
Source: Author

Software	Year	Developer(s)	Properties
AutoCAD	1982	*Autodesk* (USA)	• The most widely used drawing software. • A rather simple interface and lower cost in comparison to other complicated software such as *CATIA*. • Started as 2D drafting software and in 1985, *AutoCAD 3D* was released, opening the door to many innovations, including, but not limited to, BIM[110].
MicroStation	1986	*Bentley Systems*[111] (USA)	• CAD software for two and three dimensional design and drafting. • Similar to *AutoCAD* with more icons and menus and less typing. • Depends more on computer mouse and less on keyboard.
TurboCAD	1986	Hendrik Vermooten and Hein Oosthuizen (South Africa)	• A mid-range 2D/3D drafting software lower in cost in comparison to its main competitor *AutoCAD*.

[110] Autodesk (n.d.) *Op Cit.*

[111] Not to be confused with the UK based luxurious car makers *Bentley Motors* who, according to their Head of Design Dirk van Braeckel, also use clay models along with various CAD software in their car designs such as *Alias* and *Icem Surf* for the surface modeling, *Catia V5* for engineering and *Photoshop* for realistic renderings. Source: Poldre, L. (2012) *Interview with Dirk van Braeckel, Head of Design at Bentley Motors*. GrabCAD Blog. Retrieved 15.11.2017 from: http://blog.grabcad.com/blog/2012/04/24/interview-with-dirk-van-braeckel-head-of-design-at-bentley-motors/

Table 3: Three-dimensional Modeling Software
Source: Author

Software	Year	Developer(s)	Properties
CATIA	1981	*IBM* in collaboration with Marcel Dassault (USA)	• Three-dimensional modeling program for multi-disciplinary users. • Became a tool for architects after it had been exclusively used by aircraft designers. • A significant CAD/CAM/ CAE[112] software. • Architect Frank Gehry's studio is one of the most well-known users. • Not widely preferred in small practices for its' high cost and complexity.
ProEngineer	1987	*Parametric Technology Corporation (PTC)* (USA)	• A CAD/CAM/CAE PLM[113] software. • Currently known as *Creo Parametric* • Developed as mechanical CAD software but caused a major change in architectural 3D CAD industry by introducing the concept of 'parametric modeling'[114]
3D Studio	1990	*Autodesk* in collaboration with *The Yost Group* (USA)	• Later known as *3ds Max.* • Released as modeling and visualization software that is widely used to produce high quality renderings.
Maya	1998	*Alias|Wavefront* (USA) Currently owned by	• Three-dimensional animation, modeling,

[112] CAE stands for Computer Aided Engineering

[113] "Product lifecycle management (PLM) is an information management system that can integrate data, processes, business systems and, ultimately, people in an extended enterprise. PLM software allows users to manage this information throughout the entire lifecycle of a product efficiently and cost-effectively, from ideation, design and manufacture, through service and disposal". Source: SIEMENS (n.d.) *What is PLM Software?* Retrieved 10.10.2017 from: https://www.plm.automation.siemens.com/en/plm/

[114] Gindis, E. and Kaebisch, R. (2017) *Up and Running with AutoCAD 2018: 2D Drafting and Design*. [E-Book]. pp 511-512.

		Autodesk	simulation, and rendering software. • Mostly used for film making. • similar to *3ds Max*, however, *3ds Max* offers better compatibility with other *Autodesk* products such as *AutoCAD*
Rhinoceros	1998	*Robert McNeel & Associates* (USA)	• Mainly used for modeling and visualization. • Can produce parametric design with the help of various plugins such as *Grasshopper*.
SketchUp	2000	*@last Software* (USA), Currently owned by *Google LLC*	• Simple and fast three-dimensional modeling software. • One of the most commonly used programs in the early design phase. • It can be considered the easiest software to learn among this list.

Table 4: BIM Software
Source: Author

Software	**Year**	**Developer(s)**	**Properties**
Allplan	1984	*Nemetschek* (Germany)	• The first software to be based on BIM concept. • The most difficult to learn among *Nemetschek* BIM software products.
Vectorworks	1985	*Diehl Graphsoft* (USA), currently part of *Nemetschek*	• Mostly for individual designers and small projects.
ArchiCAD	1987	*Graphisoft* (Hungary), currently part of *Nemetschek*	• The first BIM software to be available on a personal computer. • Suitable for individual as well as team production. • Offers MEP[115] support.
Revit	2000	*Revit Technology Corporation* (USA) Currently owned by *Autodesk*	• One of the most widely used BIM software. • Similar and competitor with *ArchiCAD*

[115] MEP stands for Mechanical Engineering Project.

Digital Project	2013	*Gehry Technologies* (USA)	• A design, engineering and fabrication BIM software. • Suitable for creating powerful and complete parametric modeling. • Possibly the highest in cost and the most complex to learn.

In a conversation with architect and academician Cho Im Sik, Dutch architect, artist and author Lars Spuybroek makes a significant remark stating that one "cannot 'do' computer without 'thinking' computer" [116], this could be understood as such that the designer can utilize computer tools and programs only after fully understanding the logic behind each tool/ program. For example, the act of drawing a wall plan in two dimensional CAD is very different than drawing the same wall in BIM. In two-dimensional CAD, the wall in plan is drawn two dimensionally either by using four lines similar to drawing by a pencil or by drawing one thick line similar to using thick marker. The process is repeated afterwards in section, elevation and three-dimensional perspectives. In BIM, the wall is drawn once by entering predetermined full information such as height, width, thickness and materials. Designers need to be aware of these differences in the same way they are aware of the differences in functions and methods of manual sketching and drawing tools. The architect further argues that the majority of design tools used prior to the digital age such as copying, rotating and aligning are considered "primitive computer tools". He supports his argument by quoting from theorist and architect Bernard Cache that design equipment, compass and ruler for instance, are "very simple computers". As a result, Spuybroek continues: "we have always used computers. So there is no inherent opposition to design with and without computers"[117].

[116] Spuybroek, L. (2008). *The Architecture of Continuity: Essays and Conversations*. V2_Publishing. Rotterdam: Nai. p. 162

[117] *Ibid.*

This statement of Spuybroek is not an underestimation of the power a computer as a tool embodies since no tool is innocent as he assures, and rendering computers as merely tools is a misunderstanding of both computing and technology[118]. The point he tries to make lies in the idea that architects need to utilize the computer's potential to the maximum and search for more complex forms, forms that can't be executed by traditional tools, in other words, to intervene at the phase where the pencil must leave:

> "In a time and world where we can truly think complexity, we shouldn't deny ourselves an architecture of the complex. I don't think it's responsible that as we acknowledge the complexities of life, of perception, of social patterns, we architects keep throwing cubes at the world. Minimalists just can't accept life in its impurity and complexity."[119]

Spuybroek's enthusiasm about the computers' ability to transform freehand sketches into all kinds of complex forms, brings with it another major concern related to architectural discipline; in current day practice, focus is made more on rapid fabrication, minimal calculations, and building's performance in regards to climatic concerns. This might be pushing aesthetical concerns into secondary level. Architect and writer Karrie Jacobs believes that this issue might be behind the negative publicity some of the world-wide known architects are receiving. Santiago Calatrava, for instance, is labeled with sketches that look like "worst-case scenarios, architecture as extravagance, the Versailles School of infrastructure" which then turn into behind-schedule over-budget projects, while Frank Gehry is known for formalism but not for pragmatically-thinking[120]; and these are among architects who are "watching their stars fall" as Jacobs assures:

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[118] *Ibid.*

[119] *Ibid*. p. 163

[120] Jacobs, K. (2014) *Santiago Calatrava: The World's Most Hated Architect.* Co.Design. Retrieved 25.07.2017 from: https://www.fastcodesign.com/3039658/santiago-calatrava-the-worlds-most-hated-architect

> "We live at a time when LEED[121] Platinum certification, a mark of a building's sustainability and the product of endless small calculations, is a status symbol. Many architects rely on computer design that manipulates aesthetic gestures to favor programmatic ones. In this era, the grand aesthetic gesture is deeply suspect."[122]

Technology correspondent for TV Channel *Sky News* and the author of the book "*The Explorer Gene*" Tom Cheshire approaches architectural design software from a different point of view. He states that in the case of BIM, while the software simplifies the design process, it could lead to killing creativity. In the interview he holds with Benjamin Marks, the head designer and owner of a London-based architecture and design firm, the architect states that design used to start with a drawing either on paper or computer, BIM, however, is not about drawing lines but rather assembling smart objects. This way "BIM will only enable you to build what the construction industry enables you to build, because it's inherently linked into products that are available… It might open up the gap between so-called commercial practices and so-called design-led practices", and as a result, Marks believes this will divide architects into two groups of "artists" and "technicians"[123], the second group's work can be classified as component collection practice similar to Sutherland's "winking girl". A possible outcome is that in order to avoid being limited to the software capabilities, "artist" architects will either need to hire "technician" architects specialized in complex software or devote time and practice to learn the complex software themselves. While complex designs do not necessarily require computers, it is important to note that "time" is also a crucial factor in today's architectural practice. Historical monuments such as the Duomo in Milan, for example, might have taken six centuries[124] to be completed, however, the time

[121] LEED: Leadership in Energy Efficient Design.

[122] Jacobs, K. (2014). *Ob Cit.*

[123] Cheshire, T (2017) *BIM's 'Google Docs for buildings' is transforming architecture – but could it kill creativity?* WIRED Magazine. Retrieved 10.10.2017 from: http://www.wired.co.uk/article/architecture-software-creativity

[124] The construction started in 1386 but wasn't officially opened until 1965.

interval between the initial design of a building and completion of the construction today is not more than few years.

3.2.2 Digital Pen and/ or WIMP-Based Architectural Sketching

While mouse-based drawing software started dominating the field of architectural drawing production, some attempts were made to introduce digital tools to quick sketching phase as well whether with mice or digital pens. Johnson et al state that those digital pens were largely affected by the dominance of mice until the 1990s, when commercial tools based on the digital recognition of handwriting began to find their way into the market[125]. The same observation was made by Mark D. Gross[126] along with Ellen Yi-Leun Do[127]:

> "A look at Ivan Sutherland's pen-based '*Sketchpad*' program reminds us that interacting with computers through a pen-based interface is not a new idea. As early as the 1970s, interest in machine processing of hand drawn diagrams led to some experimental sketch recognition systems. However, with the widespread acceptance of mouse and menu (WIMP style) interfaces in the 1980s, general interest in pen-based input waned, and did not revive until inexpensive and cordless digitizing technologies became widely available in the 1990s."[128]

[125] Johnson, G., Gross, M. D., Hong, J. and Yi-Leon Do, E. (2009). *Op Cit.* p.6

[126] Architect and a professor of computer science, Gross has works and publications in various areas of research such as intelligent computer aided design, virtual environments and design simulation, modular robotics and computationally enhanced construction kits and craft, tangible interaction design, sketch and diagram recognition, and digital fabrication. He co-developed digital sketch software such as *Digital Clay*, and sketching to fabrication software such as *Zotebook.*

[127] Architect and professor Do has numerous publications in the fields of design computing, creativity and cognition, tangible interaction and human-computer interaction. She, along with Gross, co-developed sketch software such as *BoE (Drawing of the Back of an Envelope), VR Sketchpad*, and sketching to fabrication software such as *Sketch It Make It.*

[128] Gross, M. and Yi-Luen Do, E. (2000). *Drawing on the Back of an Envelope: a framework for interacting with application programs by freehand drawing*. Computers & Graphics 24. p.836

While not as popular as in today, some important pen-based tablets did emerge in the 1980s such as *Koala Pad* in 1984 followed in the same year by *Wacom WT Series*. *Koala Pad* was a tablet that worked with PC; users could use any stylus or pointer on the pad surface to produce freehand sketches or geometrical shapes in colors, other features such as copy, mirror, fill and zoom were also available (Figure 18). The overall quality of the sketches made by the pad was unsatisfactory at the time since lines were not fluent enough; as a result, the device was discontinued. *Wacom*, on the contrary, produced many tablets with accompanying digital pens that made their way to design studios and audiences such as digital artists, graphic designers, illustrators, and architects (Figure 19). Professor of architecture and urban design Ray Gordon states that he prefers sketching with *Wacom* tablets for architectural drafting purposes since they are slim devices with highly accurate, ergonomic, pressure-sensitive pens, and an easy software installation. Sketching with a mouse on the screen, Gordon continues, is impractical due to difficulties in maneuvering and lack of accuracy, adding to that, putting more strain on the wrist while drawing[129]. After *Wacom* tablets; *Apple* released the *Newton MessagePAD* in 1993, which in itself did not influence architectural design but would later lay the seeds to current-day *iPad*s. A broader review of *Wacom* and other sketching tablets such as *iPad* will take place in section 3.3 (2007- Smart Technology Invasion).

[129] Gordon, R. (2013). *Wacom Pen Tablets Review*. Boomer TECH Talk. Retrieved 15.11.2017 from: http://boomertechtalk.com/review-wacom-pen-tablets/

Figure 18: The *KoalaPad* Touch Tablet Box
Source: Vernoni G. M. (2015) *Koala Technologies KoalaPad TouchTablet*. Old Computer. Retrieved from: http://www.oldcomputr.com/koala-technologies-koalapad-touchtablet/

Figure 19: *Wacom* Tablet in Use
Source: Square Group (2013) *Wacom Intuos Pro Review September 2013*. [Video file] Retrieved 15.10.2017 from: https://www.youtube.com/watch?v=sVCnKHQHqUY

Apart from tablets, a number of sketching software developments and researches were conducted by scientists and academicians who major in architecture or directly related field(s). Some of these sketch tools found their way to markets while others were meant for academic research environments. A number of the most influential of these software products are as follows[130]:

Table 5: Sketching Software Developments
Source: Author

Software	Year	Developer(s)	Properties
3DM (Figure 20)	1992	Butterworth et al	• Using a Head-Mounted-Display (HMD) and sketching three-dimensional surfaces in a virtual environment. • A very early approach to model in Virtual Reality (VR)[131]
Sculptor (Figure 21)	1995	Kurmann	• A geometry based approach to make and manipulate simple volumes in virtual space simply by clicking and dragging[132].

[130] These programs and their brief comparisons were listed in Schubert, G., Artinger E., Yanev, V., Petzold, F. And Klinker, G. (2012) *3D Virtuality Sketching: Interactive 3D-sketching based on real models in a virtual scene.* Presented at Proceedings of the 32nd Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA). The last software *ILoveSketch* was not mentioned in this paper but in Schubert, G., Tönnis, M., Yanev, V., Petzold, F. And Klinker, G. (2014) *Dynamic 3D-Sketching: A Design Tool for Urban and Architectural Design*. In Gu, N., Watanabe, S., Erhan, H., Haeusler, M. H., Huang, W., and Sosa, R. (eds.) (2014) *Rethinking Comprehensive Design: Speculative Counterculture*. Proceedings of the 19th International Conference on ComputerAided Architectural Design Research in Asia. The Association for Computer-Aided Architectural Design Research in Asia (CAADRIA), Hong Kong

[131] Virtual Reality (VR) is about creating computer-generated environment replacing the real world, while Augmented Reality (AR) is about overlaying digital content onto the real world, meaning that unlike virtal reality, augmented reality users can still see, feel, and be aware of the surrounding environment. Source: Friedman, E. (2016). *Augmented and Virtual Reality for Architecture, Engineering and Design.* Brainxchange. Retrieved 20.09.2017 from: https://brainxchange.io/augmented-virtual-reality-architecture-engineering-design/

[132] Kurmann, D. (1995). *Sculptor - A Tool for Intuitive Architectural Design*. In Tan, M. and Teh, R. (eds) The Global Design Studio - Sixth International Conference on Computer Aided Architectural= =Design Futures (CAAD Futures), Centre for Advanced Studies in Architecture National University of Singapore, Singapore. pp. 323-330

Digital Clay (Figure 22)	1998	Schweikardt and Gross	• Sketch recognition software that interprets abstract drawings and constructs three-dimensional models accordingly. • Sketches are made with a stylus on a touch-screen surface[133].
Teddy (Figure 22)	1999	Igarashi, Matsuoka and Taraka	• Sketch tool using pen on display-integrated tablet, users could draw two dimensional forms that the software uses as basis to construct three-dimensional polygonal surfaces[134].
BodyPaint 3D	2000	*Maxon*	• Software that applies texture directly to a three-dimensional volume using UV mesh. • A virtual three-dimensional model is needed to be constructed first[135]. • Currently embedded as a tool set in *Cinema 4D*[136] and can be used to create realistic animations of virtual architectural environments (a sketch tool for the post-production phase).
DDDoolz (Figure 21)	2000	Achten, de Vries and Jessurun	• The basic drawing element is a cube that constructs arrays representing building masses[137], similar to *Sculptor*.

[133] Schweikardt, E. and Gross, M.D. (1998) *Digital Clay: Deriving Digital Models from Freehand Sketches*. ACADIA'98 Association for Computer-Aided Design in Architecture. p. 202

[134] Igarashi, T., S. Matsuoka, and H. Tanaka. (1999). *Teddy: A Sketching Interface for 3D Freeform Design*. Proceedings of the Siggraph 1999 (26): 409–16. Los Angeles: ACM.

[135] Schubert, G., Artinger E., Yanev, V., Petzold, F. And Klinker, G. (2012) *Op Cit*. p.4

[136] Since *Maxon* is part of *Nemetschek*, Cinema 4D performs best with *Nemetschek* BIM products such as *Allplan*.

[137] Achten, H., De Vries, B. and Jessurun, J. (2000) *DDDOOLZ A Virtual Reality Sketch Tool for Early Design*. CAADRIA 2000: proceedings of the Fifth Conference on Computer Aided Architecture Design Research in Asia, School of Architecture, The National University of Singapore. pp 451-460

The Augmented Round Table (Figure 20)	2003	Wolfgang Broll et al	• *B*ased on Augmented Reality (AR) unlike *3DM.* • Offered possibility to create and modify three-dimensional objects in real environment by using sticks and gestures[138].
ILoveSketch (Figure 22)	2008	Bae et al	• three-dimensional sketching software similar to *Teddy*
Sketch Book (Figure 23)	2009	Schneider and Petzold	• Sketching in virtual three-dimensional scene by placing transparent layer over the entire virtual scene.

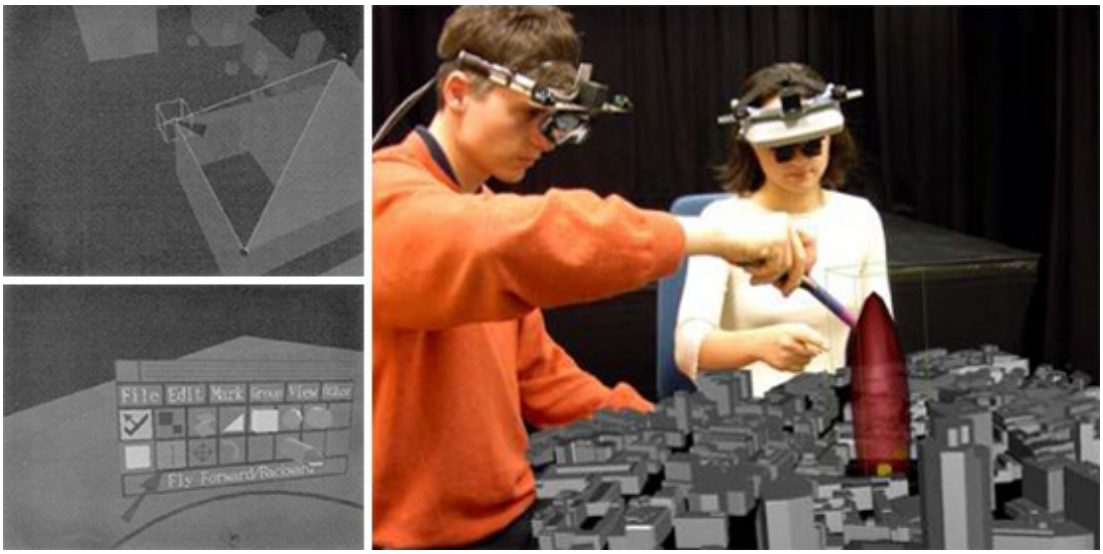

Figure 20: Left: 3DM; sketching in VR (Virtual Reality), right: *The Augmented Round Table*; sketching in AR (Augmented Reality) (Collage by author)

Sources: Left: Butterworth, J. et al. (1992). *3DM: A Three Dimensional Modeler Using a Head-Mounted Display*. Proceedings of the 1992 Symposium on Interactive 3D graphics. ACM Press. p. 136.

Right: Broll, W., Stoerring, M. and Mottram C. (2003) *The Augmented Round Table – a new Interface to Urban Planning and Architectural Design*. In Rauterberg, M. et al. (eds.) Human-Computer Interaction—Interact '03.p. 1103

[138] Broll, W., Stoerring, M. and Mottram C. (2003) *The Augmented Round Table – a new Interface to Urban Planning and Architectural Design*. In Rauterberg, M. et al. (eds.) Human-Computer Interaction—Interact '03.p. 1103

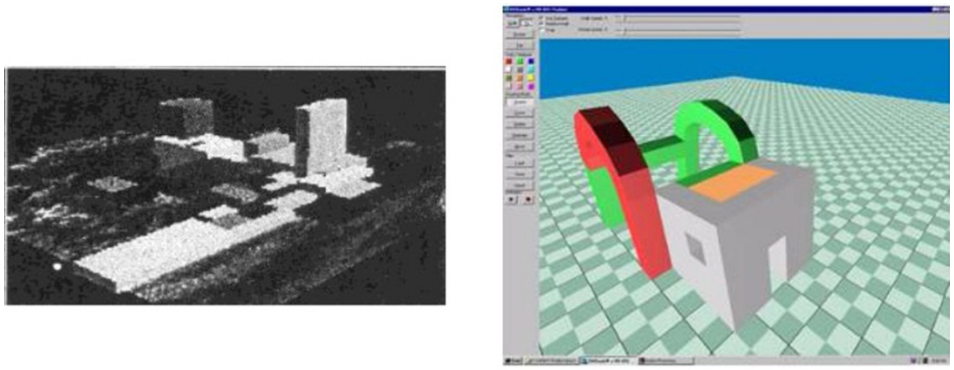

Figure 22: Left: Scene created with *Sculptor*, Right: Sketch created in *DDDoolz*
Sources: Left: Kurmann, D. (1995). *Sculptor - A Tool for Intuitive Architectural Design*. In Tan, M. and Teh, R. (eds) The Global Design Studio - Sixth International Conference on Computer Aided Architectural Design Futures (CAAD Futures), Centre for Advanced Studies in Architecture National University of Singapore, Singapore. p. 326
Right: Achten, H., De Vries, B. and Jessurun, J. (2000). *DDDOOLZ A Virtual Reality Sketch Tool for Early Design*. CAADRIA 2000: proceedings of the Fifth Conference on Computer Aided Architecture Design Research in Asia, School of Architecture, The National University of Singapore. p. 3

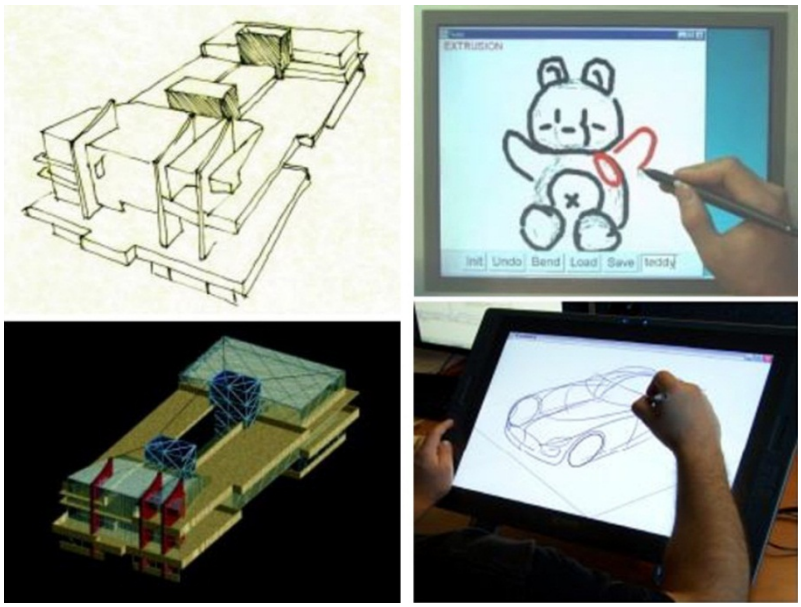

Figure 21: Left: Architectural sketch with digital model created in *Digital Clay*, Right above: A sketch made in *Teddy* and below: A sketch made in *ILoveSketch* (Collage by author)
Sources: Left: Schweikardt, E. and Gross, M.D. (1998) *Digital Clay: Deriving Digital Models from Freehand Sketches.* ACADIA'98 Association for Computer-Aided Design in Architecture. p. 205.
Right above: Igarashi, T., S. Matsuoka, and H. Tanaka. (1999). *Teddy: A Sketching Interface for 3D Freeform Design.* Proceedings of the Siggraph 1999 (26). Los Angeles: ACM. p.409
Right below: Bae, S. H., Balakrishnan, R. and Singh, K. (2008). *ILoveSketch: as-natural-as-possible sketching system for creating 3d curve models*. UIST '08 Proceedings of the 21st annual ACM symposium on User interface software and technology. p. 151

Figure 23: Digital model and a digital sketch made by *Sketch Book*
Source: Schneider, S. and F. Petzold. (2009). *A Virtual Design Platform: Bridging Barriers When Designing with Computers*. Proceedings of eCAADe 2009. eCAADe 2009. Istanbul (27) p.211

By closely examining the descriptions of these programs, it can be noted that all of them had one thing in common; they did not try to merely introduce digital tools into sketching, but rather sought to interpret a way of sketching that would combine two-dimensional doodling along with three-dimensional modeling. Among the aims behind this "digitizing" of hand-sketches were to simplify three-dimensional modeling for users with inadequate experience with the digital mode of designing, and to be able to directly transfer the sketch into digital format and eliminate the process of imitating and reproducing the exact sketch in complex software, since "this rift in media is inherently distracting, and the translation process often necessitates a copious amount of time spent redrawing and digitizing existing work"[139]. In addition, the projects that involved augmented reality (AR) and virtual reality (VR), attempted to make three-dimensional relationships easier to comprehend by placing the user in the modeling space in a natural intuitive environment[140].

[139] Schweikardt, E. and Gross, M.D. (1998) *Op. Cit*. p. 204

[140] Butterworth, J. et al. (1992). *3DM: A Three Dimensional Modeler Using a Head-Mounted Display*. Proceedings of the 1992 Symposium on Interactive 3D graphics. ACM Press. p. 135

Since sketching and model making have always intrigued architects in the early stages of design, there were other attempts to integrate physical sketch models with freehand sketching in the digital environment. As Pallasmaa points out; both the line and the model crafted by the human hand are "expressive and emotional", and computers are essentially different in that sense[141]. A research pursued by a team led by Gerhard Schubert from Technical University of Munich entitled "*3D Virtuality Sketching*", was an attempt in this direction. The team listed a comparison of the advantages of sketching and model making showing that while freehand sketching was fast, flexible and able to represent any scale, sketch models excelled in spatial impression, ability to be explored and manipulated with both hands, and offering tactile feedback[142] (although lacking features such as walk-through animations). For this reason, Schubert continues, and since the previously listed tools dealt with one field of activity meaning that users had to switch tools for different tasks, leading to interrupting the process, they attempted to develop a tool which enabled the use of physical models with digital cameras that projected various views on a screen for the user to digitally sketch on, and those sketches were interactive; they changed their position whenever the point of view on the screen changed (Figure 24):

> "The aim is to develop digital tools that strengthen rather than hinder the design process so that a continuous workflow results according to the motto 'the simper the tool is to use, the less it gets in the way of the actual process of designing'. As a result, established design tools are not entirely replaced by digital methods but instead combined with a view to making the most of both worlds: by combining the advantages of each realm, we expand the possibilities of designing in real and virtual environments"[143].

[141] Pallasmaa, J. (2009). *Op. Cit*. p. 100

[142] Schubert, G., Artinger E., Yanev, V., Petzold, F. And Klinker, G. (2012) *Op Cit*. p.5

[143] *Ibid*

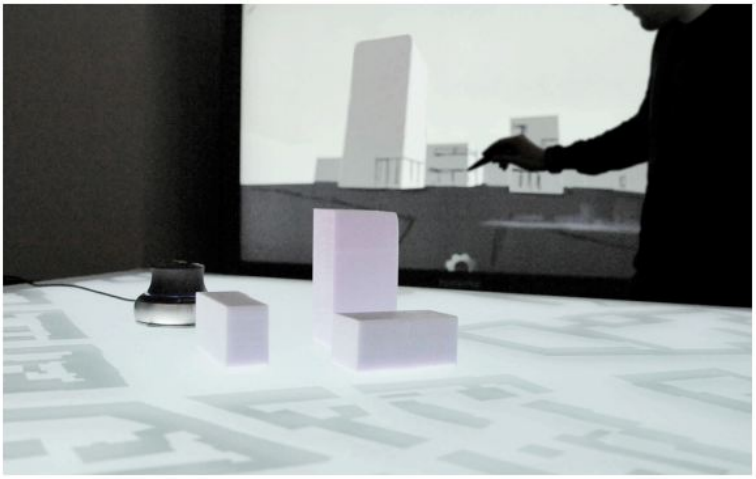

Figure 24: Multi-touch table with integrated 3D object recognition and directly linked 3D drawing tool in the background
Source: Schubert, G., Artinger E., Yanev, V., Petzold, F. And Klinker, G. (2012) *3D Virtuality Sketching: Interactive 3D-sketching based on real models in a virtual scene.* Presented at Proceedings of the 32nd Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA). p. 414

While the listed programs seemed to perform better for individual designers, this system of Schubert et al held potentials for collaborative designing with multiple users who could work on the table and the screen and provide feedbacks for one another. Whether physical models are more convenient than digital models in the early stages of design is a matter of debate; and it comes to the individual designer's choice to favor one medium over the other. By setting model medium aside, one problem could be noted in this system is that, unlike other programs, sketching surface is set perpendicular to the table; this may cause sketching position to become less comfortable for the designer.

Although the results of these programs were not quite satisfactory in terms of facilitating the transition from hand-sketching to screen-drawing (since they did not develop into essential design tools for the architects who depended on computers in the first place); they, nevertheless, paved the way into current day more complex, yet, more user-friendly sketching programs. In fact, it is possible to say that programs such as *DDDoolz* and *Sculptor* were early versions of the currently widely-used *SketchUp*.

3.3 2007- Smart Technology Invasion

Although the term "smartphone" is usually associated with the 2007 introduction of *iPhone*, it was known since the mid-1990s describing mobile phones that came with a touchscreen, a stylus, and a keyboard[144]. Steve Jobs, the former CEO and co-founder of *Apple Inc*., criticized these "smartphones" for "not being so smart" and moreover, being difficult to learn and use. *Apple* attempted in its "revolutionary" *iPhone* to get rid of both the stylus and the keyboard and substitute them with a "multi-touch" technology that was far more accurate, ignoring unintended touches and offering the possibility for multi-finger gestures, and the result was an "interplay of hardware and software"[145]. This phone and the *iPad* that followed in 2010 brought other advantages such as high-resolution photography, "desktop-class applications", and the ease of internet access. This advancement in photography meant, in terms of architectural practice, rendering "sketching as observation" in this era unnecessary since digital photography became much more abundant (architects may not carry digital cameras or logbooks all the time but they do carry mobile phones as an inseparable equipment). Moreover, the instant digital photography along with the ease of internet access brought by these devices simplified transferring ideas among architects, especially in "sketching as a tool for communication" and in the early stages of design in particular. What the smartphone and smart tablet PC did here was that, instead of digitally photographing or scanning a sketch and then transferring the digital photograph into a computer with internet access, a single small-sized portable device brought all these steps down into two clicks: one to take the photograph and one to send it. An example is mentioned in an interview Martin Pederson held with Steven Holl:

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[144] In fact, the term made an appearance in 1990 issue of "*Popular Science Magazine*" describing a "programmable" land phone with "touch-sensitive buttons" on the screen. *Ericsson* was the first company to coin the term with its *Ericsson GS88 Penelope* mobile phone composed of a touch screen, a stylus and QWERTY keyboard. Source: English Langage and Usage (n.d.) *Smartphone*. Retrieved 17.11.2017 from: https://english.stackexchange.com/questions/281682/origin-of-the-term-smartphone

[145] Appleblub/N2TechGeeks (2013) *Steve Jobs - iPhone Introduction in 2007 (Complete).* [Video file]. Retrieved 15.10.2017 from: https://www.youtube.com/watch?v=9hUIxyE2Ns8

> "When he (Holl) creates a direction he's pleased with (or stumped by), Holl shares the resulting drawing with the design team. 'I've sent them by *iPhone* from an airport in Korea,' he says. Once a concept is established, the process becomes, in Holl's words, digitally 'supercharged'. The leap from watercolor to 3-D computer drawing and model can happen literally overnight—or in the time it takes to fly from Seoul to New York City."[146]

As for the "desktop class applications", it can be said that the influence of these applications (shortly known as apps) appears the most in the process of "sketching as designing" with a variety of two-dimensional and three-dimensional sketching apps. One of *Apple*'s most significant competitors *Samsung* believed in the importance of the stylus especially for users in the creative fields such as architecture and developed smartphones and tablet PCs' with *Samsung S-Pen stylus* ever since their *Samsung Galaxy Note* smartphones and *Samsung Galaxy Note 10.1* tablet PC (launched in 2011 and 2012 respectively). It wasn't until 2016 when *Apple* realized the significance of the digital pen and decided to launch their first *Apple Pencil* to be used with the *iPad Pro*. *Apple*'s first rejection of the stylus came from Jobs philosophy with the multi-touch screen; "God gave us 10 styluses. Let's not invent another"[147]. The reason behind Jobs' stance was, according to technology news and media network "*The Verge*" reporter Nick Statt, that he (Jobs) did not anticipate the *iPhone* with its small screen to serve as a tool for graphic designers and illustrators[148], not to mention architects.

This attitude of Jobs can be linked to that of Sutherland's who is the pioneer of the field. W. J. Mitchell quotes the latter's conception about the computer in contrast to hand drawing, stating that he believed the structure beyond computer drawing was the essence of its usefulness, and hand drawings (due to lacking

[146] Pedersen, M. (2013) *Op. Cit.*

[147] Isaacson, W. (2011). *Steve Jobs*. London: Little, Brown. p.309

[148] Statt N. (2015). *Here's why Apple made the stylus that Steve Jobs hated*. The Verge. Retrieved from: http://www.theverge.com/2015/9/9/9298117/apple-pencil-stylus-ipad-pro-steve-jobs

inherent structure) were nothing but "dirty marks on paper."[149] The devices of both Sutherland and Jobs were not initially intended to be used for creative designing, and for activities such as freehand sketching. However, as time progressed, the devices did, in fact, affect architectural creative production in the long run. While *iPhone* still does not work with *Apple Pencil*, architects can use the pencil with *iPad Pro* in the same way they use their logbooks. Statt states:

> "Now, the Pencil is an option for those who want to use *iPad Pro* as if it were a sheet a paper and the stylus as if it were — wait for it — a real pencil. *Apple* has designed the pen so that it has little to no latency. It can draw thicker lines with applied pressure and orient its toolset to whether you're tilting the pen, for shading, or dragging it along the surface to draw lines or form letters".[150]

This quote shows how the new era of technological advances proved the necessity to push the limits of the new devices into imitating conventional means, which is what their success criteria is now based on, and this conventional-like sketching system brought sketching applications that can be classified as an interplay between WIMP and traditional pen and paper sketching.

3.3.1 Digital Sketching Hardware Developments

This section will cover the latest technology in digital sketching tools such as sketching surfaces (tablet PCs), sketching instruments (digital pens and brushes), and auxiliary sketching tools (surface dials). Tablets come in two types; touch-screen types where sketching and viewing take place on the same surface, and types where sketching takes place on a surface and the result is viewed on a connected monitor. *Wacom* tablets come in both types; tablets with black sketching surface[151] (similar to

[149] Mitchel, W. J. (1989). *A New Agenda for Computer-Aided Architectural Design*. Paper presented at ACADIA Conference Proceedings. Gainesville. Florida. p.29. Retrieved From: https://cumincad.architexturez.net/system/files/pdf/3824.content.pdf

[150] Statt N. (2015) *Op Cit*.

[151] Black anodized aluminum and fiberglass composite resin.

the concepts of *RAND Tablet* and *KoalaPad*), and tablets with LCD[152] screen (similar to tablets such as *iPad*). The first type, due to its high accuracy in comparison to mouse pointers, is very useful in architectural presentation tasks such as post-production render editing. For conceptual sketching however, the second type can be more preferable since any detachments between sketching surface and display surface may interrupt the thinking sequence.

Sketching instruments come in stylus, digital pen or brush form. The stylus is a thin tool useful for delicate touching purposes but with no internal electronics. A digital pen, on the opposite, has a battery, a wireless connection, and covers a broader range of activity. The *Apple Pencil*, for instance, embodies the features of pressure sensitivity for various line thicknesses, and a tilting recognition for creating shades (Figure 25). Other pens such as *Adobe*'s *Ink & Slide* can synchronize drawings to cloud storage, and these drawings can be accessed through different tablets or computers since they are stored in the pen's memory, not the tablet's. Another known digital pen is the *Pencil* by *53*; inspired by carpenter pencil[153], it maintains pressure sensitivity and tilting recognition qualities, while lacking precision due to its blunt tip, and thus performs more like a piece of "charcoal" or a "crayon"[154]. Nevertheless, this pencil is foregrounded by its built-in rubber part at the end functioning as an eraser, which, along with a real wood body, makes the pen a more natural tool and the closest to a real pencil (Figure 26). Some of these digital pens come with "palm-rejection" technology in which the screen does not detect the palm skin, avoiding unnecessary smudges while sketching.

[152] LCD: Liquid Crystal Display.

[153] Fiftythree Official Website (2014). *Making Fiftythree; pencil: a tool in the making*. Retrieved 20.09.2017 from: http://making.fiftythree.com/a-tool-in-the-making/

[154] *Ibid*.

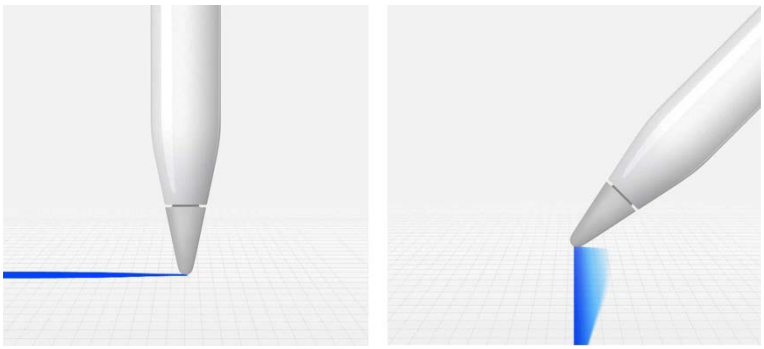

Figure 25: *Apple Pencil*'s pressure sensitivity and tilting recognition demonstrated
Source: *Apple* Official Website (n.d.). *Apple Pencil for iPad Pro*. Retrieved 15.12.2017 from: https://www.apple.com/lae/apple-pencil/

Figure 26: Above: *53 Pencil*'s pressure sensitivity, tilting recognition and eraser demonstrated. Below: the same tool versus a carpenter pencil (Collage by author)
Source: Above and below: Fiftythree Official Website (2014). *Making Fiftythree; pencil: a tool in the making*. Retrieved 20.09.2017 from: http://making.fiftythree.com/a-tool-in-the-making/

Apart from pencil-like digital pens, digital brushes such as *Sensu Artist Brush and Stylus* (Figure 27) offer the possibility to paint and sketch on tablet surfaces with the help of synthetic brush hair infused with conductive properties useful for painting in watercolor-like mediums, and a rubber end that is useful for sketching with lines. Among the disadvantages of the brush are that, first, caps have to be placed very carefully after use and any bent bristle must be cautiously removed with tweezers, making the brush a bit impractical, second, the liquid behavior of the paints is unnatural, thus, fails to provide natural effects such as light flow.

Figure 27: Above: *Sensu Artist Brush and Stylus* showing the brush and the digital pen ends. Below: The brush painting on a tablet surface (Collage by author)

Source: Above and below: Strietelmeier, J. (2012). *Sensu Artist Brush Capacitive Stylus Review*. The Gadgeteer. Retrieved 20.09.2017 from: https://the-gadgeteer.com/2012/04/26/sensu-artist-brush-capacitive-stylus-review/

Other than these tools, another important advancement in digital sketching has been released; that is the *Surface Dial* by *Microsoft*. The *Surface Dial* is a fist-sized puck that can be placed on the working screen or the table (Figure 28). In itself, it is not a sketching tool, but helps in accelerating digital sketching and drawing processes. Holding and pressing the puck helps in displaying radial menus of tools, users can rotate the puck to change colors without the necessity to lift the pen of the surface, making the workflow easier and faster [155]. It can be said that instead of forcing the designer to decide between using either the mouse or the digital pen, he/she can hold the pen in the dominant hand while controlling the puck in the other hand, thus, speeding up sketching. While the *Surface Dial* works with *Microsoft*'s *Surface Studio*, *Dell* introduced a similar puck called the *Totem* that works on its *Canvas* tablet. *Dell Canvas* is a display surface and requires other computers connectivity unlike *Microsoft Surface Studio* which is a stand-alone computer. While *Surface Studio* excels in technical specifications, *Canvas* is a more affordable device. Both devices, however, are more suitable for in-studio sketching purposes due to their heavy weights and large sizes.

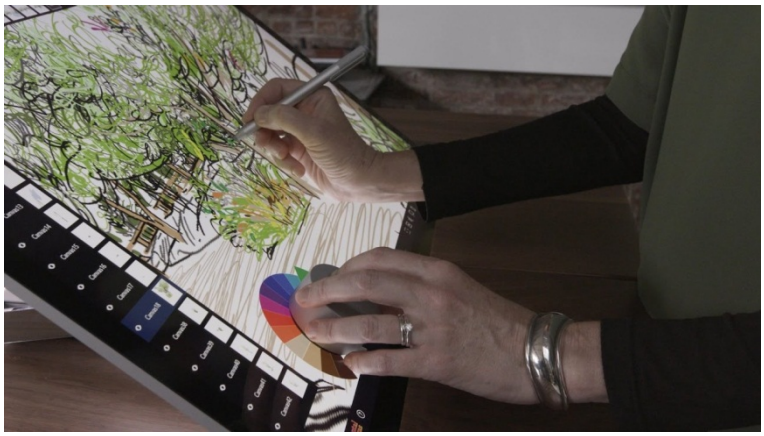

Figure 28: A sketch made using *Microsoft*'s *Surface Studio*, a digital pen, and the *Surface Dial*
Source: Microsoft Surface (2016). *Mental Canvas on Surface Studio with Surface Dial*. [Video file] Retrieved 25.09.2017 from: https://www.youtube.com/watch?v=53KJerdHkdA

[155] Microsoft Official Website. (n.d.) *Surface Studio*. Retrieved 20.09.2017 from: https://www.microsoft.com/en-us/surface/devices/surface-studio/overview

3.3.2 Digital Sketching Software Developments

Generally, the applications that benefit architects can be put in three groups:

1. Applications that quickly view computer-drawn projects are useful not for sketching but rather feedback among designers as well as presenting ideas to clients. Among these are *iRhino 3D*, *Graphisoft BIMx* and *SketchUp Mobile Viewer*[156]. These applications are practical in orbiting, panning, zooming, and rotating the model with a tap or drag of one's finger, and also saving various views as images and instantly sharing them online (Figure 29).
2. Two-dimensional drafting applications offer a variety of options regarding freehand sketching, applications such as *Morpholio Trace*, *Adobe Ideas*, *Sketchbook, Paper, Concepts, ArchiSketch*, *Arrette Sketch*, *Evernote*, *Mental Canvas*, *Sketches* and *Good Notes*.
3. Three-dimensional modeling applications such as *Autodesk FormIt* and *Shapr3D* allow users to make quick three-dimensional sketch models with digital pen, along with the ability to import from or export to WIMP system software for further developments.

[156] In addition to the mobile app, *SketchUp Mobile Viewer* offers *HoloLens* technology which allows users wearing the lens to navigate inside 1:1 scale virtual model. Source: *SketchUp* Official Website. Retrieved from: https://www.sketchup.com/products/sketchup-viewer

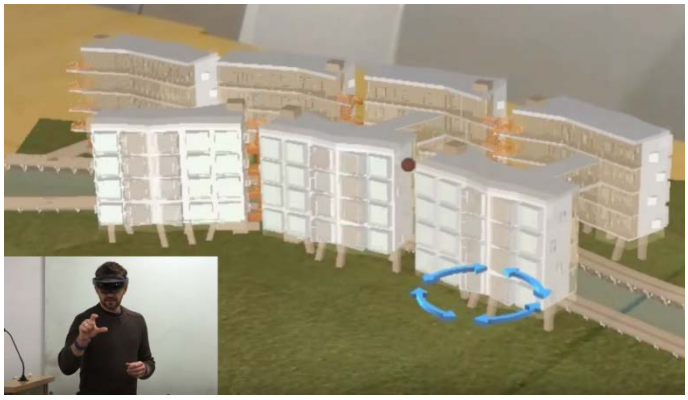

Figure 29: Experiencing *SketchUp Viewer* for *Hololens* with a demonstration of the complete app
Source: SketchUp (2017). *SketchUp Viewer for Hololens Demonstration*. [Video file]. Retrieved 25.11.2017 from: https://www.youtube.com/watch?v=dmpoCjz0Yc0

As software case studies, examples will only cover the second and the third group of applications, since the first group is not as directly influential on freehand sketching as the other two.

- ***Concepts*; A two-dimensional sketching application**

Concepts can be regarded one of the most widely used two-dimensional sketching applications. The philosophy behind its creation, as Erica Christensen, the Director of Community at *Concepts* developer *TopHatch*; was to connect age-old patterns of creation with the advantages of evolving technology:

> "This meeting of traditional and digital mediums is a key reason why we developed *Concepts* as a design tool. There is freedom in exploring your ideas by hand - the connection between mind, hand and paper are shown to be important to the creation process, forming new and connective landscapes inside the brain. Yet modern presentation needs are digital in nature, and current digital design software is non-intuitive. They are expensive in terms of learning curve and money. These systems were developed to meet needs from thirty-plus years ago and new technologies have raced beyond their capabilities."[157]

[157] Christensen, E. (Author's Communication via e-mail, May 22, 2017)

Christensen continues that their main audiences (designers of all types including architects), can quickly produce their designs with vector-based tools that allow them to import a variety of files from sketches to on-site photographs to PDFs, besides, create unlimited projects; trace, duplicate, iterate, transform and adjust drawings in an unlimited number of layers, then export them with a touch for a quick sharing among colleagues. The export is set to multiple standard and high-resolution formats so the designs can be uploaded to existing CAD programs for further engineering or a professional printing.

Architect Erick Mikiten (AIA, USGBC, LEED-AP)[158] suggests that applications such as *Concepts* are convenient middle-grounds for communication between two generations of architects; those who "missed the computer revolution" on one hand, and those who were "brought up in school in CAD" and aren't sufficiently trained to sketch by hand on the other. This tool as both paper-like and digital is an ultimate solution for the both the groups. As his personal experience with the application, Mikiten assures that he prefers using *iPad* with *Concepts* over computer or sketchbook; computers require a long time and thinking and offer less visual ability, while sketchbooks are not as practical as the application especially in showing the layers of development in the design:

> "It used to be that when you were in a rush prepping a design for a client, you'd have to quickly white out the change, *Xerox*[159] it, trace over the *Xerox*, scan the changes, throw on your *Copic* marker color, scan it again, then send it to the client… In Concepts, you can manipulate your layers how you like them at any time. It keeps all the simple things from paper and keeps it simply inside the app, all in one place. I'd just like to be able to work with chunks of layers, a CAD-like layer tree for groups of layers to be turned on and off with one click." [160]

[158] AIA: American Institue of Architects, USGBC: United States Green Building Cousil, LEED-AP: Leadership in Energy and Environmental Design- Accredited Professional.

[159] *Xerox* is the name of a brand well-known for computer supplies such as photocopiers. The architect uses the term "*Xerox* it" as in "photocopy it".

[160] Christensen, E. (2017). *The Layers of Architectural Design: Architectural Design Q&A: An Interview with Erick Mikiten*. Retrieved 22.05.2017 from: https://medium.com/@ConceptsApp/the-layers-of-architectural-design-f12411072882

Other advantages the architect mentions are the ability to copy sketches in a fast and convenient way instead of redrawing every detail while discussing alternative designs with the clients: “I’m able to copy the entire sketch and simply tweak it during the conversation… a fairly quick task to sketch and color inside *Concepts* with a pen and Filled Stroke tool. Zooming in and out, the details remain clear”, furthermore, the possibility to export high-quality images straight into CAD software. Finally, Mikiten recommends the application for giving the designs a personal hand-drawn touch preferred by the clients while still maintaining connectivity with the digital world. (Figures 30 and 31) show sketches created using *Concepts*, the sketch set in (figure 30) is made by Mikiten as “sketching as designing”, while the sketch in (figure 31) is made by the author as “sketching as observation”. While all the advantages mentioned by Mikiten were valid in sketching as observation as well, the slipperiness of the glass surface makes sketching a bit less comfortable in comparison to paper surface, in addition, the constant switching between tools and color shades requires attention to the previous ones.

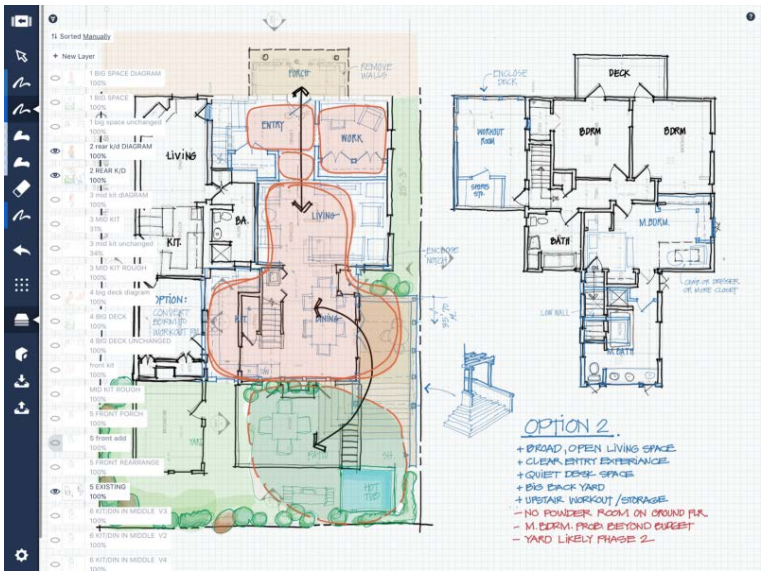

Figure 31: Layers of design development sketches by architect Erick Mikiten (*iPad Pro, Apple Pencil + Concepts*)

Source: Christensen, E. (2017). *The Layers of Architectural Design: Architectural Design Q&A: An Interview with Erick Mikiten*. Retrieved 22.05.2017 from: https://medium.com/@ConceptsApp/the-layers-of-architectural-design-f12411072882

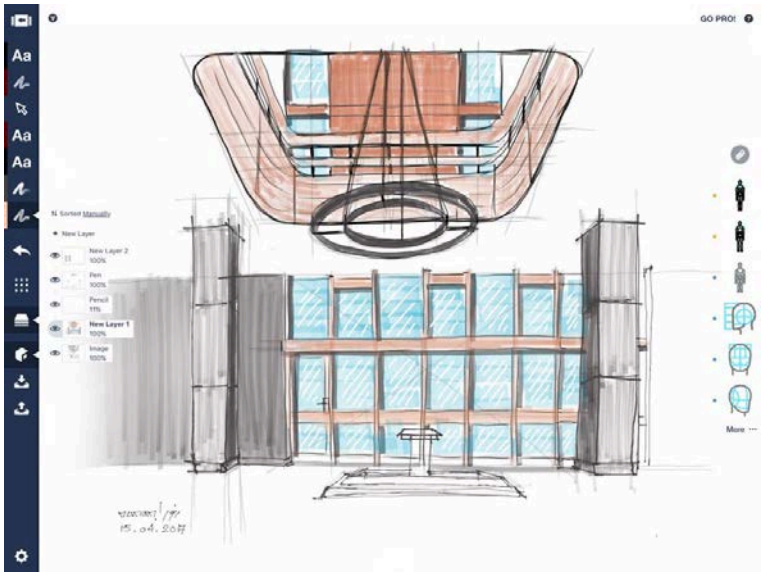

Figure 30: METU Faculty of Architecture; Sketching by observation (*iPad Pro, Apple Pencil + Concepts*)

Source: Author

- ***Mental Canvas*; an Approach in-between the Two and the Three-Dimensional Sketching**

Mental Canvas is a software product that enables making two-dimensional wire-frame sketches in different layers. What sets it apart from other sketching software products is that those layers are not placed on a single plane but rather on all (x, y, z) planes in an interactive way that creates the illusion of a three-dimensional scene (Figure 32). Julie Dorsey, the founder of *Mental Canvas*, calls this "graphical media"; neither fully flat nor fully 3D. When compared to three-dimensional modeling, as Dorsey continues; it is faster, more fluid, easier to edit, and it is the designer (not the computer) that is in full control of the outcome[161]. A drawback of the software might be the loss of the sense of scale, however, the developers are not only aware of this loss but see in it a different kind of potential:

> "*Mental Canvas* may feel intimidating at first, lacking the safety of architectural scales that come with most CAD modeling software, or an ordinary piece of paper. However, this infinite space has been created with the intention of liberating the architect or designer from the constraints of a computer."[162]

When it comes to architects' opinions about such software, Carol Hsiung, Senior Designer at FXFOWLE[163], states that the quality of a sketch lays in its incompleteness since it leaves room for interpretation, in addition, "its ability to tell a story, or convey a meaning in a way that CAD models and words can't", and *Mental Canvas* in this case, Hsiung assures, expands the idea of sketching by making it less flat, in this way; clients who face difficulties understanding two-dimensional

[161] Zilliacus, A. (2016). *This New Drawing App Shows How Digital Software Will Save Sketching, Not Destroy It.* Archdaily. News. Retrieved 11.11.2017 from: https://www.archdaily.com/799167/mental-canvas-new-drawing-app-shows-how-digital-software-will-save-sketching-not-destroy-it

[162] *Ibid*

[163] FXFOWLE is one of the top 50 architectural firms in the United States in 2017 according to Architect Magazine ranking. Source: The Journal of the American Institute of Architects (2017) *The 2017 Architect 50*. Architect Magazine. Retrieved 06.12.2017 from: http://www.architectmagazine.com/architect-50/2017/

drawings can apprehend better when several views communicate a "holistic concept"[164]. The software is currently only available for professional design firms and has not yet been developed for the individual users.

Figure 32: A sketch created and rotated in *Mental Canvas*
Source: Mental Canvas Official Website. Retrieved 25.12.2017 from: http://mentalcanvasweb.blob.core.windows.net/scenes/springstudio/index.html

[164] Zilliacus, A. (2016). *Op Cit.*

- ***Shapr3D*; A Three-dimensional Modeling Application**

In an interview with the author, the entrepreneur and software engineer Istvan Csanady who founded and developed *Shapr3D* (Figure 33) stated that the idea behind the application was to make a professional, yet easy to use 3D modeling tool for industrial designers, product designers, engineers and architects, with software that can be learned in about 15 minutes, which is not possible with desktop CAD packages. The user interface and the user interaction are based on natural multi-touch gestures, and the stylus is utilized as if it was an actual pencil: "We believe that this kind of interaction is not only more natural than traditional CAD, but will be able to cover the 100% of a desktop CAD system's feature set in a few years"[165]. While many of the users are using the application as a full solution, indeed it is suitable for early stage ideation, sketching, and prototyping. When asked whether users had to be talented in drawing/ designing to start, Csanady assures that users need to be experienced first in 3D modeling (regardless of the tool), and then learn to use the software; the second step is simplified with *Shapr3D* and the team have witnessed users with little or no experience in 3D modeling who created satisfactory results using the application.

[165] Csanady, I. (Author's Communication via e-mail, Sep 27, 2016)

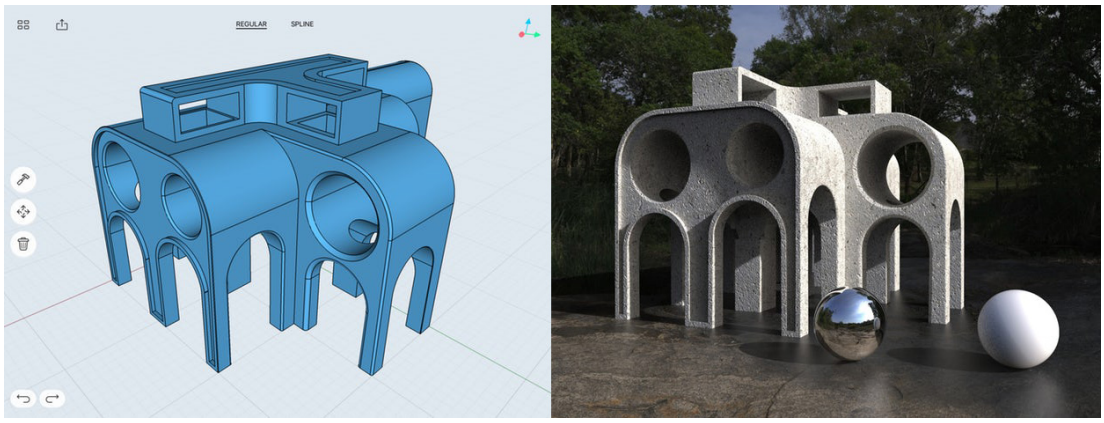

Figure 33: Left: A model made by *Shapr3D* using *iPad Pro* and *Apple Pencil*. Right: A rendered image of the model.
Source: Keskeys, P. (n.d.) *Apps for Architects: Sketch on a Touchscreen Drawing Board With Shapr3D*. Retrieved 25.12.2017 from: https://architizer.com/blog/practice/tools/architects-app-of-the-week-shapr3d/

When comparing these digital sketching applications with the traditional means of sketching on paper (including sketch models), some of the most significant differences that appear on the surface can be summarized as follows:

- **Size:** Although users are limited with the size of the screen, they can produce infinite sketches in an infinite paper space and zoom in/out whenever needed. This feature does not suit users who prefer sketching on sheets in large scale such as A2 or larger space to begin with.
- **Precision:** Users can sketch in freehand movement allowing the application to turn their undetermined wiggly lines into sharp straight ones with measurements.
- **Variation:** A single digital pen can function as a variety of sketching tools such as pencils, pens, markers, watercolors, airbrushes and erasers. In addition, it offers a variety of thickness and color (or material) options; which is a practical feature when travelling, however, while the digital pen on the screen can imitate the end-result, the plastic tip sliding on glass screen cannot imitate the feeling of the pen sliding over the paper or the water flow of watercolors over watercolor drawing paper. Besides, while switching between tools, tip thicknesses and various colors, users may face difficulties in remembering the previous tools, thicknesses and color shades used.

- **Correction:** The ability to "undo" in case of a mistake is one of the important advantages of digital sketching over traditional sketching, particularly when sketching with tools that are normally inerasable in the traditional method.
- **Reproduction:** The ability to copy/paste is another very useful feature when large numbers of sketches need to be replicated.
- **Layering:** Multiple layers option is similar to tracing option in traditional method. This is a very useful feature especially when used with photographs, as long as users would be careful enough not to sketch in the wrong layers.
- **Sharing:** The ability to import from/export to other formats such as PDF and DWG, is a crucial feature for instant sharing or transferring the sketch to the computer for further developments. Some sketch applications offer direct export to laser-cutters, making physical sketch model-making faster and easier (in case of the abundance of laser-cutters)

3.3.3 Smart Writing

With all the advantages accompanying digital sketching, some architects still would not compensate for sketching using pen and paper; these sketches however, still need to find their way into a digital medium either through photography or scanning. This method might consume time since further editing would require further scanning and photographing. As a result, an ultimate solution to this problem can be found in smart writing (Figure 34). In this system, users can use traditional-looking sketchbooks with traditional-looking pens, and their sketches can immediately appear in an associated application on the smart phone, the tablet PC, and/or the computer via a wireless connection and cloud storage. These applications usually enable vector[166] mode of saving; meaning that the sketches can be easily editable once imported to the digital medium. This process is made possible through

[166] "Vector" and "raster" are the two types of digital graphic files; in vector files, the individual lines can be detectable while in raster files, since the entire image is composed of square pixels, the software can only detect the differences in color shades.

the *Ncode* technology in which very small marks of lines and symbols are placed over the paper surface in a certain order, and a camera installed inside the digital pen keeps a record of the pen's movement over the paper surface through these marks' locations[167].

Moleskine, which is one of the most well-known brands for producing sketchbooks and journals preferable by architects, has launched a smart writing set of a *Paper Tablet*, a *Pen+* smart pen and a *Moleskine Notes* application using this technology to allow transferring all notes and sketches from the paper to the screen in real time, this way users can "smoothly digitize, edit, organize, and share notes and sketches made on the move, for seamless integration between paper and cloud"[168]. Smart writing can be regarded, by far, the closest to the combination of an intuitive process of freehand sketching and a rapid digital editing possibility. While a very promising and ideal technology for architects who prefer carrying a sketchbook and an attached pen all the time, some deficiencies maybe noted such as in the case of coloration since the electronics embedded in the digital pen do not scan the sketch but rather memorize the pen's position and pressure at each stroke[169], therefore, any use of colors on the paper becomes undetectable, and thus, a re-coloring must be applied digitally, and the same problem applies to erasing. Furthermore, these sketchbooks are usually paired with their own pens; consequently, using a different pen or a sketchbook type/brand will risk the system to lose its digital characteristic.

[167] Neo Smart Pen Official Website (n.d.). *Ncode™ Technology*. Retrieved 05.01.2018 from: https://www.neosmartpen.com/en/neosmartpen/

[168] Moleskine Official Website (n.d.) Smart Writing Set. Retrieved 05.01.2018 from: https://us.moleskine.com/smart-writing-set/p0202

[169] Neo Smart Pen Official Website (n.d.). *Op. Cit.*

Figure 34: Left; *Moleskine Smart Writing Set,* Right; *Ncode* Technology elaborated (Collage by author)

Source: Left: *Moleskine* Official Website (n.d.) Smart Writing Set. Retrieved 05.01.2018 from: https://us.moleskine.com/smart-writing-set/p0202

Right: Neo Smart Pen Official Website (n.d.). *Ncode™ Technology*. Retrieved 05.01.2018 from: https://www.neosmartpen.com/en/neosmartpen/

CHAPTER 4

DIGITAL SKETCHING IN PRACTICE

4.1 Sketching Practice of International Architects

In this section, the works and thoughts of a selection of international architects known for their freehand sketching will be discussed in terms of their relation to digital drawing/sketching tools. These architects are the "creative geniuses" in their architectural practices. They received their education in the pre-digital age, and had designed projects before and after the massive advance of today's technology. The first group of architects; Frank Gehry and Daniel Libeskind are selected based on their offices' contribution in developing architectural computer software and hardware, and the second group of architects; Steven Holl, Renzo Piano and Santiago Calatrava are selected based on their unique style in sketching that became almost a signature; Steven Holl in the tools he uses (watercolors), Renzo Piano in the type of sketches he produces (diagrams) and Santiago Calatrava in the source of inspiration behind his sketches (nature).

These names are a selection of a wider range of architects that could not be included in this concise study. However, it is worth mentioning another prominent name associated with hand drawings and digital production: Zaha Hadid. Hadid is not widely discussed in this study since she is better known for her oil paintings rather than quick sketches, the influence of her drawings, nevertheless, is evident in changing the direction of global architectural production as Lebbeus Woods wrote in his valuable series of texts concerning the matter. First, he stresses on how her dependence on cheap drawing materials in creating her significant paintings was part

of her approach to design; "a wringing of the extraordinary out of the mundane"[170], second, he notes how these paintings (in his opinion) had their impact on the computer involvement in architecture:

> "Zaha's drawings of the 1980s are different, and in several ways. Most notably, she had to originate new systems of projection in order to formulate in spatial terms her complex thoughts about architectural forms and the relationships between them. These new projection methods were widely copied in their time, and influenced, I believe, the then-nascent computer modeling culture."[171]

This impact was in both directions as Woods continues, in order for Hadid's designs to get built; she had to adapt her paintings to construction limitations such as property lines, materials, client demands and so on. Besides, they needed to transform into computer drawings ready for manufacturing. This did not push Hadid towards quitting traditional methods; on the contrary, she continued producing complex curvilinear and fluid dynamic forms by hand using tools such as French curves, but she made sure these drawings can quickly and easily be reproduced using computer software.[172]

4.1.1 Frank O. Gehry

Canadian-American Frank Owen Gehry (born in 1929) is one of the most influential architects associated with digital drawing and fabrication. His sketches are the kind that would not simply evolve into orthogonal set, or a building, without the help of computer software, although his own knowledge in the digital field is inadequate. The architect's acquaintance with the digital medium dates back to 1989; when his sketch of *Vitra* Museum in Germany paved the way into introducing

[170] Woods, L. In Sheil, B. (2008). *Protoarchitecture: Analogue and Digital Hybrids*. AD Primers. John Wiley & Sons Ltd. UK. Retreived 01.02.2018 from: https://lebbeuswoods.wordpress.com/2009/03/23/zaha-hadids-drawings-1/

[171] *Ibid*.

[172] *Ibid*.

computers to his studio for the first time. In an interview with the film director Sydney Pollack, Gehry states his fascination with the shapes he produced when sketching, not realizing they could transform into a physical space. His first attempt was in the museum, when he tried to further manipulate curvature forms, which led his office to seek the help of up-to-date technology back then[173]. Architecture Professor Susan C. Piedmont-Palladino points out that it was not the sufficiency of the digital medium, but the insufficiency of the traditional medium that pushed Gehry towards computers:

> "If technology is always a step ahead of society, creativity is always one step ahead of technology. By the late 1980s, architect Frank Gehry; a devoted model maker had realized that his tools could not keep pace with his imagination. Curiously, it was not the efficiency of digital technologies that attracted Gehry to the computer but the power of visualizing and representing things too difficult, or impossible, to do by hand".[174]

This quotation although implies some limitations and restrictions related to freehand sketching especially with forms such as Gehry's complex designs, Brillhart does not underestimate the involvement of freehand sketching as the core step in architectural design process regardless of the form complexity. He, too, mentions the case of Gehry to support his point:

> "Frank Gehry recognized how lagging the architectural discipline is in relation to other industries such as aerospace drawing and engineering, and took it upon his office to confront the digital deficiencies. His company, *Gehry Technologies*, developed out of his architectural office, forges new architectural drawing software that has, in turn, led to a new architecture and several of the world's most iconic projects" [175]

This does not mean the abandonment of freehand drawing, on the contrary, as Brillhart assures: "Take Frank Gehry's case, which is rooted in drawing and

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[173] Pollack, S. (Director) (2005) *American Masters: Sketches of Frank Gehry*. [Video file]. Retrieved 15.10.2017 from: https://www.youtube.com/watch?v=vYt2SQPqTh0&t=75s

[174] Piedmont-Palladino, S. (2007). *Tools of the Imagination: Drawing Tools and Technologies from the Eighteenth Century to the Present*. Princeton Architectural Press. p.89

[175] Brillhart J. (2011). *Op. Cit.*

sculpture. The conceptual front-end thinking - the idea - is developed and exercised through hand drawing before it is translated and solidified in the computer"[176]. What can be driven from these quotes by Piedmont-Palladino and Brillhart is that Gehry sought expanding technological limitations instead of simplifying his imagination, or his complex sketches. *Gehry Partners, LLP*, state that the firm currently relies on *Digital Project*[177]; a sophisticated software described as "High Performance BIM" where it is possible to design, engineer, and fabricate BIM for the world's most demanding projects[178].

Architect and Professor Roger K. Lewis argues that in Gehry's case, while it is not possible to produce construction drawings without the use of computers, it is a risk for architects to blindly follow this path as it would result in a large number of low quality architecture. According to him, Gehry's designs are "sketchbook squiggles or crumpled paper and are ultimately transformed into volumetrically complicated, expressively curvaceous buildings impossible to draw"[179], and projects such as the Guggenheim Museum (Bilbao, Spain) (Figures 35 and 36), the Walt Disney Concert Hall (Los Angeles), the Stata Center (MIT) and the Jay Pritzker Pavilion in the Millennium Park (Chicago), could not have seen daylight without digital models, yet, the unlimited possibilities offered by the digital are in themselves limitations of another kind: "This is because CAD can seductively induce 'I can, therefore I shall' thinking" [180].

[176] *Ibid*.

[177] Gehry Partners, LLP (n.d.) Retrieved 03.10.2017 from: https://www.foga.com/home.asp

[178] Digital Project (n.d.) Retrieved 03.10.2017 from: http://www.digitalproject3d.com/

[179] Lewis, R. K. (2011) *Computers are great tools for architects, but don't let CAD go wild*. Washington Post. Retrieved 03.03.2017 from: http://www.washingtonpost.com/wp-dyn/content/article/2011/02/11/AR2011021103539.html

[180] *Ibid*

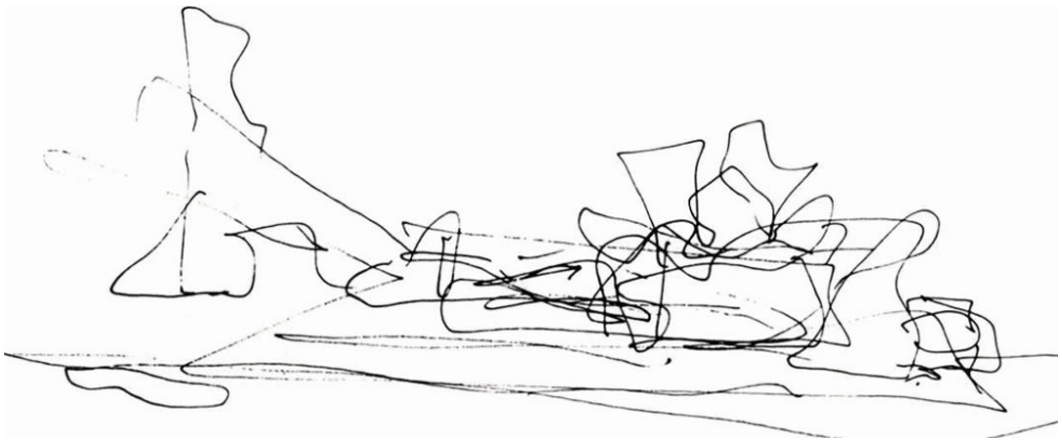

Figure 35: Sketch of Guggenheim Museum

Source: Keskeys, P. (2016) *How Architecture Is Born: 7 Flowing Scribbles by Frank O. Gehry and the Buildings They Inspired*. Retrieved 25.07.2017 from: https://architizer.com/blog/how-architecture-is-born-frank-gehry/

Figure 36: Guggenheim Museum in Bilbao; completed project

Source: Keskeys, P. (2016) *How Architecture Is Born: 7 Flowing Scribbles by Frank O. Gehry and the Buildings They Inspired*. Retrieved 25.07.2017 from: https://architizer.com/blog/how-architecture-is-born-frank-gehry/

4.1.2 Daniel Libeskind

Polish-American architect Daniel Libeskind (born in 1946) is one of the most significant figures associated with forms that are "innovative", "bold", and "technologically" remarkable. These designs always start with a sketch that later develops into architectural space through the help of advanced technology. For this purpose, his office invested in the *HP*'s *Z2 Mini* (Figure 37); the first small-sized workstation in the world that is designed specifically for CAD users. Before delving into the details of this technological impact on Libeskind's works, it is important to go back to the beginnings of his career; his first construction project being the Jewish Museum in Berlin (commissioned in 1989) (Figure 38). Until the architect's first building was finalized[181], critics dismissed his designs as "unbuildable" or "unduly assertive"[182].

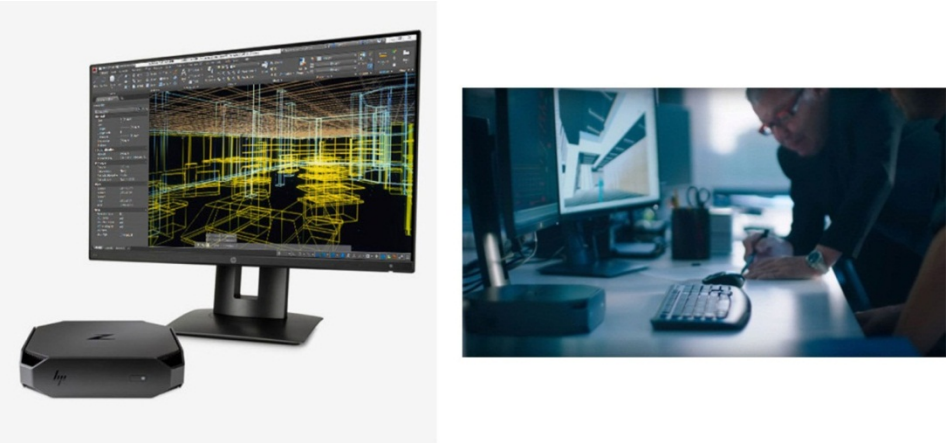

Figure 37: *HP Z2 Mini* Device at Studio Libeskind (Collage by author)

Sources: Left: *HP Z2 Mini The world's first mini workstation designed for CAD users*. Retrieved 25.09.2017 from: http://store.hp.com/us/en/mdp/business-solutions/hp-z2-mini-workstation--1
Right: *Reinventing Design with Studio Libeskind - The Power of CAD | Z Workstations | HP* [Video file] Retrieved 25.09.2017 from: https://www.youtube.com/watch?v=2cdceRbuIEc

[181] Although the Jewish Musuem was Libeskind's first commissioned project, it was not the first to be opened. Felix Nussbaum Haus Museum, in the German city of Osnabrück, preceded the Jewish Museum and opened three years prior to it in 1998 when the architect was 52 years old.

[182] Architectuul (n.d.). *Daniel Libeskind*. Retrieved 30.11.2017 from: http://architectuul.com/architect/daniel-libeskind

Libeskind states: “I can hardly conceive that not that long ago I sat down to do a building by hand”[183]. In a Facebook Live tour with *Architizer*[184] and *HP*, Libeskind talks about how he conceived his first building drawings after winning the international competition in 1989: “When I think of my first building Jewish Museum in Berlin was done by hand and I can’t believe I live in the same world”[185]. He explains, in a separate video about his experience with *HP Z2 Mini*, how he designed this project completely by hand and sent the exhibition designers a role of drawings composed of plans, sections and elevations without the 3D model which did not exist, when introduced to advanced digital technology, it opened the door to take his architectural production into a different level: “You suddenly see something that you never saw before, that is able to respond to your desires in a more immediate and more complex way” [186].

By taking a close look at Libeskind’s Jewish Museum, it can be said that this first “completely hand drawn” project looks rather flat in comparison to the more recent works he has achieved. The sketch seems an axonometric projection of the plan where there is a deal of complexity, and a lesser complexity is applied to façade openings. In more recent works such as the 2007 Royal Ontario Museum (Figure 39), the sketches seem to be directly perspective imagination without depending on plan sketches first. A possible interpretation could be that the complexity in digital tools had their effect on the evolvement of the types of sketches Libeskind produced over the years. An important remark here is that Libeskind, similar to Gehry, does not always start with architectural sketches but abstract sketches that may or may not

[183] Franklin, S. (2017) *Studio Libeskind Reveals the Technological Power Behind Its Iconic Architectur*. Architizer. Retrieved 01.10.2017 from: https://architizer.com/blog/studio-libeskind-hp-z2-mini-workstation/

[184] Founded in 2009; *Architizer* is a website devoted to searching, evaluating and sharing building products among architects all over the world.

[185] Franklin, S. (2017) *Op Cit.*

[186] HP Online Store (n.d.) *Designed for designers Studio Libeskind: Architects. Designers. HP Partner* [Video file] Retrieved 01.10.2017 from: http://store.hp.com/us/en/mdp/business-solutions/hp-z2-mini-workstation--1#

evolve into architectural space. About the relation between his sketches and technology, Libeskind explains:

> "I try to use those drawings architecturally. It's not very easy. Sometimes I fail to use it but I always do the drawings that go beyond what can be inserted into technology and then try to see how technology can veer itself and slide in order to produce something that I had in mind in a drawing that was never really practical – so it was not drawn for a building. I use drawings as source of the space but I cannot always instrumentalize a drawing."[187]

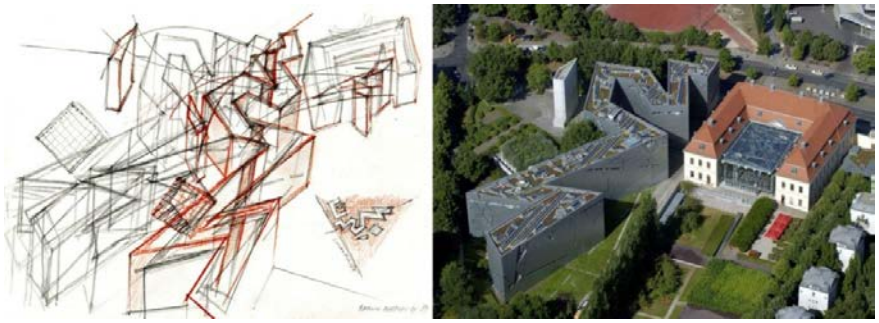

Figure 39: Jewish Museum in Berlin: Sketch and Completed Project (Competition: 1989- Completion: 1999- Opening: 2001)

Source: Keskeys, P. (2016) *How Architecture Is Born: 7 Poetic Sketches by Daniel Libeskind and the Buildings They Helped to Shape.* Architizer. Retrieved 25.09.2017 from: https://architizer.com/blog/how-architecture-is-born-daniel-libeskind/

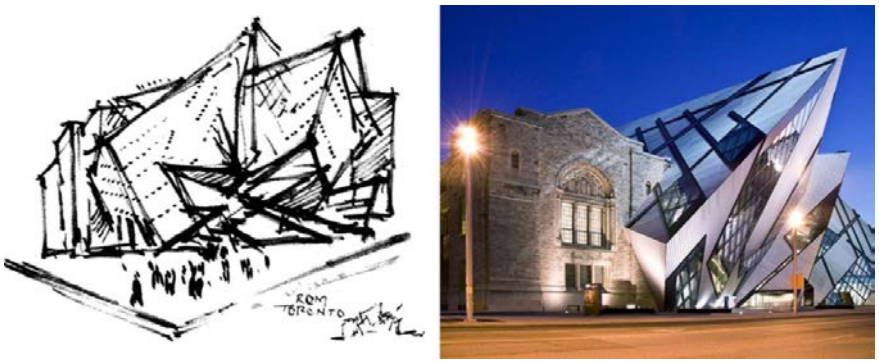

Figure 38: Royal Ontario Museum in Toronto: Sketch and Completed Project (Competition: 2002- Opening: 2007)

Source: Keskeys, P. (2016) *How Architecture Is Born: 7 Poetic Sketches by Daniel Libeskind and the Buildings They Helped to Shape.* Architizer. Retrieved 25.09.2017 from: https://architizer.com/blog/how-architecture-is-born-daniel-libeskind/

[187] Franklin, S. (2017) *Op Cit*

Libeskind is also known for his series of "chamber works"; a set of 28 drawings he created as theoretical works of paper architecture (similar to the previously mentioned works of Woods and Hejduk). When *Moleskine* published its book series "*Inspiration and Process in Architecture*"[188] to celebrate "style and craftsmanship in the creative process, that primordial step of sketches and freehand drawings"[189], it devoted one of the books to the drawings of Libeskind (from Micromegas to Chamber Works to Sonnets in Babylon, in addition to real architecture) as examples of creative works in architecture (Figure 40).

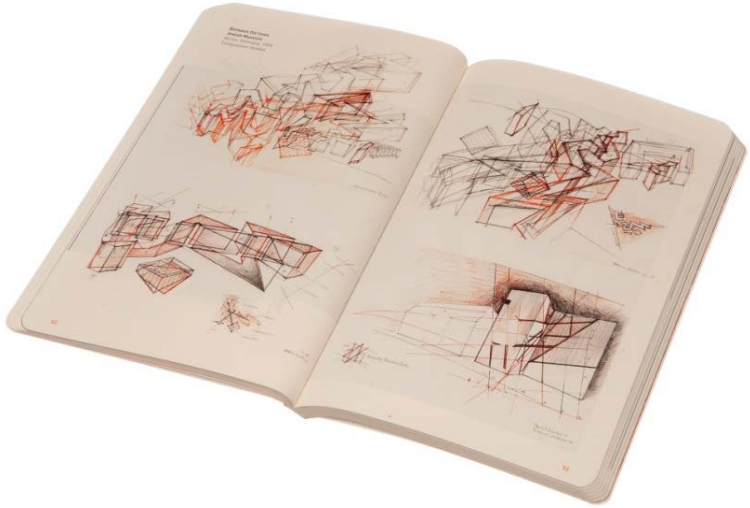

Figure 40: Inspiration and Process in Architecture - Daniel Libeskind (*Moleskine* Book Series)
Source: Moleskine Official Website. (n.d.). *Inspiration and Process in Architecture – Daniel Libeskind.* Retrieved 15.01.2018 from: http://www.moleskine.com/au/collections/model/product/inspiration-and-process-in-architecture-daniel-libeskind

[188] This 2011 series was preceded by other book series by *Moleskine:* "*The Hand of the Architect*" (2009), "*The Hand of the Designer*" (2010) and "*The Hand of the Graphic Designer*" (2011). In "*The Hand of the Architect*", it published hundreds of sketches of about 100 international architects "revealing that sometimes the hand is faster than the computer". Source: Moleskine Official Website. (n.d.). *The Hand of the Architect.* Retrieved 15.01.2018 from: http://www.moleskine.com/au/the-hand-of-the-architect

[189] Moleskine Official Website. (n.d.). *Inspiration and Process in Architecture.* Retrieved 15.01.2018 from: http://www.moleskine.com/au/news/Inspiration_and_Process_in_Architecture

Architect Yama Karim, a principal at *Studio Libeskind*, describes the process of designing at their studio as being "non-linear", meaning that it starts with a hand drawing that goes to computers to physical models and then back to hand drawings. No formula and no set of rules apply in the process apart from the fact that they use "every source in every medium possible" to get the desired results. Libeskind comments on Karim's explanation in these lines:

> "I always start drawing by hand something very primitive that looks ancient but it starts with a gesture and then engages into small physical models and then it engages in the full matrix of technology, then it changes as you discover things you never knew about the initial gesture."[190]

Technology definitely plays a "pivotal" rule in the process as Libeskind assures, he outlines four factors of the influence of technology on his designs as follows; speed, technicality, budgeting and communication:

> "I think we wouldn't be able to do the buildings we do or plans without technology we have. You could've dreamed about it but you could've never done it in time, never done it technically as an accomplishment or on budget… Technology gives us sense of being in real world in much more visual sense than just sitting at the desk by yourself. It's not just the speed but conversation with creative people, you can engage everybody from clients to genius designers to incredible technicians to people interested in materials and you can engage them in a singular conversation that goes beyond anything you could do by going out on the street looking for telephone directory."[191]

Libeskind's enthusiasm towards technology drove him into partnering with *HP* in 2014 after a conference on creativity in New York: "We were already using *HP* products and decided to go further. So we immediately said yes to integrate *Z2 Mini* at the agency. The scale is excellent, the screen is beautiful, but especially the

[190] Franklin, S. (2017) *Op Cit*

[191] *Ibid*

operation is very easy, in a few hours only I knew how to use it."[192] In addition to the four factors mentioned above, a fifth factor could be added that new technology is becoming more and more user-friendly and simpler to learn. This factor could be an advantage for the generation of architects trained to draw by hand, making new technology less intimidating to practice, while for later generations, it could be a tempting reason to abandon the traditional pen and paper sketching.

4.1.3 Renzo Piano

The Italian architect Renzo Piano (born in 1937) is best known for high-tech projects that successfully communicate with the surrounding environment. These projects carry careful considerations for various factors such as human scale, solar analysis and immediate environment studies[193], and these considerations are clearly reflected in Piano's sketches which mostly take the form of diagrams (Figure 41). Diagrams can be very effective tools of representation as Stan Allen, architect, theorist and the former dean of Princeton University School of Architecture, assures; they specify the relationships between the form and the activities it conveys while organizing the structure and the distribution of functions; thus, they become powerful means for the architecture in engaging with the complexity of the real[194], which can be considered among the reasons behind Piano's preference towards such form of representation.

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[192] Muuuz Magazine (2017). Daniel Libeskind et HP: La station de travail Z2 Mini. Archi Design Club. Retrieved 25.09.2017 from: http://www.archidesignclub.com/en/magazine/rubriques/design/48576-daniel-libeskind-et-hp-la-station-de-travail-z2-mini.html

[193] Delaqua, V. (2017). *The Importance of The Sketch in Renzo Piano's Work.* Archdaily. Retrieved 11.10.2017 from: http://www.archdaily.com/877340/the-importance-of-the-sketch-in-renzo-pianos-work

[194] Allen, S. (2009). *Practice: Architecture, Technique and Representation*. (2nd Ed.). Routledge, Abingdon, UK. p. 51

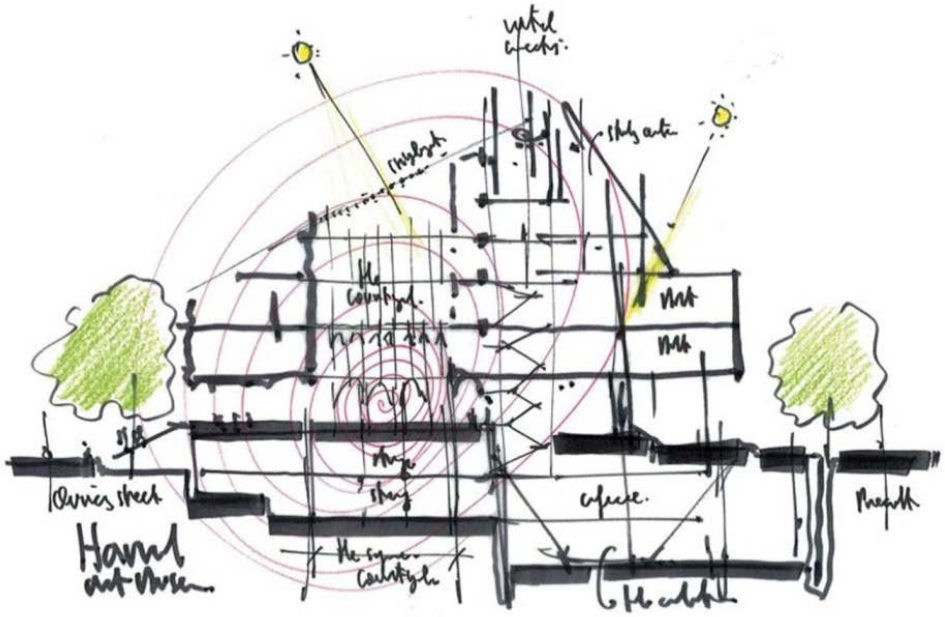

Figure 41: Sketch - Reform and Expansion of the Harvard Art Museums / Renzo Piano + Payette

Source: Delaqua, V. (2017). *The Importance of The Sketch in Renzo Piano's Work.* Archdaily. Retrieved 11.10.2017 from: http://www.archdaily.com/877340/the-importance-of-the-sketch-in-renzo-pianos-work

As he explains in his interview with Edward Robbins, Piano assures that his approach to sketching resembles a "craftman's approach"; thinking and doing simultaneously where drawing lies in the center of the process. He records his ideas on pieces of paper folded in four parts to fit his shirt pocket. These ideas are described to be in "midway between writing and sketching" where he uses as reminders of certain elements of spaces or details. The resulting sketches vary from the general concept to the smallest bolt detail.[195] Piano also pays the same attention to physical models, he does not believe that three-dimensional modeling programs compensate for concrete models in the same way drawing programs do not compensate for hand drawing. In a conversation with architect and photographer

[195] Robbins, E. *Op. Cit.* pp 126-130

Paul Clemence, he clarifies his opinion about integrating computers in architectural studios, which is clearly less enthusiastic in comparison to those of Gehry and Libeskind:

> "With the computer you need to tell it exactly what to do; where to start, where to stop. When I am doing the sketch, I don't have to tell the sketch where to start, where to end. **It's instinctive**. Sketching, like the model, **has the quality of imperfection**. **Neither has to be precise**. It gives you freedom. It gives you the possibility to change. The computer is perfect in the moment when you cannot be perfect."[196]

Piano explains his concerns about precision in the early design stages as such that this may lead to trap the designer in the shape or the form[197], moreover, he does not prefer producing precise perspective drawings or what he calls "wedding cake models" as they fail to express architecture while capturing the space magic in a "fake" way, as one would assume they completely understand the space solely by looking at a render or a precise model, while in reality, a full understanding of the space is not possible until the space is actually built[198]. A summary of this opinion could be that an imperfect freehand sketch or a sketch model is the perfect tool to express the imperfection of the un-built space. This does not mean that Piano opposes advanced technology and depends solely on conventional tools; on the contrary, he sees technology as a tool that one should know when and how to use it:

> "I find the distrust of advanced technology still more ludicrous, especially when it culminates in the fiercely academic tones used in the condemnation or acclaim of high technology. Architects should work with the tools that their time offers them. Refusing to deal with contemporary material culture is futile, perhaps even a bit masochistic. Let us put it this way: technology is

[196] Clemence, P. (2014) *Q&A: Renzo Piano, Master of Museum Design, on the New Whitney.* Metropolis Magazine Digital Edition. Retrieved 25.09.2017 from: http://www.metropolismag.com/architecture/cultural-architecture/qa-renzo-piano/

[197] *Ibid*

[198] Robbins, E. *Op. Cit.* p 129

like a bus. If it helps you to get where you want to go you take it. If it's going in a different direction, don't."[199]

Apart from the matter of imperfection, Pallasmaa notes that this approach of freehand sketching accompanied by physical model making has benefits of another kind; this process puts the designer in a haptic contact with the space and the object, whereas computers create a distance between the maker and the object flattening the "magnificent, multi-sensory, simultaneous and synchronic capacities" of one's imagination[200].

4.1.4 Steven Holl

American architect Steven Holl (born in 1947) is best known, alongside his creative designs, for his watercolor sketches. His journey with interpreting color in his conceptual sketches began around the 1980s when he shifted from black and white pencil sketching to watercolor illustrations as architect Jordi Safont-Tria states; unlike pencil sketching, watercolors offered the opportunity for the colors to flow on the surface creating heterogeneous depths[201]. Watercolor is considered one of the most difficult techniques of painting for it requires careful consideration of the amount of water applied along with the direction of the brush stroke and its strength in order to avoid a chaotic result. Holl found in this natural flow of colored water an advantage that could be interpreted in the built product as well, he explains:

[199] Piano, R (1997) *Renzo Piano: Logbook.* London: Thames and Hudson. p.248

[200] Pallasmaa, J. (2005). *The Eyes of the Skin: Architecture and the Senses*. John Wiley & Sons Ltd. United Kingdom. p. 12

[201] Safont-Tria, J., Kwinter, S., and Holl, S. (2012) *Steven Holl - Color Light Time.* Lars Müller Publishers. Zurich, Switzerland. p. 26

> "With the watercolor, in the quickest way, I can shape a volume, cast a shadow, indicate the direction of the sun in a very small format. And I can carry these things around because I am always traveling."[202]

Jacob Schoof, editor at the magazine "*D/A Daylight and Architecture*", made an analysis of Holl's approach to design and summarized it in steps; first, a conceptual watercolor sketch is born: "This seed that starts the project is something you're emotionally feeling as well as intellectually feeling. The concept sketch, via watercolor, is a perfect way to begin"[203], second, physical models come to help understand material and light quality: "Models are an excellent way to experiment with materials, their translucency or transparency, and the reflections and refractions they produce. The models that we build are full of different properties of light. This is something you can never achieve in computer renderings"[204]. Computers come in the third step, and are employed in the same way as any other contemporary design office.

Holl stresses the significance of computer in producing his architecture. In an interview with architectural journalist Martin C. Pederson for "*Metropolis*" magazine, Holl states that his office began its digital drawings with a single computer in 1992. For the Kiasma Museum project in Helsinki (Figure 42), they used a combination of watercolors and computer drawings. Holl explains their presentation, the architectural outcome and the significance of the digital tool, stating that they scanned the watercolors into the boards, presenting the freehand sketch along with the computer drawing. The latter was a vital part of the presentation: "That building is very sophisticated in three dimensions. It has a doubly warped

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[202] Keskeys, P. (2015) *How Architecture Is Born: 7 Fluid Watercolors by Steven Holl and the Buildings They Inspired*. Retrieved 25.07.2017 from: https://architizer.com/blog/how-architecture-is-born-steven-holl/

[203] Schoof, J. (n.d.) *Designed for All Senses: The Architecture of Steven Holl*. Retrieved 26.07.2017 from: http://www.velux.com/daylight-and-architecture/evolving-architecture/designed-for-all-senses, originally published in: Steven Holl in GA Document 110. Quoted in McCarter, R. (2015) *Steven Holl*. Phaidon Press. p. 329

[204] *Ibid*

curve that's holding the whole thing up. I don't think we could've done that without digital"[205]. Dominik Sigg of Steven Holl Architects stresses the significance of three-dimensional design software and the role they play in turning Holl's sketches and physical models into buildable projects:

> "3D design software is absolutely essential in our process. Starting with Steven's watercolors, we build elaborate 3D models and go through much iteration which we test with 3D prints in a rapid prototyping process. As the project progresses, especially if the geometry is complex[206], we keep adding detail to the computer model until every corner condition and handrail termination is resolved. It's an indispensable design tool."[207]

Figure 42: Left; Kiasma Musuem Watercolor Sketch. Right; Kiasma Musuem Digital Drawing

Sources: Left: *Kiasma, Museum Helsinki. E-Architect*. Retrieved 25.12.2016 from: https://www.e-architect.co.uk/helsinki/kiasma-museum-contemporary-art / Right: *AD Classics: Kiasma Museum of Contemporary Art / Steven Holl Architects*. Retrieved 25.12.2016 from: http://www.archdaily.com/784993/ad-classics-kiasma-museum-of-contemporary-art-steven-holl-architects

[205] Pederson, M. C. (2013). *Point of View: Q&A Steven Holl*. Metropolis Magazine Digital Edition. Retrieved 25.12.2016 from: http://www.metropolismag.com/Point-of-View/March-2013/Q-A-Steven-Holl/

[206] Steven Holl's geometris are rather basic in comparison to those by Frank Gehry

[207] Modelo Blog (n.d.) *Dominik Sigg of Steven Holl Architects.* Retrieved 25.07.2017 from:

https://modelo.io/blog/index.php/dominik-sigg/

4.1.5 Santiago Calatrava

Spanish-Swiss architect Santiago Calatrava's (born in 1951) approach to design, as an architect/engineer, is to analyze the mathematics behind the natural forms and translate them into buildable structures. He is known to be the expert of "combining natural motifs and high technology"[208]. For this reason, the role of computers becomes certain in turning his freehand sketches into calculated precise spaces or design details. Calatrava says that "[t]he hand drawing of course can never have the precision of the computer. But it's very important to go through the process until you reach the limit of what you can do with your hand."[209] About his system of sketching, Bryan Lawson states that while Calatrava does not prefer generating alternatives, his sketches reveal a process of thinking about the design in various ways at the same time. For this purpose, he uses multiple sketchbooks simultaneously, these sketchbooks vary in size (the smallest being pocket size and the largest being A3). Sketches are made either with pen or freehand watercolors, with an approximate scale and some calculations performed[210]. Calatrava's Kuwait Pavilion, designed and built for the 1992 Seville Expo, is one of the examples of complex structures produced via freehand sketching and model making collaboration at a time when computer technologies were not as advanced as they are today (Figure 43). When Calatrava was asked by Daria Golovina (editor at Strelka Institute for Media, Architecture and Design), about whether his preference to sketching by pencil over working on the computer was a "deliberate dismissal of the new technologies", he assured that this wasn't a "dismissal" at all:

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[208] Golovina, D. (n.d.) *Santiago Calatrava: 'Architecture is a Pure Creation of the Human Spirit'*. Retrieved 25.07.2017 from: http://strelka.com/en/magazine/2014/06/26/santiago-calatrava-architecture-is-a-pure-creation-of-the-human-spirit

[209] Pedersen, M. C. (2012) *Q&A: Santiago Calatrava, the Fine Artist.* Metropolis. Retrieved 25.07.2017 from: http://www.metropolismag.com/architecture/qa-santiago-calatrave-fine-artist/

[210] Lawson, B. (2005) *How Designers Think: Dymistifying The Design Process.* (4th Ed.) Architectural Press, Elsevier. p. 217

> "Computers have completely transformed the engineering technology, for example. Now we can conduct static and dynamic analysis, track the development of the whole project, which was not possible in the past. Nevertheless, I think that creative process in architecture is primarily an intellectual one, and pencil is an essential tool in it. Drawing by hand is obviously a time-consuming practice and has its own limitations, but it is also a **deeper, more meditative, more personal, more intuitive way of working** which is very important for an architect."[211]

This dependence on the manual drawing skills as a means of expressing creative genius led to accusing Calatrava for being self-indulgent and arrogant, as Eisenman remarks: "When Calatrava came to Yale, he got up after a long introduction. He said: 'I'm going to draw.' He had a camera over a drawing board. He turned on music. And he drew for a whole hour. He turned the music off and walked off the stage"[212].

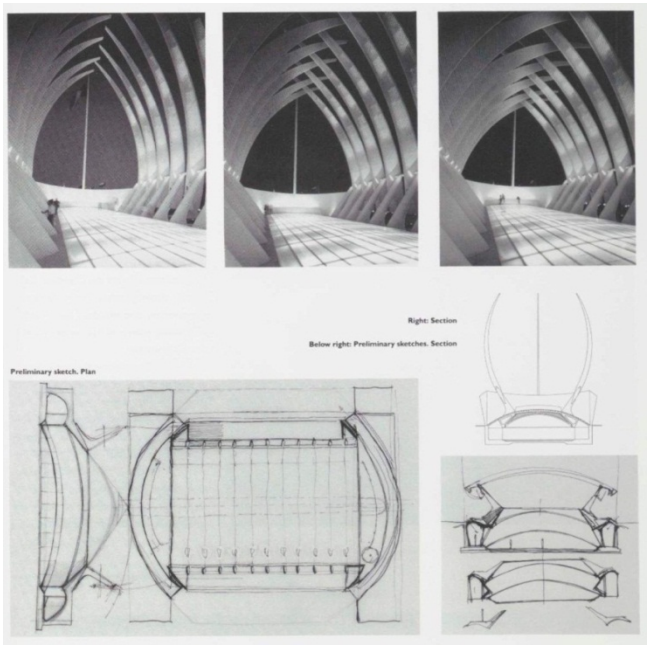

Figure 43: Kuwait Pavilion Sketches and Construction. Santiago Calatrava (1992)

Source: Bonfante-Warren A. (ed.) (1993) *Santiago Calatrava: Structure and Expression*. An Exhibition organized by Matilda McQuaid. MoMA, New York. p.19

[211] Golovina, D. (n.d.) *Op Cit*

[212] Cited in Jacobs, K. (2014) *Op. Cit.*

4.2 Sketching Practice of Turkish Architects

In Turkey, architects are not popular in being artists; however, it can be seen in the example of architect Emre Arolat (Figure 44) that conceptual sketches can be utilized as works of art and a form of the architect's signature on his built projects. In order to have a better understanding of the sketching practice in architecture in Turkey, this section aims at exploring sketching means and methods actively used in architectural design offices in Turkey's capital Ankara through conducting a survey that covers the architects who run their own practices.

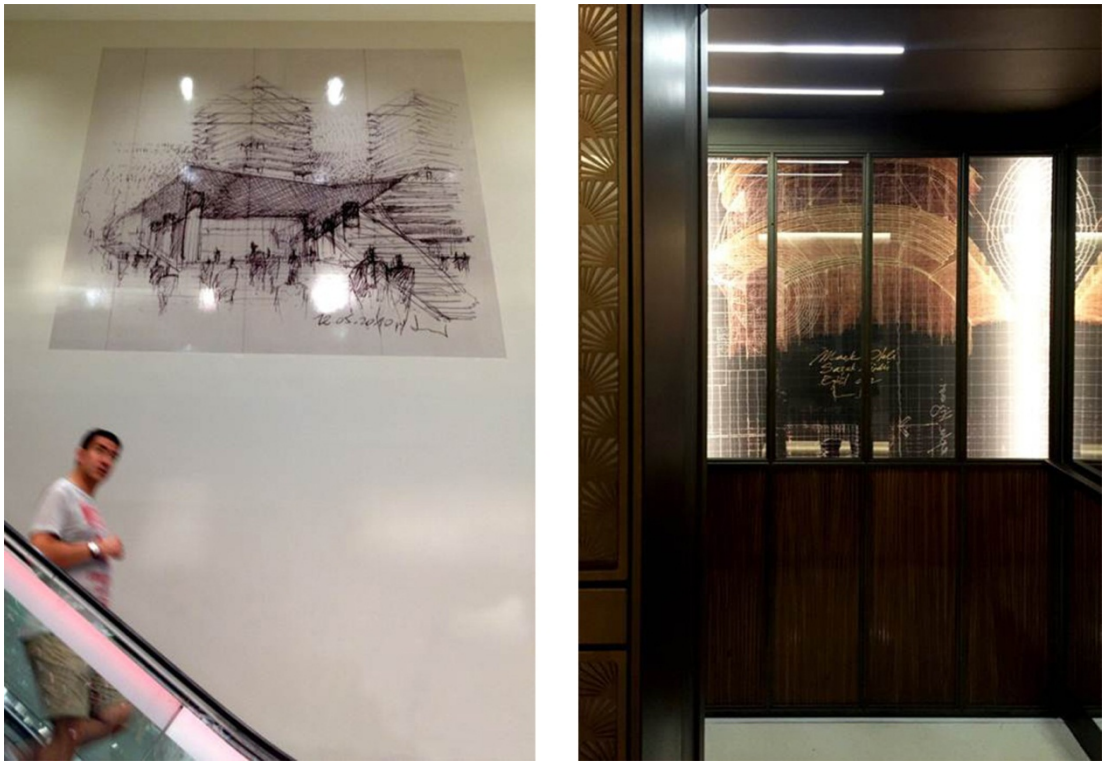

Figure 44: Examples of sketches as "creative genius paradigms": Emre Arolat sketches embodied in his buildings at Istanbul Zorlu Center (Left) and Maçka St. Regis Hotel (Right)
Source: Courtesy of Dr. Mustafa Haluk Zelef

The survey that was conducted comprises of two parts; the first is a questionnaire of 19 questions (Appendix A), and the second is further interview with some of the participants. The questionnaire is divided into three sets of questions; the first set of 7 questions (Practice Information) aims to compile general information about the age, sex etc. of the participants along with general information regarding their practices, the second set of 6 questions (Sketch Production) investigates their approach towards sketching in general and the third set of 6 questions (Digital Sketch Production) concerns their approach and thoughts towards digital sketching. Copies of the survey were distributed to 30 members of Turkish Independent Architects Association (locally known as TSMD[213]) either by hand or by e-mail and 26 of these architects responded. Four participants agreed to take part in a further personal interview with the author; Professor Dr. Celal Abdi Güzer who is also an academician with publications related to sketching in architecture, Cumhur Keskinok who is well-known for his signature style in sketching in the traditional medium, Ragıp Güneş Gökçek who favors digital medium for freehand sketching, and Hasan Okan Çetin who uses both mediums in practice.

This survey has been prepared with the help of two other surveys regarding sketching in early phases of design conducted in the UK and Australia. The UK-based 2008 questionnaire, prepared by Edwards which targeted some of the leading UK architects was "partly" adopted as basis for Turkey's questionnaire. The Australia-based 2006 survey was prepared by the team of Zafer Bilda, John Gero and Terry Purcell[214] and tested three expert architects' ability to design with and without sketching; the results of this survey were compared to the answers of the Turkish architects.

[213] TSMD stands for *Türk Serbest Mimarlar Derneği* which translates to Turkish Independent Architects Association.

[214] The researcheers are from Key Centre of Design Computing and Cognition, Faculty of Architecture, University of Sydney

4.2.1 The Questionnaire

Questions (9-13) in the second set (Sketch Production) are taken from Edwards' questionnaire where he investigates the sketching practice of 10 of UK most leading architects (Table 6). Edwards' survey aimed at understanding the role played by freehand architectural drawing in the development of architectural concepts in design phase. The questions covered areas such as the types of drawing produced at various design stages, the types of tools preferred, and the relation of these freehand drawings to the "CAD phase. The criteria for selecting the ten architects for Edwards' survey is, as Edwards explains; architects with medium or large sized practices with each architect having his own design approach, varying from urbanism to high-technical designs to rationalism to art and social motivation. These architects carry the reputation of "designers" based on their multiple architectural awards. The most important criteria which directly concerns this study is that "[e]ach architect was of a generation trained in the tradition of the freehand drawing but practicing in an age where digital representation was the norm", and that "[t]he resulting tension between the screen and the sketchbook interested the author"[215], which is similar to the main focus point of this study as well. In a conversation with the author, Edwards was asked the following:

> "Is there a possibility that the architects you have interviewed in 2008 have moved from traditional pen and paper towards digital pen and tablet PC? And if you were to redo the interviews in 2017, would you change anything in your questions?"

His response was the following:

> "I suspect you will find architectural practice has changed a lot over the ten years. But I'd like to think that freehand drawing still plays a key role in taking ideas from the mind into the first tangible design ideas." [216]

[215] Edwards B. (2008). *Op cit.* p.238

[216] Edwards B. (Author's Communication via e-mail, May 22, 2017)

While Edwards target architects' ran medium to large sized practices that varied from 21 to 174 architects (Table 6), in the case of Ankara survey, boutique architectural design offices of less than 10 architects are also taken into consideration since the sizes of architectural practices in the country are relatively smaller than those in the UK.

Table 6: Participants in UK Survey

Source: Edwards, B. (2008). *Understanding Architecture Through Drawing.* The Cromwell Press. Trowbridge. Wiltshire. p. 259

Architect	**Name of Practice**	**Size of Practice**
1. Bob Allies	Allies and Morrison	74 architects
2. Will Alsop	Alsop Architects	40 architects
3. Ted Cullinan	Edward Cullinan and Partners	35 architects
4. Sir Terry Farrell	Farrell and Partners	45 architects
5. Lord Norman Foster	Foster and Partners	174 architects
6. Malcolm Fraser	Malcolm Fraser Architects	17 architects
7. Sir Nicholas Grimshaw	Grimshaw Architects	34 architects
8. Richard Murphy	Richard Murphy Architects	28 architects
9. Allan Murray	Allan Murray Architects	24 architects
10. Gordon Murray	Murray Dunlop Architects	21 architects

Table 7: Participants in Ankara Survey

Source: Author

Architect	**Name of Practice**	**Size of Practice**			
		1-9	**10-19**	**20-29**	**30+**
1. İlhan Kural	Kural Mimarlık	●			
2. Aytek İtez	İtez Mimarlar	●			
3. Neşe İtez					
4. Kadri Atabaş	Atabaş Mimarlık	●			
5. Enis Öncüoğlu	Öncüoğlu Mimarlık				●
6. Saadet Sayın	SAYKA Mimarlık		●		
7. Özcan Uygur	Uygur Mimarlık		●		
8. Tülin Çetin	TÇMH	●			

9. Celal Abdi Güzer	CAG Mimarlık Atölyesi	●			
10. Lale Özgenel					
11. Erkan Kaçar	May Tasarım Yapı Mimarlık	●			
12. Cumhur Keskinok	Keskinok Mimarlık	●			
13. Nami Hatırlı	Hatırlı Mimarlık	●			
14. Yeşim Hatırlı					
15. Tolga Hazan	Hazan Mimarlık		●		
16. Burak Peri	Mavi Peri Mimarlık	●			
17. Eren Başak	Baobab Mimarlık	●			
18. Kerem Yazgan	Yazgan Tasarım Mimarlık				●
19. Seçkin Sezer Baydar	SGB Mimarlık	●			
20. Onat Öktem	ONZ Architects	●			
21. Ekrem Bahadır Çalışkan	EBC Mimarlık	●			
22. Evren Başbuğ	STEB	●			
23. Onur Yüncü	Onur Yüncü Architects	●			
24. Ragıp Güneş Gökçek	rgg Architects	●			
25. Hasan Okan Çetin	SMAG Mimarlık	●			
26. Ali Sinan	Ali Sinan Mimarlık	●			

Table 8: Set 1 in Ankara Questionnaire- Office Information (Continued)
Source: Author

Architect	Graduation Period						Practice Foundation Period						Position	
	1960-1969	1970-1979	1980-1989	1990-1999	2000-2010	2010-2017	1960-1969	1970-1979	1980-1989	1990-1999	2000-2010	2010-2017	Founder / Co-Founder	Partner
İlhan Kural	●							●					●	
Aytek İtez		●											●	
Neşe İtez		●						●					●	
Kadri Atabaş		●							●				●	
Enis Öncüoğlu			●				●							●
Saadet Sayın			●						●					●
Özcan Uygur			●							●			●	
Tülin Çetin			●							●			●	
Celal Abdi Güzer			●								●		●	
Lale Özgenel			●											●
Erkan Kaçar			●									●	●	
Cumhur Keskinok			●							●			●	
Nami Hatırlı			●							●			●	
Yeşim Hatırlı				●									●	

Tolga Hazan				●					●					●
Burak Peri				●							●		●	
Eren Başak				●							●		●	
Kerem Yazgan				●							●		●	
Seçkin Sezer Baydar				●							●		●	
Onat Öktem					●						●		●	
Ekrem Bahadır Çalışkan					●							●	●	
Evren Başbuğ					●							●	●	
Onur Yüncü					●							●	●	
Ragıp Güneş Gökçek					●							●	●	
Hasan Okan Çetin					●							●	●	
Ali Sinan						●						●	●	

Table 9: Responses to the research questions by UK architects interviewed by Edwards

Source: Edwards, B. (2008). *Understanding Architecture Through Drawing.* The Cromwell Press. Trowbridge. Wiltshire. p. 240

Architect	**Does design exist in head before the first drawing?**	**Type of first drawings made**	**Drawing tool used**	**Paper Used**
Bob Allies	Yes	Site plan and building diagram combined	Two sizes of black felt-tip pen	Sketch pad and tracing roll
Will Alsop	Yes	Abstract drawing or painting followed by plan	Painting followed by soft pencil or charcoal	Large cartridge sheet
Ted Cullinan	Yes	Section, overhead axonometric	Black and colored felt-tip pen	Tracing paper
Sir Terry Farrell	Yes	Section, plan view	Black felt-tip pen	Layout paper
Lord Norman Foster	Yes	Urban plan, section	Pencil and black felt-tip pen	Cartridge pad
Malcolm Fraser	Yes	Plan and section diagram	Black felt-tip pen	Narrow white tracing roll
Sir Nicholas Grimshaw	Yes	Masterplan and detail	Blue broad gauge fountain pen	Sketchbook
Richard Murphy	No	Plan and section	Black felt-tip pen	A3 tracing pad
Allan Murray	No	Site analysis and plan	Pencil	Narrow detail paper roll
Gordon Murray	Yes	Site analysis and design diagram	Varies	Narrow yellow tracing roll

Table 10: Responses to the research questions by Ankara architects interviewed by author (Set 2 in Turkey Questionnaire- Sketch Production)

Source: Author

Architect	Does design exist in head before the first drawing?	Type of first drawings made						Drawing tool used	Paper used (and Preferable working size)
		Site Plan	Plan	Section, Elevation	3D Drawing	Diagram, Analysis	Other		
İlhan Kural	Yes	●	●	●	●*			Pencil and pen	Tracing papers and whatever papers available (Size varies)
Aytek İtez	Yes	●	●	●				Pencil and pen	Tracing papers and drawing papers (A3, A4)
Neşe İtez	No		●	●				Pencil and pen	Tracing papers (A3)
Kadri Atabaş	Yes	●	●	●	●			Pen and water-colors	Logbook (A4, A5)
Enis Öncüoğlu	Yes	●	●		●	●		Digital pen and fountain pen	Yellow Tracing paper and digital tablet (A3, A4)
Saadet Sayın	No	●	●	●	●			Pencil	Tracing papers (A4, A5)
Özcan Uygur	No	●	●	●	●	●		Pencil	Tracing papers (A4)
Tülin Çetin	Yes			●		●		Pencil and pen (*Gliss*)	Tracing papers (A3)
Celal Abdi Güzer	No		●		●			Ballpoint pen	Tracing papers (A3, A4)
Lale Özgenel	Yes	●	●			●		Pencil	Tracing papers (A4, A5)
Erkan Kaçar	Yes		●		●			Pencil	Varies
Cumhur Keskinok	No				●			Ink and Artistic type Felt-tip pen (ex: *Pantone*)	Drawing paper (A4, A3)
Nami Hatırlı	Yes	●	●	●	●			Pencil, pen	Tracing

* İlhan Kural mentioned making rough three dimensional drawings using ArchiCAD.

								and ballpoint pen	papers and drawing papers (A4)
Yeşim Hatırlı	Varies	●	●	●	●	●		Pencil and pen	Tracing papers (A3, A4)
Tolga Hazan	No	●	●	●	●	●	●	Pencil, ballpoint pen and digital pen	Tracing papers and digital tablet (A3 and roll papers)
Burak Peri	No		●	●				Ballpoint pen	Tracing papers (A4)
Eren Başak	Yes	●	●	●		●		Pencil and pen	Tracing papers (A1, A2)
Kerem Yazgan	No	●	●	●	●	●		Pencil, pen and digital pen	Tracing papers, drawing papers, copybooks and digital tablet (A3, A4)
Seçkin Sezer Baydar	Yes	●				●		Pencil and crayons	Drawing papers (A4)
Onat Öktem	No	●	●	●	●	●		Pen and digital pen	Tracing papers, drawing papers and digital tablet (A2, A3)
Ekrem Bahadır Çalışkan	No	●	●	●		●		Pencil	Tracing papers and drawing papers (A4)
Evren Başbuğ	Yes	●	●	●		●		Ballpoint pen	Tracing papers (A3, A4)
Onur Yüncü	No	●	●	●	●	●	●*	Pencil and pen	Tracing papers and copybooks (A3, A4, A5)
Ragıp Güneş Gökçek	Yes	●	●	●	●	●	●	Digital pen (*Apple pencil*)	Tracing paper (33 cm Rolls) and digital tablet
Hasan Okan Çetin	No	●				●		Pencil	Drawing papers (A3, A4)

* Onur Yüncü specified “collage” as other type of first drawings he makes.

Ali Sinan	No	●	●	●		●		Pencil	Tracing papers (A4)

Table 11: Set 2 in Turkey Questionnaire- Sketch Production (Continued)
Source: Author

Architect	How often do you sketch?		At which phase do you sketch more?		
	Quite often	Not so often	Concept Phase	Detailing	Equally in Both
İlhan Kural		●	●		
Aytek İtez	●		●		
Neşe İtez		●	●		
Kadri Atabaş		●			●
Enis Öncüoğlu	●		●		
Saadet Sayın	●				●
Özcan Uygur	●				●
Tülin Çetin	●				●
Celal Abdi Güzer	●				●
Lale Özgenel		●			●
Erkan Kaçar		●			●
Cumhur Keskinok	●		●		
Nami Hatırlı	●				●
Yeşim Hatırlı	●		●		
Tolga Hazan	●				●
Burak Peri	●		●		
Eren Başak	●		●		
Kerem Yazgan	●				●
Seçkin Sezer Baydar		●	●		
Onat Öktem	●				●
Ekrem Bahadır Çalışkan	●		●		
Evren Başbuğ		●			●
Onur Yüncü	●				●
Ragıp Güneş Gökçek	●				●
Hasan Okan Çetin	●				●
Ali Sinan	●				●

Table 12: Set 3 in Ankara Questionnaire- Digital Sketch Production
Source: Author

Architect	Have you been using digital means in sketching? If yes, for how many years?					What hardware/ software you use the most?	Do you join more than one medium producing "hybrid" sketches?	Arrange these 3 mediums according to their advantage in sketching: Pen an paper/ Digital pen and tablet/ Computers	Do you believe that "sketch" definition includes 3D modeling programs such as "SketchUp"?	Do you think that digital sketching will replace traditional sketching in the future?
	No	1-3	4-7	8-11	11+					
İlhan Kural					●	*Apple Macintosh, iMac, MacBook Pro/ ArchiCAD*	Sometimes	1) Pen and paper 2) PC Didn't try Tablets	Yes	Probably Not
Aytek İtez					●	PC/ *ArchiCAD*	No	1) Pen and paper = PC	No	Probably Not
Neşe İtez					●	*MAC/ ArchiCAD*	Sometimes	1) Pen and paper 2) PC 3)Digital pen and Tablet	No	Most likely
Kadri Atabaş	●					—	—	1) Pen and paper	No	Most likely
Enis Öncüoğlu			●			*iPad Pro/ Sketchbook Pro*	Mostly	1) Digital pen and Tablet 2) Pen and paper 3)PC	Yes	Most likely*
Saadet Sayın	●					—	No	1) Pen and paper	No	Probably Not
Özcan Uygur	●					PC/ *SketchUp*	No	1) Pen and paper 2) PC 3)Digital pen and Tablet	Yes	Probably Not

* Enis Öncuoğlu states that digital tools will be favoured in the future; however, no digital means can replicate the feeling of pen or pencil sliding over paper. Thus, traditional means in sketching will always remain as a strong option.

Tülin Çetin			●			PC/ *SketchUp*	Mostly	1) Pen and paper 2) PC 3)Digital pen and Tablet	Yes	Most likely
Celal Abdi Güzer					●	PC/ *Vectorworks*	Mostly	1) Pen and paper 2) Digital pen and Tablet 3)PC	Yes	Probably Not
Lale Özgenel	●					—	No	1) Pen and paper 2) Digital pen and Tablet 3)PC	No	Most likely
Erkan Kaçar				●		PC/ *SketchUp*	No	1) Pen and paper	No	Probably Not
Cumhur Keskinok	●					—	Sometimes	1) Pen and paper	In between	In between
Nami Hatırlı	●					—	No	1) Pen and paper 2) Digital pen and Tablet 3)PC	No	Probably Not
Yeşim Hatırlı	●					—	—	1) Pen and paper 2) Digital pen and Tablet 3)PC	No	Most likely
Tolga Hazan				●		Tablet, Printer, Lazer Cutter/ *Grasshopper, CAD*	Sometimes	1) PC 2) Digital pen and Tablet = Pen and paper	Yes	Most likely
Burak Peri	●					—	—	1) Pen and paper	Yes	Most likely
Eren Başak	●					—	No	1) Pen and paper	Yes	Most likely
Kerem Yazgan		●				*Samsung Tablet/ Note*	Sometimes	1) Pen and paper2) Digital pen and Tablet 3)PC	Yes	Most likely
Seçkin Sezer Baydar	●					—	No	1) Pen and paper	No	Probably Not
Onat Öktem				●		Hybrid	—	1) Pen and paper 2) PC	Yes	Most likely

Ekrem Bahadır Çalışkan	●					—	No	1) Pen and paper	Yes	Most likely
Evren Başbuğ	●					—	No	Don't know	Yes	Most likely
Onur Yüncü					●	PC/ *SketchUp, AutoCAD, Photoshop*	Sometimes	1) Pen and paper 2) PC 3)Digital pen and Tablet	Yes	Probably Not
Ragıp Güneş Gökçek		●				*iPad Pro/ GoodNotes*	Mostly	1) Digital pen and Tablet 2) Pen and paper 3)PC	Yes	Most likely
Hasan Okan Çetin		●				PC/ *SketchUp*	No	1) Pen and paper 2) PC 3)Digital pen and Tablet	No	Most likely
Ali Sinan	●					—	No	1) Pen and paper	Yes	Probably Not

4.2.2 The Results

In Edward's survey, 8 of 10 architects stated that the concept roughly forms in their imagination before sketching. In Ankara however, 12 said it does, another 13 said it does not and 1 (Lale Özgenel) said it varies from one project to the other. This can lead to say that the ability to pre-imagine the design in the head is not an essential criterion for the architect's success. When Ankara architects were asked how often they sketch, 19 stated they sketch frequently while 7 said they don't sketch quite often, 6 of these 7 architects were among those who stated that ideas do form in their imagination before starting to sketch, and when asked about the phase in which they sketch more; 16 said they sketch both in conceptual design phase as well as detailing phase. This could be connected to the Australian survey which showed that sketching was not an essential activity for "expert" architects in the early phases of

design as there was no significant difference in the quality of the outcome[217], yet, most participants still preferred sketching in designing as well as in communicating ideas with team members or clients as shown in the Ankara survey.

In terms of types of first drawings made, both groups of UK and Ankara participants showed more interest in orthogonal drawings; in UK case, only Cullinan specified axonometric drawings as types he'd start with, and in Ankara, three-dimensional drawings came fifth in the order of preference which as follows:

- Plans (22 participants)
- Site Plan (20 participants)
- Section, Elevation (19 participants)
- Diagram, Analysis (16 participants)
- Three-dimensional sketches (15 participants)
- Other (3 participants)

The first four types are not difficult in comparison to the fifth in terms of sketching via a digital medium. This could be linked to the previous statement of Marks about BIM that "BIM will only enable you to build what the construction industry enables you to build", and as a construction industry dominant market, Ankara conditions might be encouraging architects towards an orthogonal mode of sketching. In sketching tools preference, 5 architects listed digital pens and tablets as preferable sketching tools, all of these 5 architects also listed three-dimensional sketches as a type of first drawings to make, however, looking at their software preference, the tablet PC applications they mentioned were two-dimensional sketching applications, this leads to say that tablet PC's in Ankara-based practices are not "yet" used to produce three-dimensional sketch models. As for the size of sketching surface, the majority stated being comfortable with sizes not larger than

[217] Bilda Z., Gero J. S. and Purcell T. (2006) *To sketch or not to sketch? That is the question.* Design Studies, V. 27 Issue 5, September 2006. pp. 587-613

A3. This means that the limited size of tablet PC screens would not be considered as a handicap in sketching.

In the set regarding digital sketching production, the architects were divided in the question concerning whether the outcome of fast digital modeling software such as *SketchUp* is in fact considered a “sketch”. While 15 said it is a “sketch”, 10 said it was not, and 1 architect (Cumhur Keskinok) was in-between. 4 of the architects who said “no” noted that they do create rough three-dimensional models in early design phases but did not consider the outcome to be a “sketch”. While the majority picked traditional pen and paper as the most advantageous sketching medium, 15 architects thought that digital sketching tools are most likely to replace traditional tools in the future, while 9 said they did not expect this to happen and 1 architect (Cumhur Keskinok) was in-between.

4.2.3 The Interviews

Semi-structured in depth interviews with some of the participants of the survey, enabled the research to elaborate some of the issues related to the sketching in the digital era. Starting with Güzer, he states the problems outlined in the problem definition earlier as such that the differences between freehand sketching and computer sketching are; first, sketches are personal reflections of the designer, and this personal touch is lost while transferred to the screen. Second, the many layers of sketches show the development phases of the idea, and each sketch in the process carry the potential to generate new concepts as designers can decide on which layers to pick and which to leave behind, on the screen however, the layers of development may get lost if the designer does not save different versions of the file each time he/she tests a new idea. Third, hand sketches are abstract in nature while computer sketches may lure the designer into going into unnecessary detailing in a too early phase. Lastly, limited software knowledge may push the designer into settling with specific geometries rather than having the freedom to fully express his/her thoughts. Kendra S. Smith assures that even simple digitally created forms can be limiting,

since it takes time and effort to render the details on the screen especially in perspective views. Moreover, most digital programs create straight surfaces more easily than round ones (a problem that has been under rectification). One of the important advantages of the digital medium is that it allows stretching those forms and allowing the designer to view them from various points which can broaden his/her imagination: "In many cases, the 'true' look of the image depends upon the needs and intent of each architect. In some situations, the more ambiguous object encourages architects to derive inspiration from the undefined form."[218]

About the question related to whether fast digital models were "sketches", Güzer argues that the answer depends on the intention behind the software usage; architects who use the software to produce quick sketches would classify the outcome as a "sketch" while those who take their time in creating and detailing the outcome would only see it as a "drawing". Smith states a similar position to which digital drawings can be considered "sketches":

> "Digital sketching programs such as *SketchUp* have attempted to imitate conceptual thinking. If a sketch is defined as being preparatory to something else, and also consists of simple forms similar to an outline, then these digital images may indeed be viewed as architectural sketches. The digital medium easily and quickly forms primary geometric shapes, similar to architects' hand-constructed diagrams. The shapes, devoid of detail, could also be considered preliminary because they provide basic conceptual information prior to design development"[219]

In his own professional practice, although using computers and software such as *Vectorworks*, Güzer prefers producing a lot of sketches during the design process (Figure 45), and in times when his team asks for feedbacks on a design on the screen, he asks for a printout on which he can design and express his thoughts via freehand sketching on tracing papers[220]. Many architects prefer this method of "freezing" the

[218] Smith, K. S. (2005). *Op Cit*. p.208

[219] *Ibid*. p. 207

[220] Güzer C. A. (Personal Communication, Dec 29, 2017)

digital model for a short while and go back and forth between the paper and the screen. Eisenman is one of those who use images as references to draw by hand; “anytime someone draws something in the computer, I want it printed so I can draw over it either with tracing paper on it or without it”[221].

Hasan Okan Çetin has tried both the traditional and the digital mediums in sketching but prefers the paper over the touchscreen, since some of the tablet devices are not advanced enough to minimize the time interval between pressing the digital pen and seeing the result on the screen. Any such delay, even for a second, largely interrupts the creative thinking sequence. However, Çetin still uses digital tools in sketching while providing design feedbacks for his team from a distance. While preserving his sketchbooks as valuable documents, the digital sketches mostly get deleted after the project is completed.

[221] Ansari, I. (2013). *Op. Cit.*

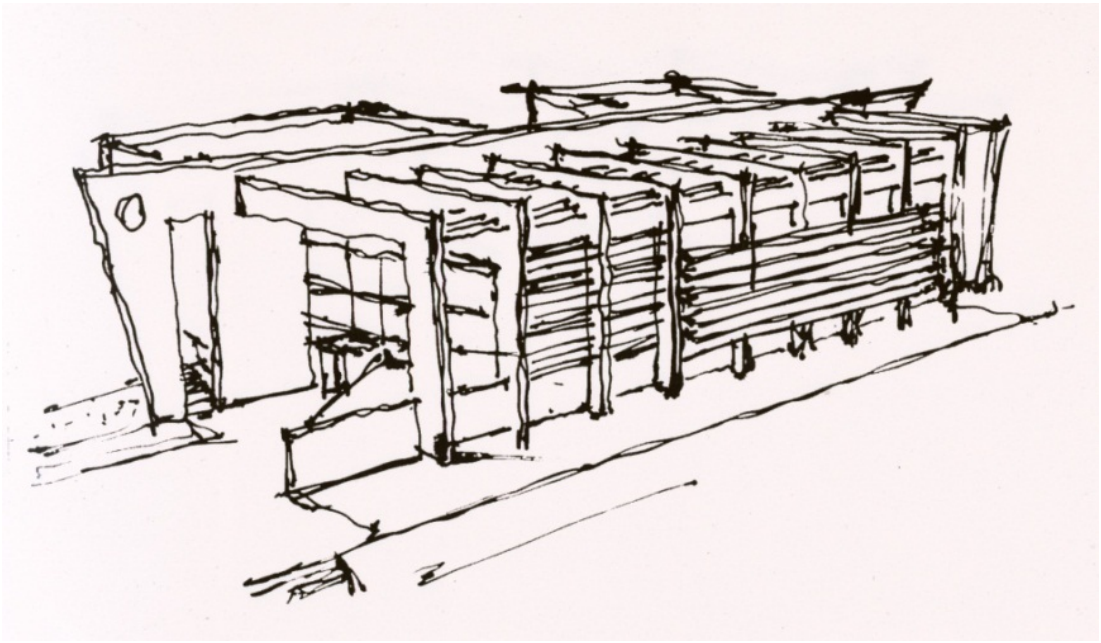

Figure 45: İnönü University Vocational Schools of Health and Health Services; a sketch by Celal Abdi Güzer
Source: Courtesy of Celal Abdi Güzer

Figure 46: İnönü University Vocational Schools of Health and Health Services; completed project
Source: CAGAW (2009). *İnönü University Vocational Schools of Health and Health Services*. Celal Abdi Güzer Architectural Workshop. Retrieved 29.12.2017 from: http://cagaw.com/project/inonu-university-vocational-schools-of-health-and-health-services

Keskinok explained his method in sketching saying that he usually starts with a plan and then extrudes it to elevation, section and perspectives. He states that a full set of "presentable" conceptual design sketches composed of perspectives and orthogonal views (Figure 47) takes him a much less time to produce in hand rather than if it was given to a specialist to produce in a computer. If the plan is roughly available on CAD, he sketches three-dimensional views directly on the CAD printout (Figure 48). These conceptual sketches are given afterwards to computer graphic specialists to be reproduced in the digital format and rendered accordingly (Figure 49). Keskinok's sketches are often straight lines drawn in rulers (but not precisely measured), then colored in various markers. In this era, it is not very common to use conceptual sketches in presentation boards whether for competitions or clients. This leads to two issues Keskinok remarks in competition and in general client presentations; first, in invited competitions to be specific, having a well-known style in sketching may lead to revealing both the architect's own and his firms identity which may affect the jury's impartiality, second, in general presentations, while some clients admire these sketches, others do not consider them as part of a finished concept representation and demand moving to computer renders phase instead[222]. According to Çetin, this happens because rough sketches are often open to interpretation and the clients in the second case cannot fill-in the blanks using their own imagination. For this reason, they demand the architects to provide them with photo-realistic renders[223]. About the invited competition issue, a discussion raises as such that even computer graphic specialist have their own styles in rendering which may be revealed as well, however, in the case of hand sketched concepts, the designer and the sketcher are usually the same person while in computer renders, the computer graphic specialist is not necessarily the designer and may produce renders for more than one firm participating in the same competition.

[222] Keskinok C. (Personal Communication, Aug 9, 2017)

[223] Çetin H. O. (Personal Communication, Aug 9, 2017)

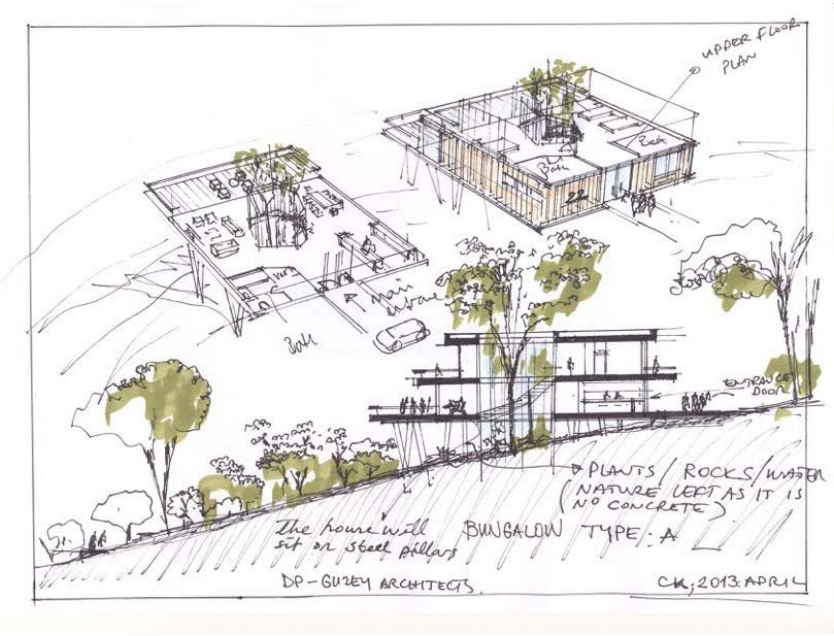

Figure 47: A conceptual sketch of oblique plans and section by Cumhur Keskinok

Source: Courtesy of Cumhur Keskinok

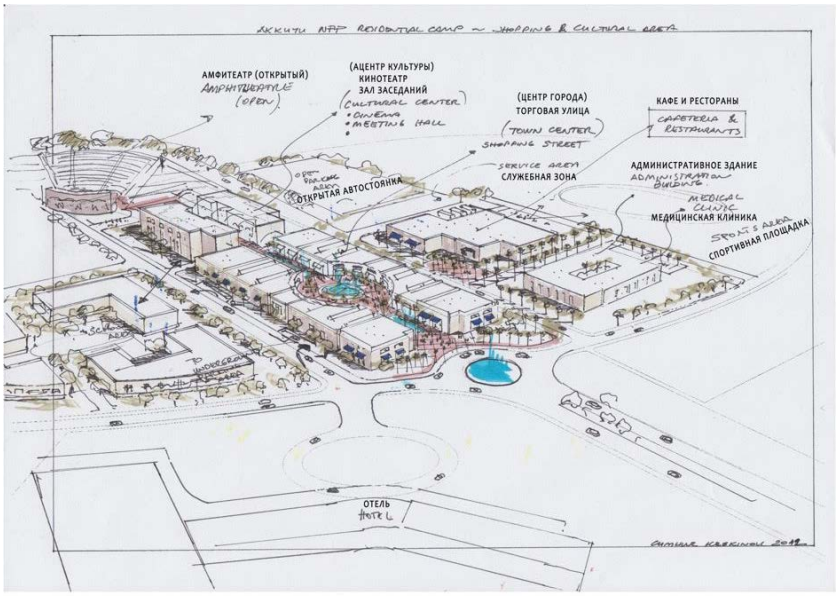

Figure 48: A conceptual bird's eye view sketch drawn over CAD plan printout by Cumhur Keskinok

Source: Courtesy of Cumhur Keskinok

Figure 49: A plan sketch diagram extruded to elevation and perspective view by Cumhur Keskinok, and a rendered image produced by computer graphic specialist based on the sketches

Source: Courtesy of Cumhur Keskinok

Gökçek declared that he prefers digital sketching on tablet PC for a number of reasons; planning presentation boards (Figure 50), sketching directly on CAD imported drawings or rendered images (hybrid sketching) (Figure 51), and preparing sketch diagrams (Figures 52 and 53). Hybrid sketching is especially beneficial while travelling in terms of keeping in touch with the office, and giving quick feedbacks without the necessity to print and scan, or having to exchange ideas verbally. In the case of diagrams, Gökçek benefits from features such as copy/paste option rather than manually redrawing components multiple times, another feature is hatch option; the ability to select an area and immediately (and uniformly) color or hatch it in a variety of colors or "mostly pre-defined" patterns, in addition, the use of a variety of line colors, transparencies and types (continuous or dotted in various frequencies). Some of these digital diagrams are used as they are in competition entries without the need to make sketches on paper and then scan them[224]. (Figure 54) shows a competition entry by the author and colleagues[225], in which both manual and digital sketches were submitted, the manual sketches were drawn on the same sketchbook by the same drawing tools, but were scanned by two different scanners which led to differences in the background coloration.

[224] Gökçek R. G. (Personal Communication, April 25, 2017)

[225] The competition entry by the author along with Melike Emerce, Mehmet Koray Karagöz and Hüseyin Hilmi Kezer, was "*The Rifat Chadirji Prize 2017 - Mosul's Housing Competition*"; organized by *Tamayouz Excellence Award.* The organizer is "an independent initiative with no political affiliation, which aims to advance the profession of architecture in Iraq both academically and professionally". The entry was announced in the shorlist of top 20 entries among 223 entries submitted by firms, practitioners and students from 42 countries. The Top 20 entries will be featured in a traveling exhibition that will visit Amman, Baghdad, Boston, Beirut, Milan, and London. Source: Tamayouz Excellence Award (2017) *The Rifat Chadirji Prize 2017 - Mosul's Housing shortlist announcement*. Retrieved 25.09.2017 from: http://www.tamayouz-award.com/news/the-rifat-chadirji-prize-2017-mosuls-housing-shortlist-announcement

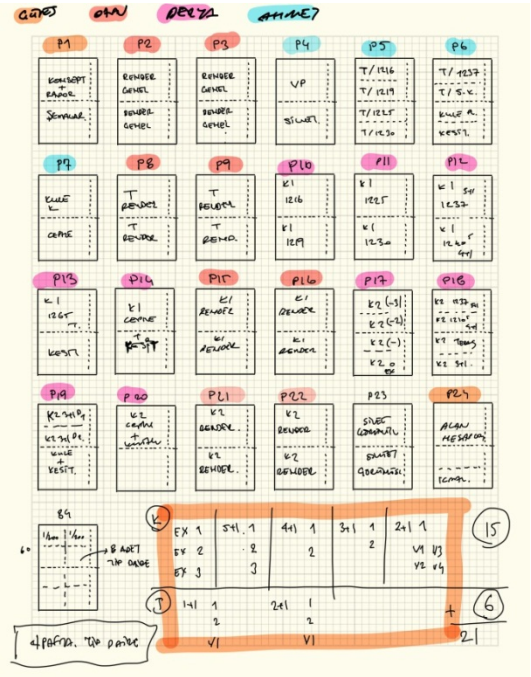

Figure 51: Presentation Board Planning (*iPad Pro, Apple Pencil + Goodnotes*)
Source: Courtesy of Ragıp Güneş Gökçek

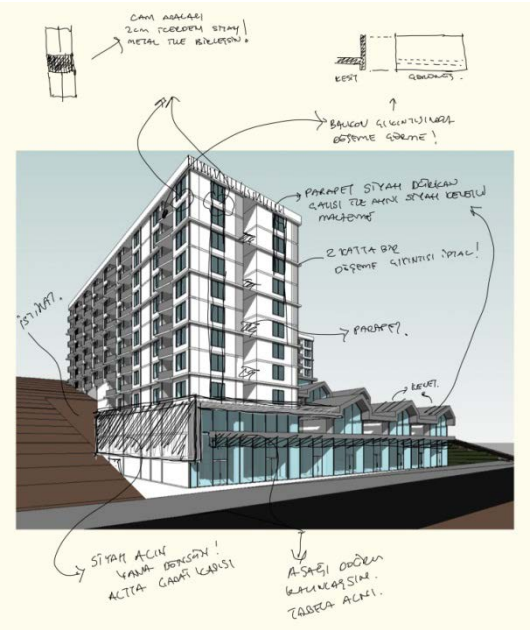

Figure 50: Hybrid Sketch on SketchUp model Image (*iPad Pro, Apple Pencil + Goodnotes*)
Source: Courtesy of Ragıp Güneş Gökçek

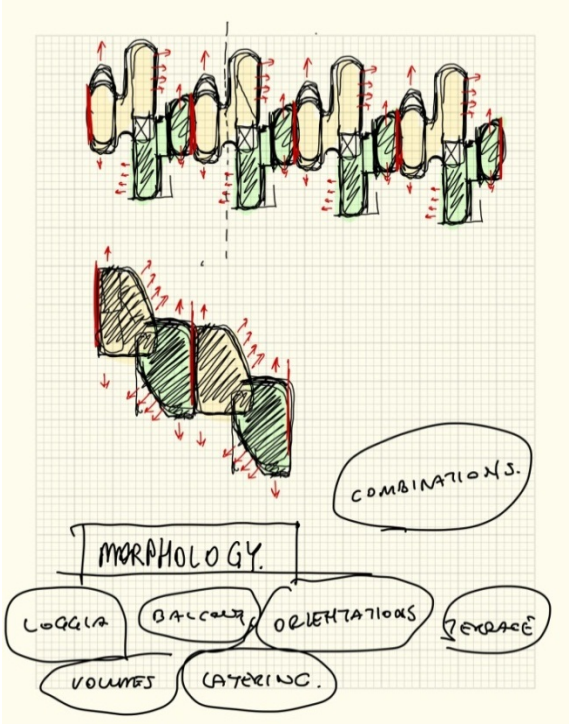

Figure 52: Sketch Diagram Showing Elements Copied and Dragged (*iPad Pro, Apple Pencil + Goodnotes*)
Source: Courtesy of Ragıp Güneş Gökçek

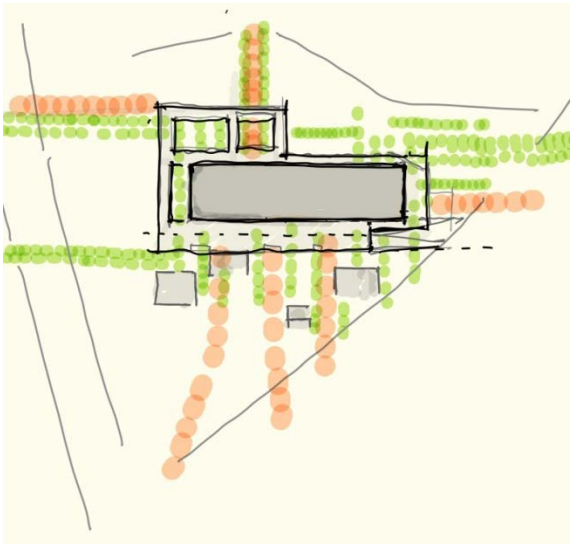

Figure 53: Sketch Diagram Showing Dotted Lines and Fill Patterns (*iPad Pro, Apple Pencil + Goodnotes*)
Source: Courtesy of Ragıp Güneş Gökçek

Figure 54: ***The Rifat Chadirji Prize 2017 - Mosul's Housing Competition*** **Entry Showing Sketches Done both in Digital (left) and Traditional (right) Methods**
Source: Author

CHAPTER 5

CONCLUSION

About the value of a sketch, Belardi states:

> "An idea arises as a type of sketch, or, according to the Italian linguist Giacomo Devoto's definition, 'a rough draft drawn with few essential marks... open to greater development, but able to be considered complete as well'. The sketch, then, despite often being the site of a stamp or a pack of matches, is neither the representation nor the embryo of the idea but rather, as Architect Franco Purini said, **'the DNA of ideas'**. It is the idea's genesis because it tends to solve, within the context of the inventive kernel of activity, every complexity of what is still outside that kernel, however temporarily."[226]

In this thesis, the value of freehand sketching as a fundamental tool in the professional practice of architecture is clarified in the light of many technological advancements that influenced, and continue to affect the practice. The question about whether freehand sketching in architecture was dead or going through revival or "renaissance" could only be answered in reference to sketch functions. Digital photography has clearly decreased the necessity to "sketching as observation", while having positive influences on "sketching as designing" and "sketching as communication tool". Computers did not have an impact on "observation", however, they clearly affected "designing", although this effect may not be classified as a decrease but rather taking freehand sketching into different dimensions in terms of hybridizing the sketch outcome, the impact on "communication" can also be classified as positive. Smart technological devices showed significant positive influence on "designing" and "communication" among architects, clients and various disciplines, while taking "observation" into a different level.

[226] Belardi, P. (2014). *Op. Cit*. (Z. Nowac, Trans.). p.24

While the digital impact on freehand sketching is increasing, there is no evidence that freehand sketching is being abandoned, or "dead". However, these technological changes led to widen the concept of sketching, and this widening led to debates among architects' opinions regarding differences in the characteristics of what are considered "freehand sketches", "sketches", "freehand drawings" and "drawings" in general, the most debatable of which is the issue of imprecision. In the traditional medium; the "speed" and the "level of abstraction" characteristics set sketches apart from drawings. When it comes to the digital medium; it was found that it is the "intention" behind, that was setting sketching apart from drawing as Smith and Güzer noted.

The various sketching and drawing software and hardware tools that developed starting from the second half of the twentieth century, first came with digital pens, then moved to mice and currently are being used by both means. The replacement of the pencil with the mouse as a "tool" resulted in impersonal representations that are too precise, too clear, and less open for interpretation. The influence of the computer as a "way of thinking", on the other hand, led to issues such as limiting the architects with only sketching what their teams can draw in the computer later, and to difficulties in following design development stages, unlike sketches which are layer-able by nature. Moreover, the speed of learning and the cost of various computer software packages are more complicated in contrast with traditional sketching tools. Current-day technology tried to overcome those issues by digitizing the pen and the paper, and brought with it a number of digital sketching tools that have been closer to imitating the traditional means in sketching than the previous attempts from 1960s onwards. Each of the hardware/ software tools has its own strength and weakness points, and this applies to traditional pen and paper freehand sketching as well.

In terms of the problem associated with the "tool"; the success of the digital medium was found to depend on four factors, as Gordon mentioned, these factors are: portability, accuracy, ergonomics and the ease of use. Taking these factors into consideration, along with the designer's own capabilities; a combination (or a

hybridization) of the traditional and the digital tools can yield into obtaining the ultimate results. This hybridization of tools bear a potential to produce new forms of architecture which single mediums fail to show as it is stated in Kulper's argument.

Concerning the matter of "way of thinking"; the digital success according to Libeskind was found to be related to the aspects of reducing the cost, and increasing the speed, in addition, providing environmental solutions, technical efficiency and faster communication.

A closer look at the production process of experienced architects both in world-wide and in Turkey cases, shows that their openness towards new technological advancements is a crucial criterion for their practices' success in the market; some of them personally use technological tools for sketching and others recruit experts in the computer graphics field to help transform their sketches into production drawings. What has been noticed is that digital pens and tablets began to find their way into office practices in Turkey, and it could be a matter of time before every office will obtain a working tablet along with each computer. Many of the architects, who preferred traditional means in sketching, showed an adaptation towards moving to digital tools in the near future. No evidences were found, however, to support the idea that those who learn using digital tools ahead show any tendency towards preferring to sketch in the traditional means at a later stage. It is true to say that almost no one learns sketching in the digital medium first, since everyone experiences pen and paper from the early childhood years, however, current young generations are showing higher familiarity towards technology at an early age, and the more they depend on smart devices, the more they tend to show a sort of resentment towards old school writing and sketching methods.

Accordingly, it would be crucial to encourage students of architecture to liberate their hands and minds from the computer at the early phases of design and practice sketching, as previously mentioned in Calatrava's quote; "it's very important to go through the process until you reach the limit of what you can do with your

hand."[227] Here, "what you can do with your hand" can cover both the traditional and the digital pen, which will eventually facilitate the candidates' adaptation to the digital world and the creative production process after obtaining their professional degrees on the long run. However, while keeping awareness of the advantages and limitations of any sketching tool, it can be useful, especially for professional architects, to keep in mind the aspects noted by Libeskind about the digital success in order not to fall in the trap of the "I can, therefore, I shall" trap warned by Lewis. This means that neither the software nor the pencil alone should be treated as a design factor but as a "tool" of facilitating the other design factors without underestimating the power of the tool itself as Spuybroek assures.

[227] Pedersen, M. C. (2012) *Op. Cit.*

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APPENDIX A

THE QUESTIONNAIRE

"SKETCH" PRACTICE IN ARCHITECTURAL OFFICES IN ANKARA"

By: Nuran Özkam| Thesis Advisor: Assoc. Prof. Dr. Haluk Zelef| METU| May 2017

Practice Information:

1. Your Name:

2. Practice Name:

3. Establishment Period:
□ 1970-1979 □ 1980-1989 □ 1990-1999
□ 2000-2010 □ 2010 or later

4. Your Position:
□ Founder/ Partner □ Partner

5. Team Member Count:
□ 1-9 □ 10-19 □ 20-29 □ 30 or more

6. Your Graduation Period:
□ 1970-1979 □ 1980-1989 □ 1990-1999
□ 2000-2010 □ 2010 or later

Sketch Production:

7. How often do you sketch?
□ Quite often □ Not so often □ I do not sketch

8. At which design phase do you sketch more?
□ Concept phase □ Detail phase □ Equally in both

9. Does design exist in head before the first drawing?
□ Yes □ No, it develops through sketching

10. Types of first drawings made (You can pick more than one):
□ Site plan □ Plan □Section, Elevation
□ 3D Perspective □ Diagram, Analysis □ Other (Please specify):

11. Drawing tool used (You can pick more than one):
□ Pencil □ Ballpoint Pen □ Ink
□ Watercolors □ Digital Tools □ Other (Please specify):

12. Paper (or drawing surface) used (You can pick more than one):

□ Tracing paper □ Drawing Paper □ Digital Tablet
□ Other (Please specify):

13. Preferable working size (You can pick more than one):
□ A5 □ A4 □ A3 □ A2
□ A1 □ Other (Please specify):

Digital Sketch Production:

14. For how many years have you been using digital tools in sketching?
□ 1-3 □ 4-7 □ 8-10 □ 11 or more
□ I don't use digital medium

15. Which hardware and software do you prefer using for digital sketching?
Hardware:
Software:

16. Do you join more than one technique and produce "hybrid" sketches? (For example, do you draw directly on digital photographs in tablet PC):
□ Yes, mostly □ Yes, occasionally □ No

17. Please sort these sketching mediums according to their advantages. (1 being most advantageous, 3 being less advantageous)
□ Pen/ Paper □ Digital Pen/ Tablet PC □ Computers

18. Do you think that "sketch" definition also encompasses fast 3D modeling software such as *SketchUP* and *Audodesk FormIt*?
□ Yes □ No

19. Do you think that digital sketching will replace traditional sketching in the future?
□ Most Likely □ Probably Not