Use of CAAD Tools on Conceptual Stage of Design

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ABSTRACT

Architectural design can be defined as a complicated process. It is necessary for the designer to take into account the series of subgroups from a group of probable operations at any stage of this process while he/she accounts for the results of design in general. That is to say, at any stage of the design process, the designer may often consider only a restricted series of the operations that can be applied for the design. Whilst trying to accomplish this, efforts are made to discover if a designer or a modeler must actually create a design, attempt to perform external representation in the early phases of the design procedure that takes place their mind.

Modern designing programs are not generally meant to be used in architecture, although design tools that do exist on computer provide humans with the possibilities to act more efficiently in terms of design. Therefore, with regard to the limitations of such software, they serve to create architecture artwork by a medium that interprets information into a determined form. This research intends to explore the inadequacy and the limitations of the CAAD programs in design procedures as well as discuss how design tools can help designers.

This study is aimed to achieve a better comprehension of the impact of CAAD tools on the conceptual stage of modern architectural design. The general methodology of the research is an interview study with a number of Iranian designers, which were selected randomly among architectural offices in Tehran (Capital city of Iran). The research will aim to discover what designers need in the conceptual stage of designing and in what way common economically accessible tools can meet their

needs.

Keywords: Computer-Aided Architectural Design, Conceptual Design, and Design Process.

ÖZ

Mimari tasarım farkli asamalardan olusan karmaşık bir süreç olarak tanımlayabiliriz. Tasarımcı proje surecinde bu asamalari izlerken tanimlanmis bir dizi yol izler. Başka bir deyişle, tasarımın her adımında tasarımcı tarafından uygulanabilecek eylemler cesitli asamalarda izlenecek yontem ve araclarla sınırlıdır. Bu durum tasarımcının, tasarım sürecinin başında ongordugu konsept dogrultusunda sonlandirabilmek icin çok fazla emek gerektirmektedir. Günümüzde farkli asamalari desteklemek icin arac olarak kullanılan tasarım programları bilgisayar temelli olup tasarımcılara verimli çalışma imkanı verse de genel olarak mimari tasarim için yaratılmamış olup tasarim surecinde verimli kullanilamamaktadirlar. Tasarımcılar bu programlardaki kısıtlamalara rağmen mimari projeleri programlarda belirlenen şekilde işlemek için çalışmaktadır. Bu çalışmanın amacı CAAD programlarının tasarım sürecinin farkli asamalarinda olasi kısıtlama ve yetersizliklerini ortaya koymaktir. Ayni zamanda bir tasarım araçi olarak, tasarim surecindeki farkli tasarim asamalari baglaminda tasarımcılara nasıl yardımcı olabileceğini tartışmaktır. Araştırmanin alan calismasi İranlı tasarımcılar ile sözlü görüşmeler yapılarak yürütülmüştür. Katılımcılar İran'ın başkenti olan Tahran'dan rastgele seçilmiştir. Çalışmanın sonunda tasarımcıların, kavramsal tasarım aşamasında nelere ihtiyacı olduğu ve bu ihtiyaçlara yardımcı olabilecek ekonomik, kolay ulaşılabilir araçların ne olduğunun bulunması amaçlanmaktadır.

Anahtar Kelimeler: Bilgisayar Destekli Mimari Tasarım, Kavramsal Tasarım ve Tasarım Süreci.

I dedicate this thesis to my beloved family who has been always my support. It is their absolute love that motivates me to stand on my foot and set higher targets.

I hope that this achievement will although a small thank for my parents' effort all those years ago when they gave me the opportunity of the best education they could.

ACKNOWLEDGMENT

I would like to thank Assoc. Prof. Dr. Resmiye A.Atun as my supervisor; for her continuous support and guidance in the preparation of this study and I would like to convey a special thanks to Prof. Dr. Yonca Hürol who taught me how to do research, Also I am thankful to my jury members: Prof. Dr. Ulaş Uğur Dağlı, Assist. Prof. Dr. Halil Alibaba

I am grateful to; a number of friends had always been around to support me morally that I would like to thank them all.

I owe quite a lot to my family who allowed me to travel all the way from Iran to Northern Cyprus and supported me all throughout my studies. I would like to dedicate this study to them as an indication of their significance in this study as well as in my life.

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“Computers have come to stay; they are changing the world whether we like it or not, and gradually they will find their way into the offices of architects and the schools of architecture all over the world.”
(Sudbo, B. 1988. p 1)

Chapter 1

INTRODUCTION

Generally, after investigating the design requirements, architects choose a different design space in the initial phases of designing. This leads to an experimental way to satisfy these requirements. Some ideas, one or two, can compose the base of this trial approach. In such a situation, the design concepts are usually examined on a more efficient basis. Therefore, the earliest phase of design is called the conceptual stage. Most of the architects prefer to display their thoughts and notions in sketches in this phase of design; they indicate their concepts on-the-fly through sketches. To some extent, considerable studies have been carried out in order to find out why sketching is regarded as a desirable way of conceptual designing. Ambiguity has been found in some researches to be one of the major reasons for this since it discloses more capabilities in the representation (Suwa Purcell, Gero, 1998: pp455-483). Discussions related to applying CAD by designers acknowledge that architects cannot obtain the ambiguous background from CAD setting necessary for conceptual designing (Salman, H.S., 2004).

It is argued if representation of initial idea, is an unavoidable precondition for conceptual designing, that is to say, whether creating and utilizing the digital presentation as external presentation is a requirement for an architect in the early phases of conceptual designing. This research pays attention to the external

presentation and also whether they play a major role more in designing phase rather than in examining in what way computer aid influences conceptual designing. However, the initial reason for this study is on the basis of a research concerning effective computer aid in the stage of conceptual design. What is expressed in this study suggests the discussion on how to make CAD tools more compatible to conceptual phases of design (BildaZafer, Gero John S.2005).

1.1 Statement of Thesis Problem

Nowadays there are several computer programs that have been created to help designers, architects and civil engineers to improve quality and increase speed in design.

The major motivation to prepare the thesis is to investigate the ability of CAAD as a designing tool to prevail over the transitional gap of design stages in architectural design process. Work done on CAAD so far is mostly on the basis of theoretic presumptions and this thesis intends to investigate experientially some features of those researches.

In the traditional background of design tools and architectural designing, there is collaboration between designers and design systems. CAAD is one of them. This collaboration is identified and acknowledged under one circumstance: the role of CAAD in the comprehension of designing process. The role is acknowledged if CAAD is utilized for producing and not acknowledged if it is utilized for realization or design investigation. Therefore, design circumstances are created in the following positions; in what way, why, how and when CAAD is utilized.

Therefore the main question of this study is propounded; Could CAAD tools are helpful in conceptual phases of design process, And related with that; What is the potential of CAAD as a conceptual tool.

But the general question of this study, which in final was discussed, is; does technological development result in contemporary architecture advancement or, on the contrary, progression in contemporary architecture causes technology to develop increasingly.

Consequently these are lots of questions related with the Computer-Aided Architectural Design tools such as:

- In WHAT WAY, WHY, HOW and WHEN CAAD is utilized.
- What is CAAD tools efficiency during the architectural design process.
- Whether CAAD technology follows design discipline or design discipline follows CAAD technology.

This thesis has one research question;

Concerning effective computer aid in the stage of conceptual design.

1.2 Aim of Study

As mentioned in the statement of thesis problem part general question and aim of this study is to determine the relationship between CAAD tools and architectural design, whether CAAD technology follows design discipline or design discipline follows CAAD technology.

In addition, this thesis intends to outline the common role of CAAD for designing in

the field of architecture: explore what CAAD is able to give additionally to the conceptual designing procedure that other systems are not, and in what way CAAD may enhance or affect design.

The following research goals are shown in Figure 1. In order to reveal the associations with the thesis content:

1- Clarifying the determinants and restrictions that affect the function of CAAD in designing.

2- Providing a realization of concept development when CAAD is being used for design regarding CAAD's (common) specifications as a means of representation, and the usage of these tools in initial phases (conceptual phases) of design process.

1.3 Methodology

The research will be distributed into four basic sections:

1. Describing the aim of the research, defining the main research questions and determining the focus.
2. The history (background) of Computer Aided Architectural Design.
3. Examine the advantages of these tools from several points of views by discussing them with experienced architects within the case.
4. Analyze the result of interviews to achieve the conclusion.

This research starts with the brief history of CAAD tools as the background then explains the purposes, questions and previous related researches according to the topic as literature review. The other step is discussing the topic with a number of experienced architects as a case on the headquarters of basic information's main criteria. Lastly, the author will try to summarize the main concepts of this

thesis and answer the research questions in the conclusion. The necessity Computer Aided Architectural Design tools during the design steps. In the next chapter, history of CAAD tools and different attitude around the world will be discussed to prepare required information for analysis and comparison to find out how these tools could be beneficial in every stage of architectural design.

This study includes qualitative and quantitative research methods to read, analyze and understand the role of CAAD in contemporary architecture as well as the usage of computer and virtual space in the design process. Methods for theoretical data collection mainly include literature and have been collected through books, articles and the web. In the literature section, certain keywords and concepts, which are to be extracted mainly from the sources about Conceptual Design, Computer-Aided design and creativity will be focused and utilized for the development of theoretical framework of the study. Findings revealed from literature will guide the studies at the interview with a number of architects.

Exploring the methodologies of investigation of the designing procedure and design behavior, we come across two methods, which are interviews for survey data and documentaries for theoretical data. Interview researches have been most frequently carried out with 15 Iranian architects. It is best used for occasions for researchers to reach professional designers' knowledge and perception of the designing subject.

1.3.1 Data Collection Method

Interviews were in informal form and carried on the phone and face-to-face contact. 15 architects from several Iranian architects' offices in Tehran, capital city of IRAN, were requested to participate in the research interview. The survey analyzed

15% of cases selected randomly among 100 architectural offices which all have over 30 years experience in the field. The selected interviewees were 35-45 years old architects. Meetings took place in July and August 2014.

1.3.2 Data Evaluation Method

The collected data from interviews was entered into *Automap* and *Nvivo*, which were then evaluated.

The theoretical data has been collected through books, articles and the web. In order to illustrate the meaning and importance of CAAD tools nowadays, as well as the effect of implementation of these issues in the future of architecture; the objective is to consider the current situation besides the design changing. The framework of this research methodology is to illustrate the result of comparing and analysing the different usage of CAAD tools in the design process to find how can these tools be beneficial all stages of architectural design. At the beginning of the field work, essential information about the history (background) of Computer Aided Architectural Design examine the advantages of these tools from several point of views as well as the way of developing CAAD tools, (gap between computer soft wares and architects).

The thesis objectives and structure;

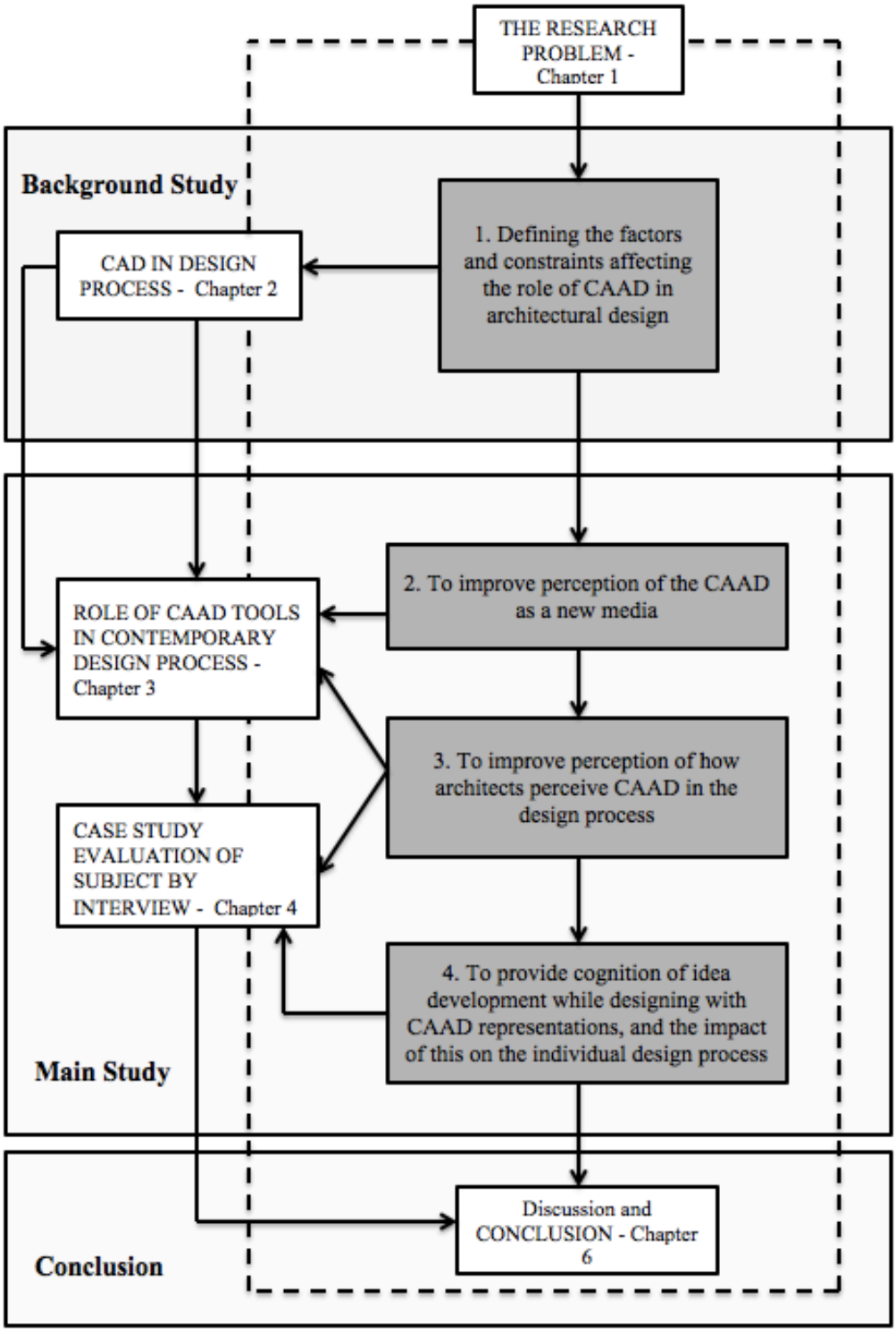

Figure 1. The thesis objectives and structure

1.4 Limitation of the Study

The calculated data has been done in interviews, which were done with 15 architects from several architectural offices in Tehran, Iran. The overall limitation of the study is to explore efficient usage of CAAD. The collection of the data was limited to conceptual phases of architectural design. The comparison of the usage of CAAD tools in initial phases of design process with usage of these tools in final phases.

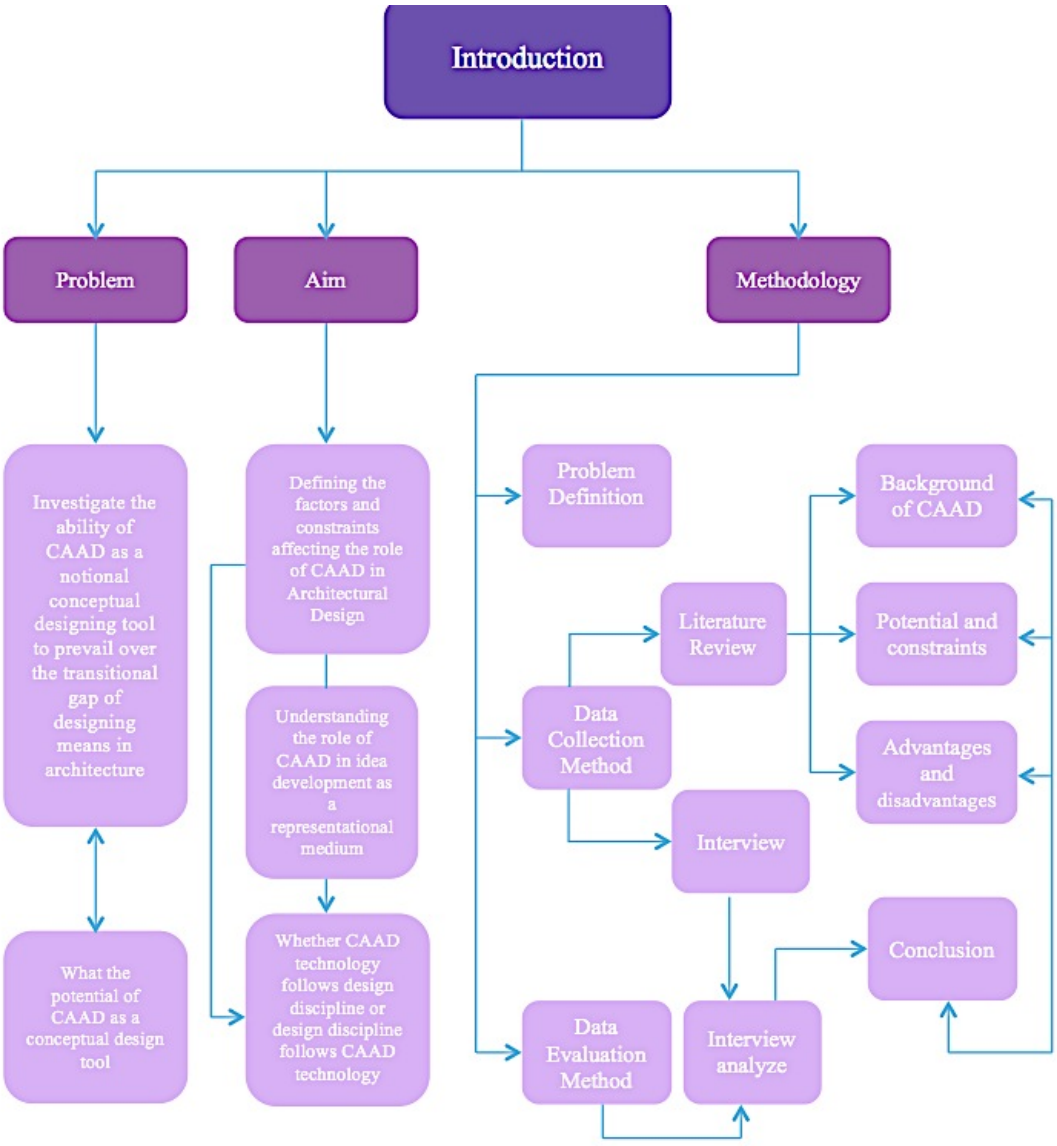

Chart 1. Summary Chart of chapter 1.

Chapter 2

THEORETICAL BACKGROUND

2.1 The Role and Importance of CAD

Computer-aided design (CAD) is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing (Narayan, K. Lalit, 2008). CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.

Background of CAAD and Usage of these Tools Design Process

Since the computer sufficiency grew over 1960s, automatic designing created lots of expectancies, most of which were not fulfilled, which may be for the fact that artificial was highly judged. Designing in architecture is a much more complex procedure than others, for it involves features which are not predictable and cannot be encoded. The exploratory procedures that lead the research depend on both data related to a specific problem and the data that is not directly relevant to it. Furthermore, the states, which characterize the designing procedure, do not come into existence until they are created. So, a state of resolving problems can be defined when it is created. These matters and also the fact that computer aid was required in architecture resulted in revisions in the attitude towards Computer Aided

Architectural Design (CAAD). The approach was based on the notion that computers could replace architects by imitating them. Computer was brought forward as a training assistance for the architects' aims and ambitions. Communication between architects and the machine got possible by computers receiving the data, retouching it, and giving an effective output. Computers are not only capable of incorporating forms, but also receiving and processing the data, which are not geometric. So, creating architectural design language to explain proceedings on making databases has become inevitable. GLID (Which is: A LANGUAGE FOR DESIGN INFORMATION SYSTEMS) [Eastman and Henrion, 1976] is a leading attempt to meet this need. It is a language that allowed a designer to assemble buildings. Manipulating the forms in architecture, pursuant to rules [Mitchell, 1974], was another way in this field. Fundamental building and functional items were gathered together to build volumes, and then buildings were built by assembling these volumes. All were saved in computer's memory in coded forms. Then the users acted on these forms based on principles taken from academic classical custom. Negroponte's (1974) primary idea of machine intellect got realized with a leading system that let the user create a designing resolvent through using items from a common menu shown on the screen. Many experiential and empiric rules of designing were prospected as it was increasingly considered like a systematic and logical task. Via working on encoded structures saved in the memory of the computer and retouching them in accordance with the principles, computers were capable of ratiocination about and predicting how a simulated setting would behave. The devices were built to accomplish the process of simulating. Plenty of simulation samples were prepared, and there was considerable progression towards the simulation of designing conditions [Rasdorf

and Kutay 1982; Lafue 1979]. The samples imitated conditions of planned setting as well as transmission to a different state. However, there was no model to embrace the relation between the parts of a structure as well as its setting. Although simulation samples have been a great means to predict and assess the operation, they have not been much help in the designing procedure. Also, they are not able to interpret the codes and their relations, so this has to be done by the architect. The computer is of little help in transmission from one condition to another; this also is left to the designer.

This type of design could not better the procedure of architectural designing and its output. Throughout the world, the system in most part (more than 90%) was just applied to plan sites or to create sketches that are not necessary to the designing procedure in architecture.[Leighton, 1984] It is likely that using them efficiently in architectural design requires increasing the utilization of computers in state simulations to further the descriptive and non-geometric data. It has to bear the meaning of the data, too.

2.1.1 What is CAD

CAD systems are the archive of detailed and extensive history of constructions and are applied by designers and architecture firms.

The first software was set up in 1960s, in order to assist designers to save time via using it in their drafts. Computer-aided design also going by the name of CAD was basically the kind of software which designers used, however, because it was not able to present all the devices required by designers to carry out a project completely, CAD that was a software of different kind was established.

2.1.2 Evaluation of CAD as Modeling Method

Starting around the mid 1970s, as computer aided design systems began to provide more capability than just an ability to reproduce manual drafting with electronic drafting, the cost benefit for companies to switch to CAD became apparent. The benefits of CAD systems over manual drafting are the capabilities one often takes for granted from computer systems today. Eventually CAD provided the designer with the ability to perform engineering calculations. During this transition, calculations were still performed either by hand or by those individuals that could run computer programs. CAD was a revolutionary change in the engineering, where draftsmen, designers and engineering roles begin to merge. It did not eliminate departments, as much as it merged departments and empowered draftsman, designers and engineers.

Current computer-aided design software packages range from 2D vector-based drafting systems to 3D solid and surface modelers. Modern CAD packages can also frequently allow rotations in three dimensions, allowing viewing of a designed object from any desired angle, even from the inside looking out. Some CAD software is capable of dynamic mathematical modeling, in which case it may be marketed as CADD.

CAD is used in the design of tools and machinery and in the drafting and design of all types of buildings, from small residential types (houses) to the largest commercial and industrial structures (hospitals and factories).

(Jennifer Herron, 2010) CAD is mainly used for detailed engineering of 3D models and/or 2D drawings of physical components, but it is also used

throughout the engineering process from conceptual design and layout of products, through strength and dynamic analysis of assemblies to definition of manufacturing methods of components. It can also be used to design objects.

CAD has become an especially important technology within the scope of computer-aided technologies, with benefits such as lower product development costs and a greatly shortened design cycle. CAD enables designers to layout and develop work on screen, print it out and save it for future editing, saving time on their drawings.

The modeling method gives us a precise means for extensive organizing and mapping of general facilities of digital designing models in accordance with diverse relations among the architect, her/his notional content, the procedures employed for designing, and the design item. Common five categories of digital design samples regarding the nature of the models are suggested below:

1) CAD models
2) Formation models
3) Generative models
4) Performance models
5) Integrated compound models

According to the field study of this attempt, in continue has been concentrated on CAD models.

Primary CAD technology indicated a change from media that were relied on paper paper-based media. In expressing this significant variation, customary CAD

samples are described as following: expressive CAD and production -assessment predicting CAD.

2.1.3 CAD expressive model

In traditional CAD the **inter communication** with two and three dimensional depiction in form assists the analytical mechanization of and pictorial designs . So early systems of CAD were described chiefly as being descriptive via utilizing diverse geometric designing programs . Up until now, the customary CAD has been being used to manipulate the diagrammatic / graphic demonstration of digital items (Figure 2). As Kalay says (2004) it didn't have much influence regarding quality on design comparing with common samples. Nowadays, because of modern digital methods, physical samples have new connections with the digital ones, which can be referred to as a 'double -directional' procedure . As an instance, , this is typical of the designing organizing system utilized by Frank Gehry that was known as an important design advancement from viewpoint of methodology that is still reliable concerning conceptual phase of designing.

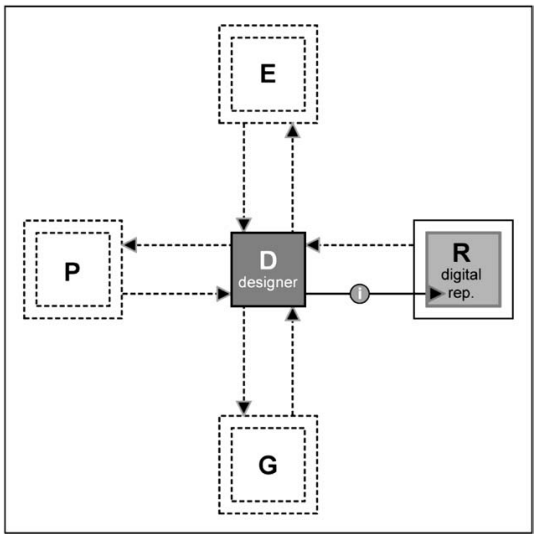

Figure 2. Traditional CAD model

In other words, the expressive designing function is more and more turning into well joined with physical rationale as well as producing processes (for example at the level of RP). Following current methods it is possible today that a physical model to be produced from digital samples that are assisted by diverse methods used to process digital materials (Sass and Oxman, in press). Moreover, the technology at present has developed and contains various technics to change the conventional data orientation: from facts to material sample. Material things can now be apprehended digitally and converted to digital samples, and counter wise. Therefore, the explanatory task of conventional CAD today has developed toward a monolithic joining of virtually and substance.

2.1.4 Generation-evaluation CAD model

Beyond sketching, modeling, and creating of things, the computerization of joined analysis and synthesis emerged tens of years earlier via operating analytic procedures on geometric samples . These are explained as predicting models as contrasted to expressive ones. These sort of appraising analytic approaches in CAD are generally related to expense assessment, functioning of structure and environment, and so on. Moreover, the complicated construction data structures that back up modern assessment processes can also back up cooperation between different designing group members including designers and constructional engineers. Therefore, beyond the operations backed up by expressive CAD samples, common digital designs have developed into predicting, clear and straightforward, rather than implied, as well, like in designing operations carried out on paper.

This sample (Figure 3) displays the circumstance where the CAD representing and assessment processes are made explicit, whereas other processes stay implied.

For instance, the creation module comes to be implicit and displays the reality that creation operations are not adjusted or automatic and is not connected straightly to the modules of representation and assessment. Clear connections, from the other point of view, demonstrate that there is a common database between representing and assessment. In reaction to an alteration in representing digitally, assessment is possible to be carried out. Any alteration and correction during representing digitally probably is reassessed because of an amalgamated database and joint data structure.

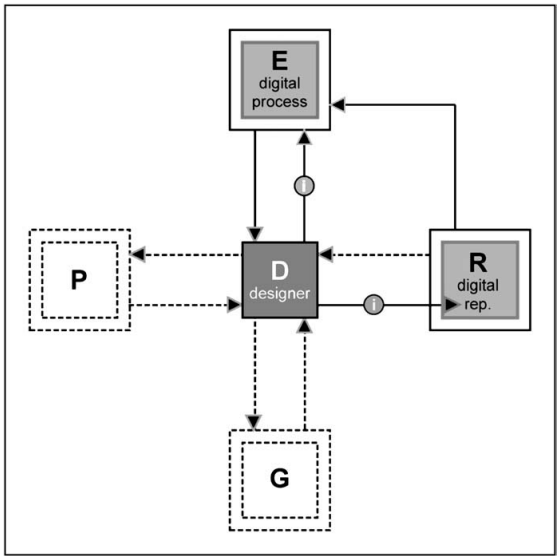

Figure 3. Generation-evaluation model

Intercommunication is so conventional with the architecture who interacts with representing a form digitally, and the procedures of manipulating and transforming of CAD are carried out by hand. We should bear in mind that in CAD the architecture communicates with the organized data of the representation like input to assess actions, which are customarily assessed visibly, and/or in a quantative manner. This procedure produces a feedback hoop of explanation via the designer that creates

suitable corrections in the representative model. In spite of the fact that modules of representing and evaluating are relied on CAD tools and that both of them are clarified and organized, the sample of designing thought is mainly of the same form as of paper-based drawing meaning that a successive straight process of data current takes place.

2.2 The Role and Importance of Design Process

With an obvious mental description of architecture a significant matter shows up: in what way are designs generated. What should be considered as well when making a checklist of design standards. It is smart to have an organized list of matters when it is done. We call such an organized list an Architecture Framework [Dietz, J.L.G., 2007]. This term is used very much widely nowadays, yet often it relates to some type of design principles and methods as well. Stating a general survey of various definitions of the words ‘architecture framework' does not help, since they are mostly on the basis of other concept of designing. Conventionally, an architecture framework could be described as a tuple [Dietz, J.L.G., 2007] in which:

1. Stands for a series of system kinds.
2. Stands for a series of design fields.
3. Stands for a series of areas of interest.

A system model specifies a category of systems that the meaning of an Architecture Groundwork is included in. An instance of this system sort is a data system; an enterprise is another kind of system, too. Principally, every system kind is admitted if it fulfills the description of a system [Dietz, J.L.G., Hoogervorst, J.A.P, 2007] system is only what that has the features mentioned below:

- Combination: a group of components of some type (physical, biologic, societal, chemical and so on).

- Setting: a group of components of the same type. The combination and the setting are separated.

- Production: the components of the combination generate items (outputs or services), which are conveyed/transferred to the components in the setting.

- Structure: series of communication links among the components of the combination with each other and with the components of the setting. Fields are features which the system sort includes intrinsically [Dietz, J.L.G., 2007]. Instances of fields are function and construction. Most available architecture groundwork includes fields such as thing, location, time, manner, reason and the user or one of their subgroups. Such fields could certainly be selected and the resulted groundwork will fulfill the certain definition of an architectural groundwork. Nevertheless, it seems that there is not any scientific base for employing these fields. Areas of interest include the common necessities such as protection, user-friendship, sustainability, etc. demanded by the shareholders [Dietz, J.L.G., 2007].

2.2.1 The Architectural Design Process

In order to generally define the issue of design, and design in architecture specifically, describing and understanding the procedure of designing is essential. Whereas there are lots of design patterns and definitions, many are in agreement with the idea that design is a procedure of fabricating objects that show modern arrangement, integration, shape, responding the purpose. (Alexander, 1967:6) Yet, designing has been thought of as being more artistic than a scientific issue because there are no prescriptions or predefined measures that can transcribe form and action

to a different object with inner consistency. Designing is supposed to be a repetitive, trail-and-error procedure, which depends deeply on knowledge, and insight. Insight came to be a ground for many hypotheses, which most of the time is called black box theories. Depending on them, design and its assessment is majorly notice. Contrary to these, another series of hypotheses regard the designing as a problem-solving procedure. Depending on the recent series, designing can be considered as an organized, bound, reasonable task. According to some researchers (Alexander[1964], Newell and Simon[1972]) there is a resolving area to any problem, i.e. a scope that bear all the feasible resolutions, during the past years. Resolving the problems can be determined as a search through possible ways in this space to find one or more resolutions that can be suitable for some purposes and, as a result, might be perceived as resolution conditions. How to solve the problem can be considered as either a decisive or probable way.

The design process define generally and mentioned as a problem solving process also in continue the position of CAAD examined briefly in the early period of these tools creation. Now for more detailed considering, first, the design process will be explained.

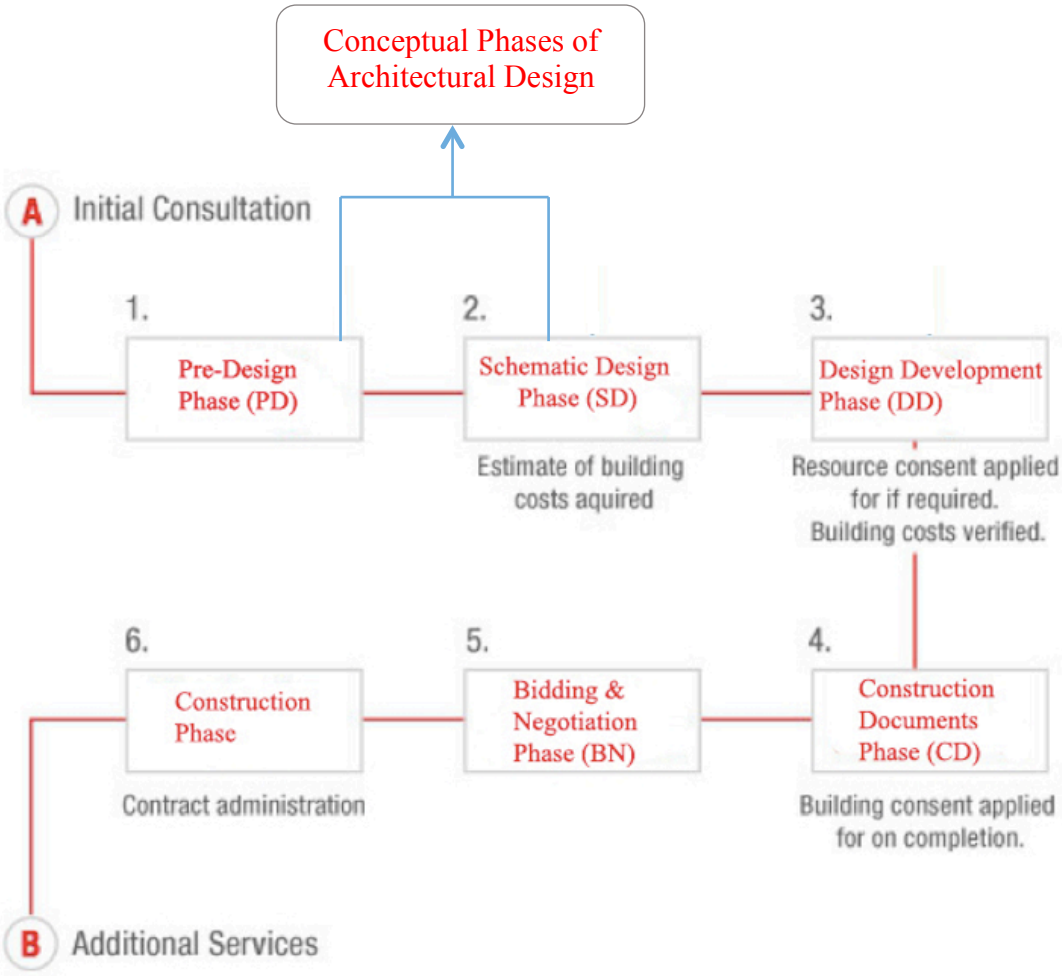

Figure 4. The Architectural Design Process

Architectural Design processes can be split into the following stages; Pre-Design Phase (PD), Schematic Design Phase (SD), Design Development Phase (DD), Construction Documents Phase (CD), Bidding and Negotiation Phase (BN) and Construction Phase (Figure 4), that the first two phases of architectural design is put in particular group as Conceptual Design (Table 1)

Table 1. Design steps of Architectural Design

	Phases	Expected Tasks (partial)
conceptual design	pre-design	- design objectives - limitations and criteria - site requirements - space relations - initial approximate facility areas and space requirements - flexibility and expandability, etc.
	site analysis	- site analysis and selection, - site development planning, - on-site utility studies, - zoning processing, etc.
	schematic design	- space layout or space schematics - conceptual site and building plans, - preliminary sections and elevations, - preliminary selection of building systems and materials, - approximate dimensions, areas and volumes, perspective sketches, study models

Schematic stage is where the overall features of buildings are defined. Critical undertakings are determined and the main resolutions are chosen. The meaning and the purpose of the program is elaborated upon in the plan elaboration step. Suggestions and ideas as well as any final decisions on the plan are presented to the customer, design jury or the evaluation committee in the presenting and assessment stage. Once the design is agreed upon and the go ahead is given, more detail is put into practice and all the documents are made ready which can include written specifications and sketches (both are a legal representation). Papers for the building are drawn up and an administrator is elected by presenting the papers to the public. The final step involves the architect overseeing the whole operation and evaluating the correctness of the construction. (McGinty, T. 1979: pp. 152-190)

2.2.2 Conceptual Stage of Design Process

The most crucial phase of designing is conceptual stage since it is the base on which the designing notions are developed (Figure 5). Most of the primary ideas appear during this stage, then go on developing, or are changed during the remainder of the designing procedure.

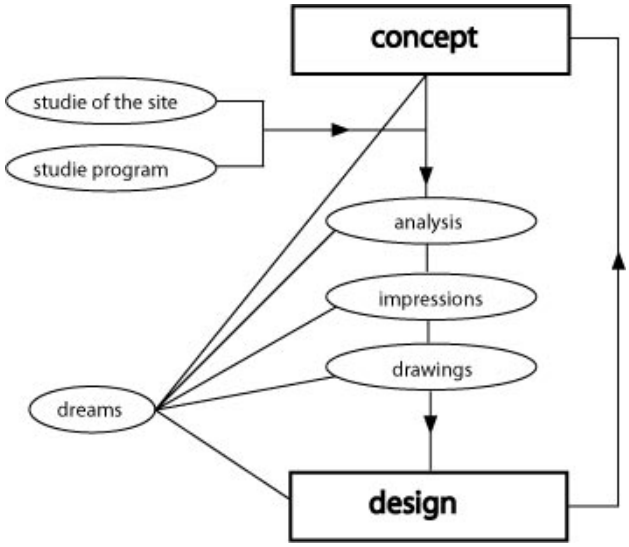

Figure 5. Conceptual Stage Of Architectural Design

It acts an important part in the entire plan. An encouraging resolution in the conceptual stage is very important to the building's expense during its life span, also, Exteriorization serves to relieve short memory, and also to develop concepts through interaction with the representation like a mediator between idea_and its extrinsic representation. (Figure 6 and Figure 7)

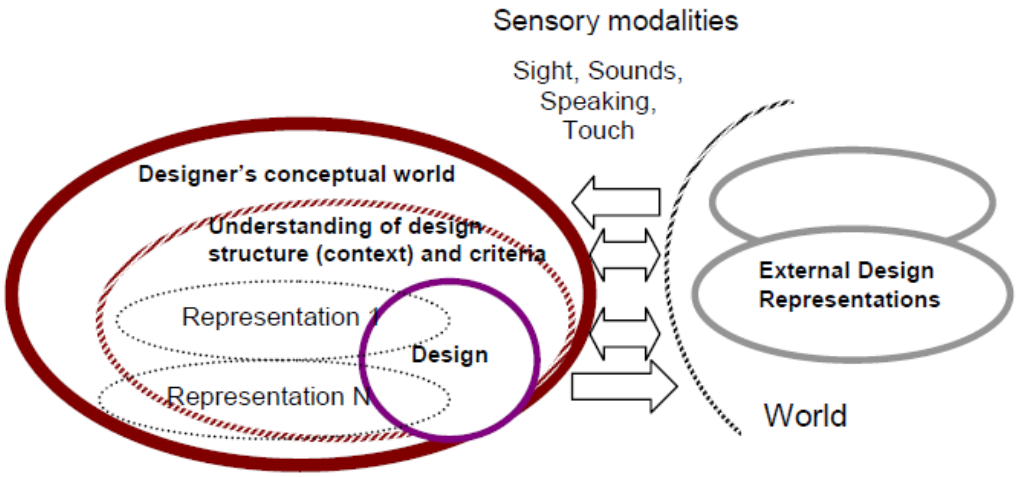

Figure 6. A designer's conception of a design and its context is built up over time (Eastman 2001)

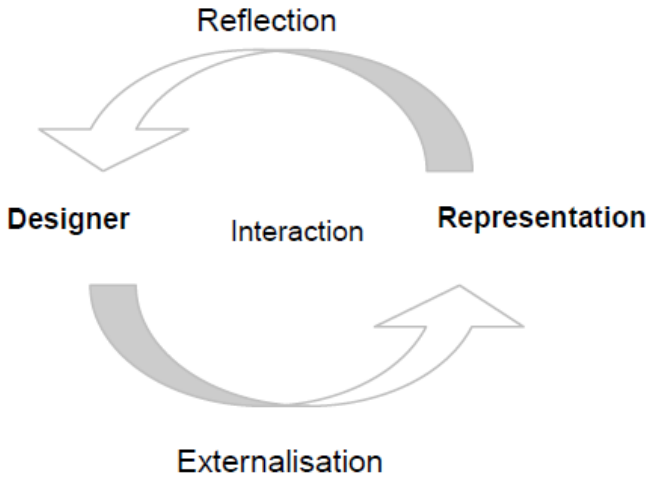

Figure 7. Externalisation and Reflection
(Schön 1987)

Customarily, freehand drawing has been used extensively over the conceptual period of designing for the formation of ideas, and has been considered as fundamental tool during this stage(Schon, 1983; Goel, 1995; Suwa and Tversky, 1997; Cross, 1999; Tversky, 1999; Kavakli, et al, 1999 and Bilda and Demirkan, 2003).

2.2.3 The Role of CAD in Conceptual Step of Design Process

Architects must complete all the stages whether they are extremely creative. Computer Aided Design (CAD) has increasingly been popular with architects due to the fact that they aid architects in performing tedious tasks. Perhaps CAD software has been more helpful in the final stages of design but that is as far as it has gone in terms of aid because it does not do so well in the early stages of design. In the early stages, architects must rely on 2-D or 3D images rather than normal models or sketches. There is a lot of effort going into developing CAD software in order to incorporate it into the earlier stages of design (Furness, T.A.1987). An interface helps architects interact and create plans so it is a critical aspect of CAD.

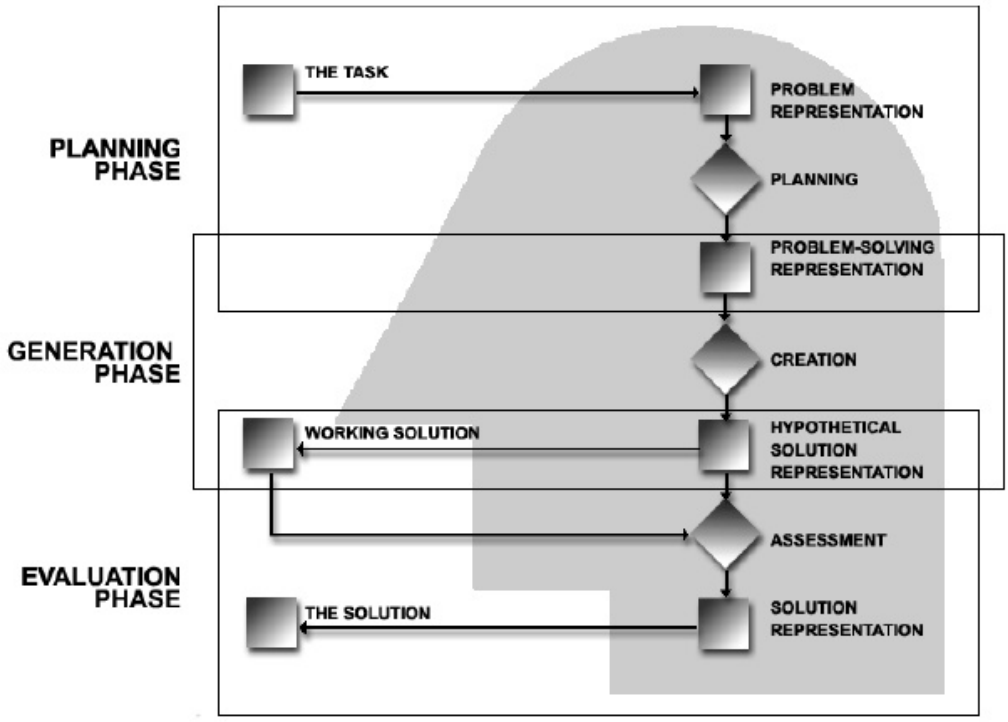

Figure 8. Descriptive Representation Of A Design Process

The CAD tools have been used increasingly by architects for decades and they have been very helpful, especially in the final steps of designing and designers have accepted the role of computer as an important an essential element in architectural design, but, In earlier stages particularly in conceptual stage of design, however, these tools have not been so helpful, therefore, because of that reason, some researches argue that computer couldn't have any role in creativity, so in this study discussion about CAAD tools situation in conceptual stage of architectural design, will be considered.

Customarily, freehand drawing has been used extensively over the conceptual period of designing for the formation of ideas, and has been considered as fundamental tool during this stage(Schon, 1983; Goel, 1995; Suwa and Tversky, 1997; Cross, 1999; Tversky, 1999; Kavakli, et al, 1999 and Bilda and Demirkan, 2003). It was regarded as a procedure of reflexion-in-action by Schon (1983). He mentioned architects built a "virtual world" by drawing; in this "world" the drawing revealed qualities and relationships that are not imagined in advance. Most of the time, drawings let the architect to put a new concept to test cheaply and rapidly on paper. Goldschmidt offered the ideas of "given that" as well as "seeing as" in 1991. (Goldschmidt, 1991; Schon and Wiggins, 1992; Goel, 1995). Studies were carried out as well on drawings to discover the way they are able to act as a suitable means for communication conversation. Some other researches on sketches design protocols revealed perceptions of different outlooks aspects of design reactions (Kavakli, et al., 1999; Suwa, 2000).It has been revealed by Dorta that no considerable distinction between customary and VR media was detected in his experimentation (1998).Designers have distinct priorities about tools, media, and ways they use over the conceptual stage

of designing in architecture. Some architects prefer to work with three-dimensional forms, whereas some others prefer computer-made models more. However, most of the experienced designers still prefer the traditional way of starting with an ordinary freehand drawing. The customary ways have some disadvantages, e.g. it is difficult to share notions with other experts, and also to move forward the next process with computer. More important problem is that when the designer faces an enormous number of options, the conceptual stage in customary way depends a lot on his insight that results in a problem in designing instruction education. Thus, through employing appropriate software package, which is able, to better express the designer's ideas, it becomes possible to discover a computational solution of helping the architect, and better comprehend and manage the designing procedure as well. This could be useful for the design and could eventually enhance it. Forerunner research has concluded that represented digital forms can be used to obtain better perception of the form in comparison to customary freehand tools since highly concentrated visualization and direct response feedback in computer media help the architect to produce images of his ideas (Marx, 2000). However, other researches revealed that although VR has considerable effect on the communication of 3D data in designing procedure, it is not much effective in enhancing the architect's work performance over traditional apparatus (Dorta, 2002).

Undoubtedly, computer has turned into a necessary apparatus in the building designing procedure in which using CAAD is very well liked. Though, modern characteristics formulated for CAAD tools, they are mostly used in the later phases of designing such as graphic tool for sketching, modeling, creating three dimensional forms rendering, and simulation (Chart 2). How designers examine concepts during

conceptual stage of designing is still coherent. Hand tools such as pen, pencil, and paper, in place of programs (soft wares); serve to spin subjects rotate ideas. Computer-Aided Architectural Design soft wares are regarded more as generating tools than as different designing means. Seemingly, there are some hindrances in most CAAD programs that hinder architects from using computer in this the conceptual phase, since normal stream of planning is inconsistent with such programs tools. So, a question comes to mind that what kind of software package can work efficiently in the initial phases of designing. However, it is necessary to find out how common CAAD tools can influence the designing procedure in the conceptual stage so that a more helpful tool that can help the designer in designing procedure could be defined. An earlier study revealed a few fundamental planes levels of design conduct behavior, which are physical, intuitive, practical, and conceptual (Suwa et al., 1998). Other studies, as well, described some specific planes of design conduct of the experienced designers (Bilad et al 2006). However, there were not many studies on the way the current soft ware programs had managed to meet the needs of designing activities and in which level they had been able to assist the designers to enhance their designs.

This study concentrates more upon design quality that if it declines or is enhanced by using various apparatuses, than on checking the architect's perceptive patterns. Here, the quality of the design is chiefly meant to refer to innovativeness and adaptability. However, it should be said that the primary incentive of this research relied on looking for efficient CAAD tools appropriate for the conceptual designing.

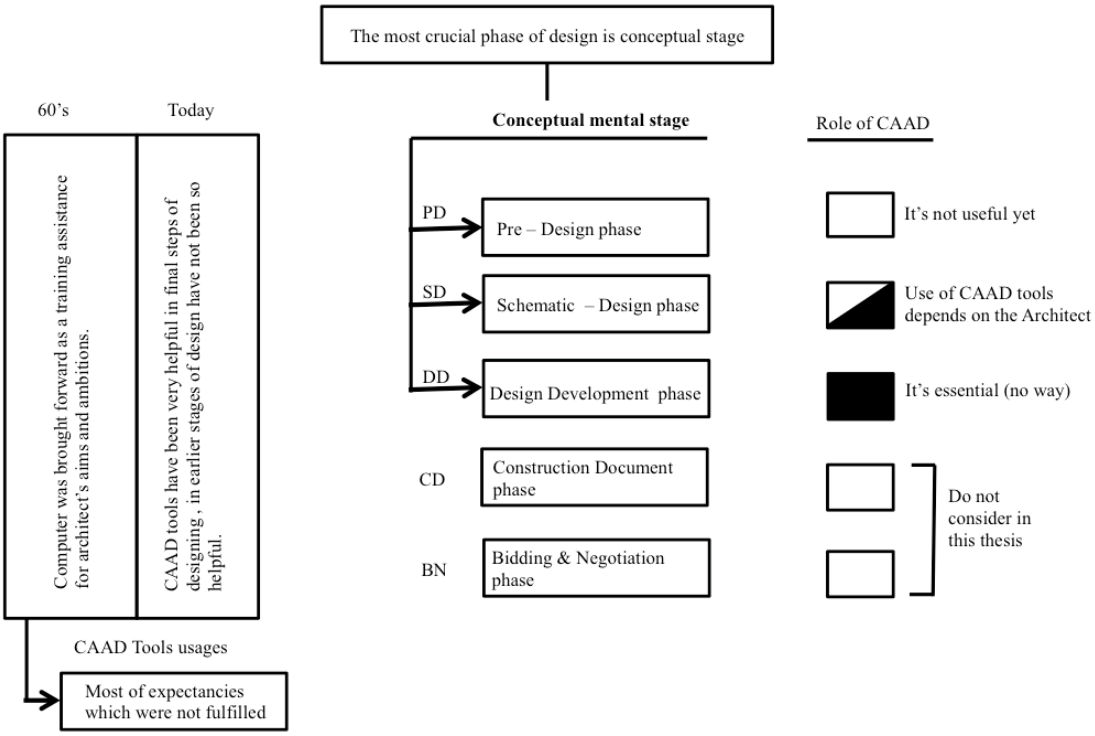

Chart 2

2.3 Evaluating Computer Aided Design in Process

In comparison with development of classic designing the history of computerized design is not long (Gero 1983). So, obviously CAD systems and pencil &paper-based designing cannot be of the same level. However, the progression of IT (Information Technology) shows that modern CAD systems are possible to alter the manner of designing in future. Haapasalo who has many researches in this area, in his book has an examination on some architects views in the case of Finland, which very relevant to the issue discussed here. In Haapasalos's (1997) research, as reported by designers from Finland information technology previously has altered architecture to a certain extent (38%), partially hasn't altered (58%) and (5%) is going to alter later. Some designers assume CAD partly enhances and partly degrades designing. Some believe CAD doesn't influence designing in which the

CAD is employed like assistant equipment. (Haapasalo 1997). Designing will therefore develop gradually. Experts compare the CAD's effect on architecture partly with the creation of the ruler. If man had not invented the ruler, designing would certainly be distinct from what it is now.

Most Finnish architects believe that CAD and IT are in acceptable state, even though enormous efforts will be made in future in order to achieve more advancement. Nowadays, CAD is commonly employed in the architectural projects from which evident profits can be gained. In a few offices of architecture in Finland the operation with CAD is inadequate: "The bike has been bought, but the chain isn't functioning". As mentioned before, according to the research that was done by Haapasalo in the case of Finland; About 66% of the offices of architecture in Finland have bought the CAD user interface, yet the amount of work done through computers is almost just one third of the whole, or almost just one third of the designers are applying computers in designing. Even tough just one third of the designers apply CAD, 80% believe that it will be an essential tool in the coming times. (Haapasalo 1997).

Usual CAD hardware includes main processing device, screen, keyboard, and mouse. Regarding design, the most significant parts include screen and pointing apparatus. İt was noticed in an earlier chapter that communication among minds, eyes, hands and the appearing lines is crucial to get the attainable perfect design outcomes. Such an interaction is not in some way responding desirably in the current CAD systems, at least for some designers. As we noted in a previous chapter the interaction between brains, eyes, hands and the emerging line is essential for the best possible design results. In present CAD programs this connection is not somehow reacting as

it should, at least not for all users. Nevertheless, some users work with CAD easily like moving a hand.

2.3.1 Attitudes From Hardware Direction

Common CAD command –line user interface can be utilized differently in architectural designing. Kiviniemi and Penttilä (1995) believe, as well, that the main distinction between CAD and conventional drawing is in the flexibility of designs, and also the absence of explicit scale. And also the tools of computer such as mouse, keyboard and screen produce the working condition that is distinct from of pencil and paper. Such a matter may be one of the biggest problems in the start point, since no straight physical links exist between hands, eyes and minds (Ekelund *et al.* 1992). In CAD lines don't appear in the place that they are drawn, also the substantial components cannot be made emphatic by, for instance, pushing on the pencil more forcefully (Haapasalo 1997). Nevertheless, as Penz (1992) says, these are just problems of learning.

2.3.2 Attitudes From Software Direction

Particularly during the early learning phases CAD needs lots of the designer's concentration and by that reduces attention at the real design that can result in a decline in the quality of the final outcome (Haapasalo 1997). Thus necessarily learning should be done comprehensively. From the other point of view, more time is spent on the real design and thought, while mechanical ordinary activity is fulfilled more rapidly with computer (Clark 1988, Stevens 1991). However, we should bear in mind that " learning to apply CAD correctly doesn't suffice. The designer has to learn to generate by using it. This needs a new way to think and behave toward CAD" (Haapasalo 1997). It isn't enough that designer learns to use CAD properly.

She or he have to also learn to create with them, which requires also a new way of thinking and reacting towards CAD". (Haapasalo 1997). In classic drawing, the designer sketches on one piece of paper at a time, while in CAD it is usual to manage the model viewing images on a few windows (e. g. external portions, plan views, outlook and parts). The outcomes of designing are generally a few sketches or a CAD model of the construction. Designing and drafting by computer is all the time in true scale and the ultimate scale has no role in drawing, thus even broad designs can be dealt with as an entirety (Penz 1992).

If the designer is accustomed to drawing in a given measure, absence of scale may result in difficulties at the beginning, for example a designer who is used to work in 1:100 scale, in 1:50 circumstance he/she will have difficulty in the beginning, yet for designers who include true measures in drawing, working will be rather unchallenging (Kiviniemi & Penttilä 1995).

The outcomes of theoretic and pragmatic investigations reveals that common computer programs are excellently adapted to the execution phase of designing process in architecture, however, their compatibility to drawing is difficult. CAD can cause drafting and producing alternatives to be done faster and more efficiently in the ultimate phases of designing. Also some designers regard it as an auxiliary tool in early design phases (Haapasalo 1997). Although CAD quickens architectural designing, the final result is not determined by whether it is accomplished by CAD or not. The design itself is an imaginative target whose process must occur in the designer's mind. For using CAD, the designer's sensibleness and occupational way of thinking are required, since the essential character of design is altering

gradually once it is compared with the created environment (Penttilä 1989).

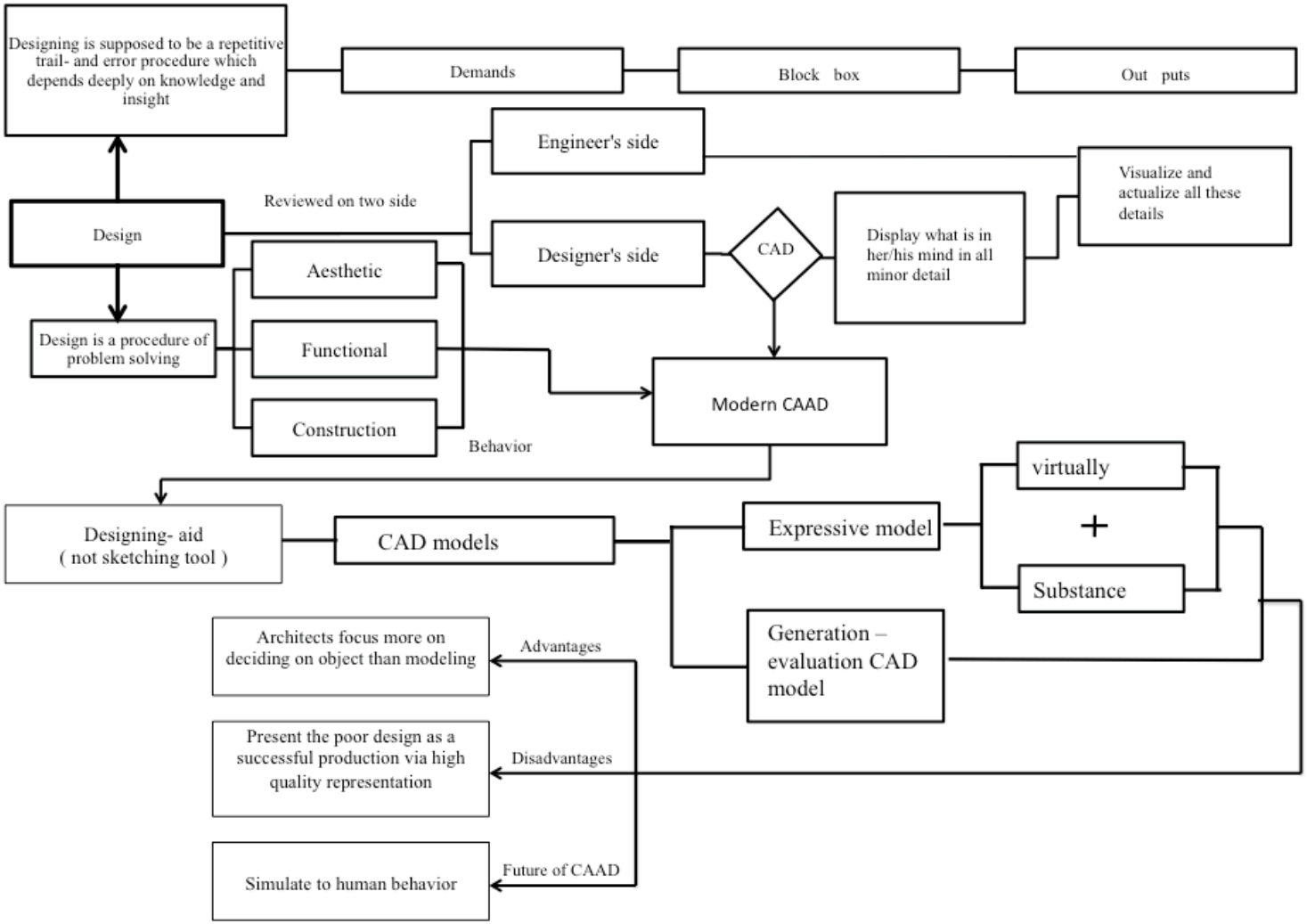

Chart 3. Summary Chart of chapter 2

Summary of chapter 2

In this chapter, first of all the CAD has been defined, what is CAD and how these tools were created and CAD has been evaluated as modeling method, of expressive model and generation-evaluation. In second part of this chapter design from 2 different view also design process by the elements and 6 steps of that, was defined. According the main question of thesis has been focused more on 3 initial phases of design process as conceptual phase. In final collaboration of these two issues (CAD and Architectural design process) were investigated and Computer-Aided Architectural design tools were evaluated.

Chapter 3

CAD IN DESIGN PROCESS

3.1 The appearance and coming of age of digital design

Over the past ten years, technology has been affecting the principal matter of designing. Exploring the complicated geometric "free forms" along with the procedure of materializing as well as assembly and production technologies have been involved in designing in architecture (Sass and Oxman, 2006; Schodek et al., 2005; Kieran and Timberlake, 2004; Schodek, 2000). Such progression has begun using considerable effects on the designing from viewpoints of theory and concept. Such specifications appeared in diverse designs, which were understood, late in the following era. In the field of architecture, the Guggenheim Museum, Bilbao by Frank Gehry was the most distinguished stimulus of hypothesizing modern formal orientations and presuming new design, actualization, as well as producing techniques. Over the post-modern sensitivity of complication via 'heterotopia', or complicated hybridize, the Guggenheim, Walt Disney Concert Hall in Los Angeles, and some plans by Frank Gehry presented modern geometrical methods released from theoretical formalities, including formalities of language. In addition, the Gehry bureau was extremely obligated to studying the possible part that digital technologies could play (Lindsey, 2001). Tradition along with theory developed concurrently.

Creative empirical models have appeared from designing activity and educational

designing experiments. Moreover, current designs of Zaha Hadid presented at the Guggenheim Museum (The Solomon R. Guggenheim Foundation, 2007) are also displayed in recent 'evolving', varied subjects of parameters, which are reflecting digital customs nowadays. The features of topologic form, development of spatial construction, from alteration viewpoints, arrangement that is not in accordance with hierarchy, and complicated, highly linked spatial circumstances grew rather important in works designed afterwards. Amid these, the Yokahama International Port Terminal planned by FOA (Kwinter et al., 2004) is a design record in forms of complication such as the affirmation on what may be called, 'highly-continuousness', or complicated topographic techniques which were hard, in presentation and also in manufacture in terms of design prior to the digital designing era. Beyond the characteristic concerning style which are often connected with digital designing, it is the organized advancement in the fields like occupational cooperation among designers and engineers (Reiser and Umemoto, 2006; Rahim, 2005; Bollinger and Grohmann, 2004; Franken, 2002 etc.) appear in methods, (for example, parametric methods) plan handling (BIM;Building Information Modeling), and construction, that have represented effects on the occupational architecture.

3.1.1 Theoretical change

Censorious essays are one of the theoretic important events concerning digital design age, too. Significant theoretic written work during the past ten years has been mostly on the digital designing field that has turned to central fields of new design theory. The importance, similar to most of the articles of the time, is attached to theoretic discussion as concerning designing, rather than practical, or principled, interpretation of methods as well as designing techniques. Important theoretic written work mostly

(Somol, 1999; Kwinter, 1998, 2001; Lynn, 1993, 1999; Kipnis, 1993), as a feature of a cultural change time, tried to deal with main theoretic subjects again (including 'official knowledge; 'samples; 'representing', etc.) that concern the theoretic dicussion of the today's descendant. Attained with the Folding in Architecture was an important beginning (Lynn, 1993). Along with significant from theorical viewpoint, primary works by Lynn (1993) and Kipnis (1993) are preludes to philosophical origins, researches of technological creativity as well as their being relevant to designing, and explanations of empirical plans. This composition of various origins of theory, philosophy, methodology, technology and profession aimed to describe the discussion of digital designing in the first ten years. Amongst monographs that are important from theoretic viewpoint are (Spuybroek (2004), Rashid and Couture (2002), Oosterhuis (2002), Van Berkel and Bos (1999), Zaero-Polo and Moussavi (2003), and Lynn (1999)) that all are considerable matters on prominent digital design works. Rosa (2003) and Zellner (1999) are features of many masses regarding digital designs which are set of brief illustrative monographs upon chosen digital works. Kolarevic and Malkawi (2005) and Kolarevic (2003) are supplying further contents concerning methodology and technology on current advancement in digital design.

3.1.2 New concepts: out reaching models of language/ official/ syntax

Presenting an extensive review of these advancements is further away from the extent of this analysis, however, it was tried to determine this main part of work, in order top resent and explain the change that have taken place in 'theory of architecture' and 'design theory'.

The specifications of this transformation in theory of architecture show that they

try to be the in contrast top patterns based on forms in the post-modern age. It seems that new theories are affected by digital technologies that back up diverse kinds of form creation relevant to complicated and topologic geometries.

The motivation regarding formal variety and distinction can be found partly like a refusal of the combination policies, which had turned to specifications of the eighth decade of twentieth century. In place of strategies of architecture, combination and transformation, the architecture of the 1990s preferred material and performance-driven examination, which was able of produce, complicated, from topological perspective, configuration and formal distinguishing on the continuousness of the architectural object. Developmental space and shape were connected to design ideas including highly-continuousness and connectedness; ideas of the facilitated topologic continuousness and variety of digital designing start replacing the complication and inconsistency of a previous generation. The new concern in structural geology, topologic geometry as well as material expression *(i.e. impressions of hardness and softness, of heaviness and lightness, which are connected with the surface character of materials*) shows an inferred critical analysis of the inspired formal complication of the earlier generation. In design theory, the deterioration and change of basic ideas including representing, design founded on preceding models, typologies, and other tenets of the foregone descendant are being substituted at present by recent series of designing ideas regarding samples of producing, animation, designing and actualization founded on implementation. These are designing ideas taken from the cooperation among emerging technologies, approaches concerning architecture and design.

3.1.3 The Evolution of the CAAD as a New Media

Defining computer systems from academic point of view, Achten (1996) introduced a number of usual fields in what we call computational matters (i.e. database structures, exchange formats, programming techniques, interface design,etc.) and what we call architectural matters (expense estimating , managing possibilities , production drawings, simulating , development structure analysis, plan composition ,shape creation , and so on).

In developing or planning existing or new CAAD software programs, CAAD experts place emphasis on both viewpoint of computer science and architecture (Kalay 2004). The variability of the philosophical views about answering the question of how to incorporate matters of architecture observes the differences of CAAD generations. In addition, this feature of philosophical development is the major cause originated from the fact that CAAD research is complicated and diverse, as CAAD investigation is specified by the increasing appearance of new views which have not been put up in primary work (Maver 1995; Reffat 2006; Kalay 2004).

The new concept of CAAD was presented by researches Sutherland and Coons (1963) through creating a system based on graphic ”Sketchpad”.

Researches Sutherland and Coons (1963) created the graphic-based system of “Sketchpad”, and in this way they presented a new notion of CAAD. This system built the original concept for the very early CAAD product. It was planned to incorporate the developing plan (from early sketch using a pen, after that bettering it with built-in shape presumption into an ideal sketch) and analyzing program

(numeric analyzing). Via this procedure, the architect could meddle with optimizing manner (Coons 1963, cited in Kalay 2004). Moreover, this can be observed like one of the unifying concepts between computation analytic potentialities and designing in architecture.* On the contrary, the Architectural Machine Group (Negroponte and Groisser 1964, mentioned in Kalay 2004) at MIT adopted:

1. An artificial intellect attitude towards evolving computation applications in architecture, where the setting can actualize activities by itself via comprehending the demands for building habitants and integrate changes with no meddling from the architects. Obviously the major dispute between two attitudes is the architect's part in computerized setting.

2. What the second generation focused on was the graphical feature aspect of CAAD programs. This contained new enhancement in designing and presenting potentialities, however but considering building plan, the abilities of system were not as many as they were before.

3. The third generation observed assortment of the important specifications of the former two generations. Though the philosophical view could just be like the first generation, the feature concerning representation has enhanced. Nevertheless however the main cause of its improvement was technological progression advancements (computer graphics, minicomputers, and input devices). Likewise, on the basis of enhancement in IT information technology, which occurs in studies on CAAD as well as training, Reffat (2006) suggested a fourth generation.

4. This suggested approach would expect envisage architectural design to be implemented cooperatively and simultaneously within intelligent and real-time 3D virtual setting to embrace the common prosperous computational

experimentations, i.e. the known digital designing (Gero2002; Reffat 2000).

Intelligent virtual designing setting, designing with agents, (Gero2002; Reffat 2000, Saunders 2001). This restudies of CAAD development indicates CAAD'S advancement is not successional, yet supported by various views and progressed via hardware and software developments. Nevertheless, the resultant systems were academically categorized under 4 major groups: social, occupational, instructional, and innovational systems.

3.2 Use of CAAD in Contemporary Architecture

Nowadays, computers support architectural designing, mainly because designing is a procedure of problem-solving task that bears aesthetic, operational, constructional features, that need a dynamic manner of dealing with data entailed involved in designing procedure. Eager acceptance of computer begun during 1960s. Nicholas Negroponte, in his book "The Architecture Machine"[Richard Padovan, 1999], exposed theories and opinions about using artificial intellect in architectural field to discussion, exploring the plausible relations between the designer and computer such as being partners where the computer and the designer could learn and progress while interacting each other. Computers are regarded as an integral portion of designing procedure, and the architectural system as a whole, making major changes to the methods. Attempts in computerized designing are mainly specified in two ways.(P.R. Wilson, 1987) One way emphasizes on the plan of generating system and analyzing, like grammars, composition , and similar . The other way emphasizes on the acclimation and the improvement, as well as the relevant processes of complication, self-organization and emerging.

A computer has the capability of becoming a designing aid to designers and engineers if it is knowledgeable about sketching items as well as designing things, and what they mean in the designer's occupational world. Common CAAD soft wares are the designer's aids. Modern CAAD products ought to be architects' aids. Behaving a like a designing-aid and not sketching tool is a requisite for a modern CAAD setting.

Computers have provided means of sketching, presentation, and data bank. In this way, they have assisted designing in architecture. Researchers reason that in the ultimate stages of the designing procedure, this assistance, as a means of presenting, is substantial**.** Since computer designing lets architects consider the designed things, this makes it possible for modelers to focus more on deciding on the object than modeling. This is very relevant to Computer Aided Architectural Design (CAAD), contrary to Computer Aided Drafting. Though the word CAD can be substituted by CAAD and vice versa in design researches, CAD is regarded as being more common. Have instructors been pleased with CAAD's role since it was developed and progressed fifty years ago? Do they intend to alter it considering the swift alterations in technology, social and cultural statuses of students' lives, and also architecture? During the past few years, researches have centered attention on CAAD considering it more as a cultural-social subject than just a matter of technique (Pektas and Erkip 2006; Tweed 2000). The appearance of digital designing as a modern theory has been debated by outstanding architects like Frank Gehry, ZahaHadid, Greg Lynn, Ben van Berkel, Peter Eisenmanas well as theorists like Kalay (2004) and Oxman (2006, 2008). These experts are anticipating new methods, procedures, and attitudes

towards designing.

Computers have altered the way of working on designing and generating in architecture, and CAAD systems have influenced many features of the methods which are employed to communicate, represent and produce. Nevertheless, actually, the part that CAAD has played so far has gone different way that was not much anticipated.

3.3 CAD and Creativity in Contemporary Design process

Architecture can be defined as the art and technical skill of designing an enclosed area to be used by human, that is distinct from abilities related to building. Like some other arts, the advancement and application of designing includes aesthetic as well as pragmatic objectives; these objectives is likely to be distinct from one another, however, they are not entirely segregated, moreover, the proportionate importance given to any of these objectives, goals, or motivations, might differ greatly from one project in the area of architecture or an art work to the other one. It is particularly significant to identify the way that regards designing as a social art, both regarding the objectives of the method (H. Hertzberger, 1991).

Creativeness

Creativeness is mostly considered as capability of generating ideas, which are creative and also are practical. ”[B.R. Lawson, 1994] For instance, Donald MacKinnon, mentions that “creativity” accomplishes at least three crucial circumstances: It suggests a reaction or a concept which is unusual or somewhat uncommon from statistical standpoint. But newness or originality of idea or action, whereas an essential aspect of creativeness is inadequate. If a reaction

is believed to be part of the innovative process, it hast to be somewhat capable of adapting to, or of actuality. It is expected to find a solution for a problem, befit a circumstance, or achieve certain identifiable purpose. Finally, real creativeness requires maintaining of the initial intuition, an assessment and complexity of it, fully advancing. [D.A. Schon, 1983] MacKinnon, as a result, perceives creativeness as a synthesis of arts, sciences, technology, and psychosomatic examining. However, it is not necessary for creativeness to represent an extraordinary capability. Nevertheless, the imagination of an inventive person is nearly connected to the strength and clarity that enables the designer to perceive, comprehend, and perfectly make an analysis of the issue or deal with the problem.

Designers often approach designing matters from antipodal viewpoint. Whereas they work in accordance with measures alike originated from the societal sciences regarding human demand, they mostly search for consistent which are extensively different in the manner by which they attempt to address or present architectural views and ambitions. Creating is intentional; it requires choice and it is not possible to be lessened to a automatic procedure. There is a thoroughly accepted meaning connected to ‘making’ or ‘doing’ that we refer to as ‘creative’; the works: a poetry, a drama, painting, a musical work, or drawings for a construction under deep thinking, the outcome of imagining; we call this ‘creation’.

The supporter of CAD often say that it sets the architects free and offers them some different ways to imagine their design to themselves, but there is a question, is that actually correct? It is tested to find out how much CAD has been able to improve designing creativeness. This is somewhat performed through using a test

developed by Herman Hertzberger (H. Hertzberger, 1991). This test revealed to some degree the insufficiency of CAD; a few ideas were put forward in this connection to find the reasons for this problem.

CAD tools have actually been in use for a period of approximately forty years. This has usually be regarded as advancing toward a more efficient manner of architectural design. CAD supporters, such as this writer, frequently have reasoned that these tools should enhance the procedure and the outcomes in architectural field. Unfortunately, no considerable assessment about these cases has been done indeed so far. Computers have likely influenced many features of designing procedure. Capability of visualizing three dimensional shapes, simulating performance features, coordinating as well as controlling the production data are explicit instances. The main purpose of this thesis is to focus on the question that if CAD tools have been able to increase creativeness of designing in architecture. It is mainly based on traditionary and experimental information as well as on analyzing the related specifications of CAD. In this study CAD is found lacking, in some manner, the capacity to support real creativeness.

In order to expand the discussion, the thesis has looked at the issue from architectural practice point of view. Occasionally, will be depended on intuition presented by a few designers that are thought about as being very innovative. Particularly, we shall focus on interviews, which have been carried out with Spanish designer and engineer Santiago Calatrava that works in Switzerland and France, also Dutch designer Herman Hertzberger. These architects have decided to not apply CAD as an innovative technique. Hertzberger's ideas appears particularly relevant and

important, because he has planned lots of well-known constructions, and also has written many books and now is teaching at the Berlage Institute in Amsterdam. He is the author of one of the most significant recent books on learning how to design, [H. Hertzberger, 1991].

Sketching is the central part of architectural designing procedure. Sketches are applied to present the outcomes of designing to customers, users, law–makers, builders, and also, more significantly, are employed as main tools during designing procedure. Let's see what Hertzberger told about sketching stage of designing:
One decisive question is when pencil is engaged in designing, before the mind or afterward. Normally, first there is an idea in your mind, after that you record it by words or sketching. However, something different can occur: as the designer is drawing, his hand and pencil may be finding something, yet I suppose that is risky. It may be reasonable for an artist, however, for a designer it is absurd.

This view may seem to differ, at first glance, from the definition of Donald Schon of the manner a designer communicate with the sketch [D.A. Schon, 1983]. Nevertheless, it can be found out that actually Hertzberger looks to support Schon's opinion as he says that we are affected via what we do and from time to time motivated by a sketch, however, we shouldn't allow the pencil to determine our ideas, conversely, the pencil has to be at the service of our thoughts" [B.R.Lawson,1994].

Nowadays computer are using by artists in visual arts as much as by architects in architecture. To explain the relationship between arts and design it should be

bring to consideration that there is a subtle boundary between these two. From time to time the ultimate production of design becomes an artistic work. It means that the architectural design could be examined from artistic point of view.

It seems that Herzberg is pointing to a very significant difference between art and designing, that is to say, how much making images is straight or not straight. Computers might be employed nowadays in visual arts straightly in producing images; today, the artist might wish to utilize computer efficiently like an additional technical method that is available to him. Such work which is the outcome of artist and computer working together is very interesting to see, and is mostly magnificent and genuine. The set of discussions about cognition and innovation have indicated that most of the artists think they enjoy today innovation chances of which they would have been deprived in the absence of computer. Certainly, no less than two circumstances are required for this type of innovation. {The important point is that the user of computer is an artist who is able to create artistic works without computer as well. }First, the computer soft wares have to present new facilities, instead of just copying the available programs. Next, we need to always remember it, the program ought to be in the responsibility of the artist that can be innovative in the method.

This is not true regarding three-dimensional designing. Herein, computer is utilized in producing certain mediator statement, which in some manner explains the ultimate item or offers directions about the way of producing it. Actually, in this procedure, a problem has appeared related to design images all the time. As a matter of fact, design sketches and models mostly displayed in galleries as though they were items of art work. The Royal Academy Summer Exhibition in London, as an example,

there is a gallery allocated to architecture. This causes further be wilderment concerning art and design correlation. (Bryan Lawson. 2002).

3.3.1 Designer's Main Roles and Pragmatic Innovation (Creativity)

Along with the growth of CAD tools during the last nearly twenty-five years, some studying has been done the designing procedure itself. Actually, substantial improvement has been made in perception of the process of designing, although there is still long way ahead of us to go [B.R. Lawson, 1997]. A few central features of designing process sound to be of great importance in advancement of CAD: firstly, the complication involved, in general, regarding the total amount of differing and finally incompatible aspects of problems in architecture. We anticipate architecture to be attractive, we hope it will add meaning to life displaying life's rituals, as well. It is anticipated to be firm and secure from technical viewpoint, supply shelter and protect us against weather conditions. These expectations can still be expanded. Nevertheless, whatever we realize regarding design is that extended range of difficulties does not offer any ways for overcoming them. What makes a design desirable underlies its incorporative function. An acceptable plan is holistic. This concept is not new, it is not unique to designing. George Sturt's *The Wheelwright's Shop* showed it to use even in domestic and functional design [G.Sturt, 1923]. Sturt demonstrated the way that a uncomplicated drawing method for creating cart wheels in the shape of a dish was a solution for lots of problems a few of which concerning the capacity to be controlled, a few related to architect tonic firmness, several of them related to laws, and etc. In architectural designing, paradoxically, a small window must provide a sight, at the same time, keep privacy, supply natural light of the day, and still

protect the place from undesirable sunlight, prevent outside weather raid, but supply normal ventilation, as well as, naturally, having a main function in the facade. In order to resolve the problems mentioned, enormous effort of mind is needed. This kind of genuine innovation entails advanced cognitive abilities. Once more, Herman Hertzberger's remarks are found helpful to make this point clear. Herein, he explains the issue of just planning a school's entry. He says the matter is that there are some whiles when lots of students need to pass through; the issue, as well, is that some when a few individuals await, the issue is that the weather is rainy so sitting there is not pleasing… and etc. So this list displays the problem. So you may utter well considering these matters, the step ought to be of suitable size, not too tiny, not too big, it ought to be covered above, it ought not . . . and etc. All the time such inconsistencies are found. This is innovation, to find answers for such problems which are opposite, and the incorrect kind of innovation can be that you simply fail to recall the reality that now and then it is rainy, that some when you have lots of people there, and you only build attractive steps based on one notion in your mind. This cannot be real innovation, it is fake! [Lawson,1997;P.42]

Probably most of us expect computers to be capable of helping us with enchanting deceive of mind. In such a kind of designing one or more matters being speculated may easily be overlooked, so outcome can be an uncoordinated design. This extremely worries the architects. They compare this procedure to juggling which involves keeping several balls at the same time in the air. It should also be noticed that most of skilled architects prefer to use small pieces of paper to sketch on while working on innovative designing. Apparently, this implies that they have to hold every event under observation. Actually, the designers utilize any tools as possible

to maintain extreme attentiveness that is needed. We certainly are aware that these periods of concentration are dispersed by further meditative thinking as well as even context thinking. Margaret Boden indicates in The Creative Mind that this is a usual characteristic of innovative process [M. Boden, 1990].

3.3.2 CAD Helps the Creativity

Then, why is computer used to help in this regard? The discussion keeps on, in some issues computers can be clearly much more efficient comparing to humans. For instance, they are not only faster, but also are more dependable in computation in comparison to us, searching for data also can be done faster by computers. Unlike us, they do not fail to remember information. Of course, in other cases like identification, interpretation and settlement of contradictory requests computers act very poorly. A very well known computer, HAL in 2001, revealed how its inflexibleness could result in mistakes which man naturally would not make. Designing in architecture is generally thought to be carried out by drawing, and we are supposed to get involved in designing rather via our sight than through any other senses. Nevertheless, this is, in fact, rather deceiving, because in real life designing in architecture is done indeed via dialogue among members of designing group and also with customers and others [B. Lawson and S.M. Loke, 1997].

Yet, since the dialogues are not recorded, while sketches are, we ignore its significance. Actually, this significance also has mainly been overlooked by designers of CAD systems. As a matter of fact, many computer programs that are to help designers entail intense graphical procedure. Thus, after so many years that CAD has been used in architectural designing, is there any evidence for CAD's being really helpful in developing creativeness? Three straightforward examples of

educational, practical, and research kind would be encouraging. First, a proof in experience: According to a study done by a research team; a learner who was studying in the initial period of CAD, achieved the first architectural degree, yet was not granted an enough high score to start working on next level. His design work in fact was well qualified from functional and technical point of view, but it was uninteresting, uninventive, stereotypic, and unappealing. He started working for an architectural company for a year utilizing the CAD tools created by a research team. Once more, he applied for the degree program, presenting an outstanding design work which was accepted and granted a final-year award. When speaking with him and watching his design, the research team found out the truth. He was talented at3D imagination, yet was not skillful in sketching, so he had limited himself to drawing shapes and spaces in which he felt self-assured. Nevertheless, computer had made him capable of representing much further complicated shapes, and then he grew when he learned to become proficient in it. Designer Ian Ritchie utilized the very same CAD tools in order to plan his creative gallery at the Natural History Museum in London. He asserted that he was capable of producing further complicated 3D shape when he had used ordinary manual sketch and the fact that he had not tested applying such complicated shapes in which CAD had not been used. Eventually, through a fascinating test, Robert Aish revealed how individuals who were not designers were able to use an ordinary CAD system to plan constructions [B.R. Lawson, 1997]. He demonstrated as well, through applying CAD, the teachers of a nursery school designed a children's nursery which was ranked by a board of other nursery school rather highly than plans generated by professional designers. Surely, this shows that non-designer's creativity can be flourished by CAD, that

impressively reduces the level of skill in sketching as well as some uncomplicated assessment procedures in order that designers would represent and investigate notions which their sketching abilities cannot support.

3.3.3 CAD Inhabits the Creativity

Such instances have taken place many years earlier, and no significant systematic researches about the influence of CAD on modern designing innovation have been carried out. It is widely believed to be useful, that does not suffice. There are lots of proofs that CAD is applied widespread professionally nowadays, however, it is another issue on the whole. Definitely, there are proofs to confirm the opinion that CAD is more advantageous compared to techniques of sketching by hand which require managing the project and coordinating information. Nevertheless, apparently, there are increasing body of experimental and traditionary proofs that CAD probably degrade innovative thinking. Many skilled designers don not utilize computer himself or herself. Therefore, as Ian Ritchie generates creative structural shape using CAD, Santiago Calatrava produces high quality structural shape without using CAD. He applies it to limitedly analyze elements, yet employs physical samples to produce shapes. Two causes make this notable. First, he is a designer and also an engineer, also he has a good basic knowledge of arithmetic and works with computer a lot. Next, he produces daring shapes, which are so difficult that they cannot be drawn using hand, yet he chooses producing physical models. Most designers who are regarded by their counter parts as innovative architects, who have considerably helped the field, conveyed worry regarding applying CAD in designing. Certainly, this can be viewed as totally Luddite attitude. About this issue we refer to Hertzberger once more:

He spent 40 years before he found out how to have communication between his paper and his mind….and he thinks he is pretty persuasive in it. he wants all his energy for his work, and he chose not to apply CAD, as when he chose not to learn playing the violin at young age. [R.Aish, 1977].

Saying this Hertzberger may be not so serious, yet he is stating a significant point. The means by which an architect displays ideas is of greatest importance to his/her working procedure. He has discovered an acceptable manner of working; he cannot discern advantages to be enough for considering the evident load of acquiring the new method as being more important. Do not forget creating the methods of their designing procedure is what learners do during performing their task. More and more students learn through scratch to design using CAD than sketching by hand. Some of us that test these students concern about a growing tendency. During recent years, I have tested design in universities of 3 countries where in every case I came across learners that were compounding effective and persuasive computer representation with designs of low quality. It appears to me that these works are just what Hertzberger referred to as fake rather than true innovation. These designs might appear very persuasive, original, yet they are surely not admirable. From the theoretical point of view, finding outstanding presentation compounded with unqualified design is always plausible. Yet, practically it rarely occurred, maybe because the sight sensitiveness required for designing and drawing skillfully are too alike for students to master just one of them. It doesn't look to be true about CAD and designing in architecture. This gets worse by some other causes. First, we are living in televisual era and any data looking televisual is unintentionally believed to be reliable. Next, thorough proficiency in this kind of computer

systems is just uncommon and scarce and we have a tendency to adore it like we adore an animal, which has been taught some tricks. Thus, it is feasible to propose computer representations which seem fascinating and even impressive, that sound reliable, whereas, such architectural representation is actually terrible. Some critics believe that in the past few years national awards have been granted for designs that before appearance of CAD would not have any chance to receive such rewards.

3.4 Computer Aided Architectural Design in the Future

The contrast frequently appears between application, in which a job should be fulfilled, and theory, in which it is intended to know why and in what way things are performed. It is a fact no one can create theories and expand it forevermore, about the subject he is working on: one has to finally ponder on the way. One has to think over his aims and how to achieve them. Initially in this study what part computers play in designing in architecture was reviewed from historic viewpoint. In the coming paragraphs, the state of computer-aided designing in coming years is examined. The oncoming parts sections are on the basis of primary notions of the parts that computers may play in designing in architecture.

"Computers are intellectual machines that allow us to simulate human behavior." [Negroponte, 1970: 1]

While making computer programs, one has to ask how man thinks and in what way designs get evolved. Saying in other way, computers need to get knowledgeable to both emulate what is figured out and, as being machines, and discover whatever is not realized. The whole succession of determining computer functions

resembles human mental activity i.e. thinking. As software is designed for the purpose of comprehending normal language, cognizance displaying, learning, or concluding, one is in fact transmitting the procedure of mankind reasoning to a device. The computer gets like a reflector that reflects human mind and how it thinks. As a result, plan will be examined like a procedure of an activity of mind by perceiving how man behaves, and also how computer behaves. In order to do this, doing single actions with considerable independence is essential. This means that all the succession of actions has to be in such a way that there is no interference from the beginning of data entrance until the outcomes are gained and the mechanism of deciding on the design must be made into the device. This doesn't imply that a computer-designer will be generated although finally it is likely to be desired. It offers the acquisition of independence in resolving certain difficulties in designing. Therefore, the designer is able to perceive the procedure of deciding through computer and measure it with others.

"A world view of a culture is limited by the structure of the language which that culture uses." (Sapir and Whorf hypothesis)

Nowadays, machines have changed the nature of the codes of language. Data banks need to be enlarged further geometric and non-geometric appendix data so that computers could be used more efficiently in the procedure of designing. They have to involve the meaning of the data, too. In designing in architecture, for instance, the software should make it possible to recognize a square irrespective of the size and direction. At present, the designer may start to observe that the systems let him do a great deal of calculations proceeding toward extensive databases, which make

interacting possible. In coming years, databases are likely to involve data about things' meaning, incidents, and relationships therefrom.

"It is not very difficult to make machines that will play chess of a sort. The mere obedience to the laws of the game, so that only legal moves are made, is easy within the power of quite simple computing machines." [Wiener, 1947: 171]

Principles, strategies &tactics, and looking for aims that are used in a game are likely to be helpful in the areas further than the game's bounds, for instance, in designing. Nevertheless, it is not clear if creating a system that plays game via employing designing principles is possible, and if this ability could present an indispensable distinction between the capabilities of the computer and mind's abilities. Von Neumann, 1945, has a theory of games that builds a way of defining them and making analysis of the strategies via working from ending point, not the starting point. A player, in the final action, tries to do a wining action if he can, and if not, with a minimum possibility to make a drawing move. Once the whole tactic is understood, it's obviously the most effective strategy to play the game. But, in designing, existing knowledge is inadequate to allow the formulating the perfect strategy of this type. Strategies, in designing, are only able to be approached. A strategy like this would depend on the connection of local practices to worldwide intentions, on approaches that are not all the time justified. As an instance, local practices included in constructing processes are specified by particularity. Contrary to this, worldwide targets may be totally ambiguous. Considering global sense of designing in architecture are, in the most favorable circumstance, it doesn't seem to be needed to ask if it is feasible to make a machine being able to play game that

will produce an optimized solution via obeying principles in Neumann's intend. Unlike this, it is undoubtedly feasible to build systems that respond local moves regardless the ultimate aim. The actual difficulty is to build the system that will present chances for attractive and challenging duologue with a modeler. The system like this will be able to learn through experiment that will provide it with the ability to better its awareness of strategy and principles of designing in architecture. This learning could be a complex of principles originated from background of architecture.

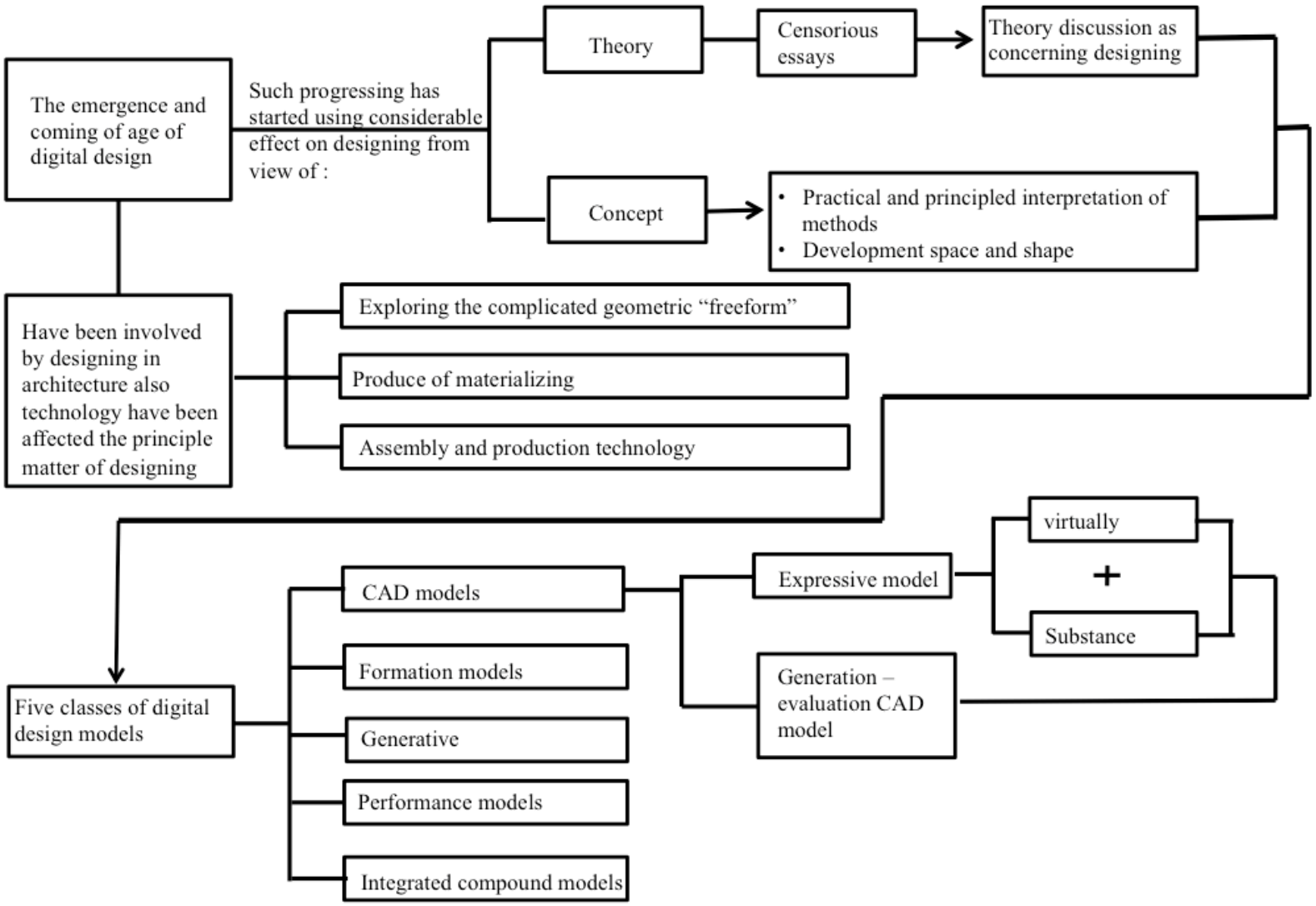

Chart 4. Summary Chart of chapter 3

Summary of chapter 3

This chapter starts with explanation of emergence and coming of digital design age. After entering the computer in architectural offices, new age of design as digital design was born. By developing use of CAD tools in design CAAD (Computer-Aided Architectural Design) tools, which specialized for architectural use, has been created. In continue CAAD was evaluated as a new media and the usage of these tools in contemporary architecture, Whether CAAD tools could be helpful in creativity. In final the future of CAAD tools has been examined.

Chapter 4

CASE STUDY: DISCUSSION AND FINDINGS

According to the main question of thesis, concerning effective computer aid in the stage of conceptual design, the survey in the form of interview has been done, also the result of these interviews answered some other questions such as;

- In WHAT WAY, WHY, HOW and WHEN CAAD is utilized.
- What is CAAD tools efficiency during the architectural design process.
- Whether CAAD technology follows design discipline or design discipline follows CAAD technology.

4.1 Method of Interview

Exploring the methodologies of investigation of designing procedure and design behavior, we come across two methods that have been created, i.e. interviews and documentary. Interview researches have commonly carried out with the experienced architects. It makes best use of occasions for the researches to reach professional designers' knowledge and perception of designing subject (Cross 1992).

15 architects from several Iranian architects' offices in Tehran (capital city of IRAN) were requested to participate in the research interview. The offices were selected randomly from thousands architectural offices, and the selected interviewees were 35-45 years old architects. Meetings took place in July and August 2014.

A short meeting in order to interview with the interviewees was arranged. The interview form was more similar to a free chat in fact than an organized questionaries' form. 10 interviews were done on the phone and 5 interviews were carried out in a face-to-face meeting. The questions were not given to the architects beforehand because of something that has been earlier lived. Experts who are interviewed usually are not positive toward filling out questionnaires including over 10 items, that may take them over twenty minutes to answer. So, when they were supposed to take part in an interview for answering questions on a questionnaire, they were likely to tend to reject the invitation. However, they looked to be more patient of being interviewed in a face-to-face meeting that maybe took about an hour. In order to make the best of the meeting time, although it looked like a free talk, the interviewer kept the conversation in the direction that was in accordance with previously prepared questions.

4.2 Results of Interview Questionnaires

To achieve a further understanding of the result, an interview was carried out later among the students involved in the experiment. The questions and the answers were presented as below.

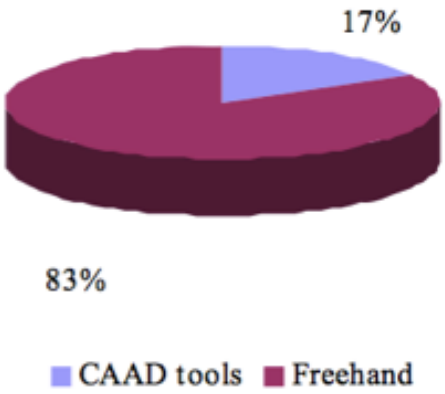

Figure 9. Interviewees' Preference on CAAD or Freehand Tools in the Creative Design

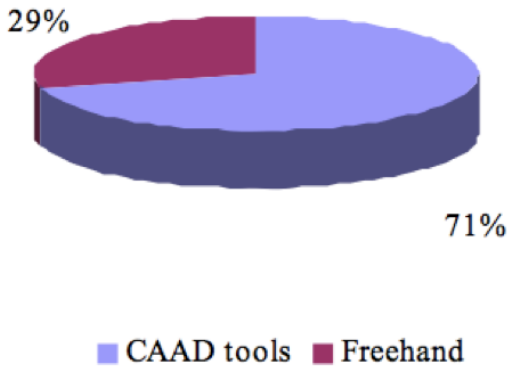

Figure 10. Interviewees' Preference of Tools on CAAD or Freehand Tools in the Procedure of Design Revision.

The first question was to find out these novice designers' preference of the tools they would use during the conceptual design phase. The response provided a rather clear answer to this issue. Most of the interviewees (83%) would prefer traditional way of utilizing freehand tools in the creative design process (Figure 9).

Nevertheless, the interview provided a positive response towards the adaptation of CAAD tools in the revision procedure of design. "Revision procedure" refers to the design procedure that immediately follows the phase of creative design—the designer revises and optimizes the idea generated in the last step. A majority of the interviewees (71%) showed a preference of using CAAD tools in the revision procedure (Figure 10).

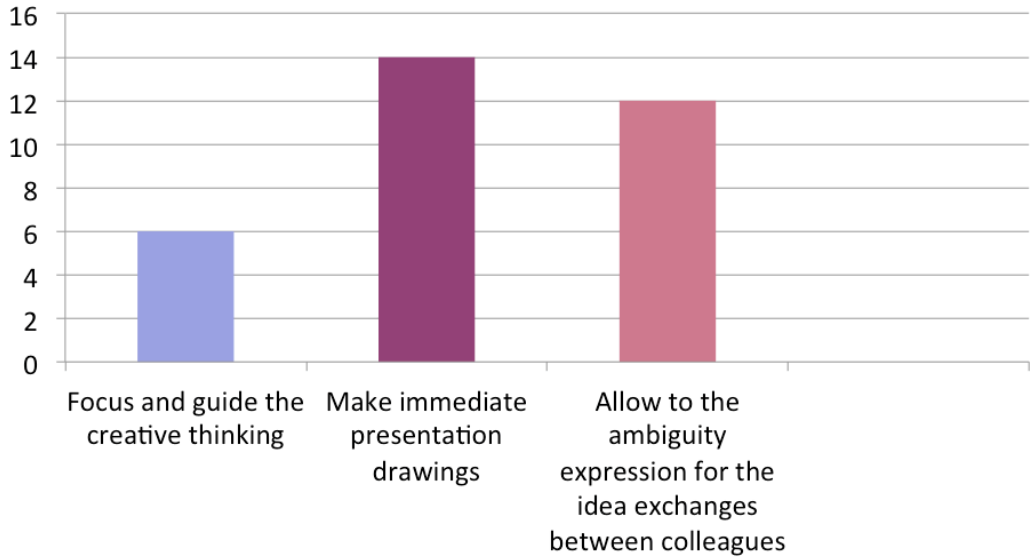

Figure 11. Bottlenecks existed in the current CAAD tools

As for the reason why the CAAD tools were less popular than the traditional freehand way in the creative design process, the interviewees' responses could be summarized by the diagram above (Figure 11). Utilizing the current CAAD tools to do conceptual design work, the interviewees have difficulty mostly in focusing and guiding the creative thinking, as mentioned by 6 interviewees, in making immediate presentation drawings, as mentioned by 14 interviewees, and in allowing the ambiguous expression for the idea exchanges between colleagues, as mentioned by 12 interviewees. These requirements could also be regarded as the key issues that were in need of improvement in the currently available CAAD tools.

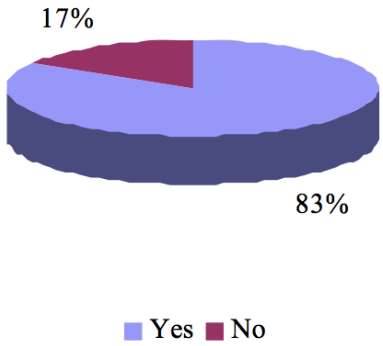

Figure 12. Interviewees' preferences upon whether current CAAD tools' interface interferes design Creative thinking.

Furthermore, the majority of the interviewees hold a negative view towards the interface of currently available CAAD tools. 83% of the interviewees hold the view that the interface does interfere with the design creative thinking (Figure 12).

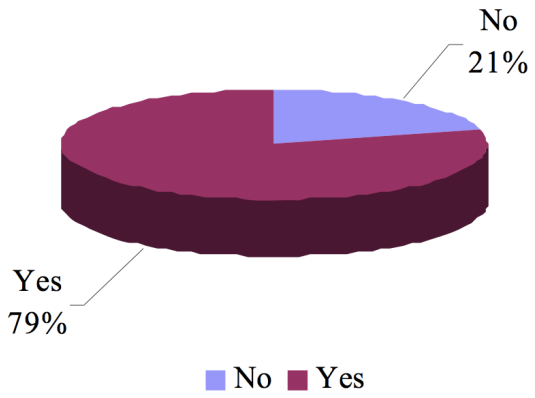

Figure 13. interviewees' view of whether there is a loss of information between the transferring of tools

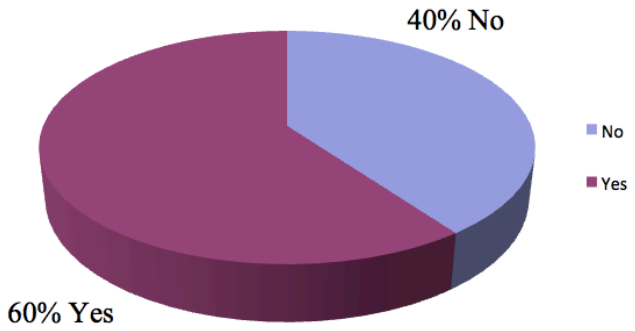

Figure 14. interviewees' view of whether CAAD tools have any effective role in creativity

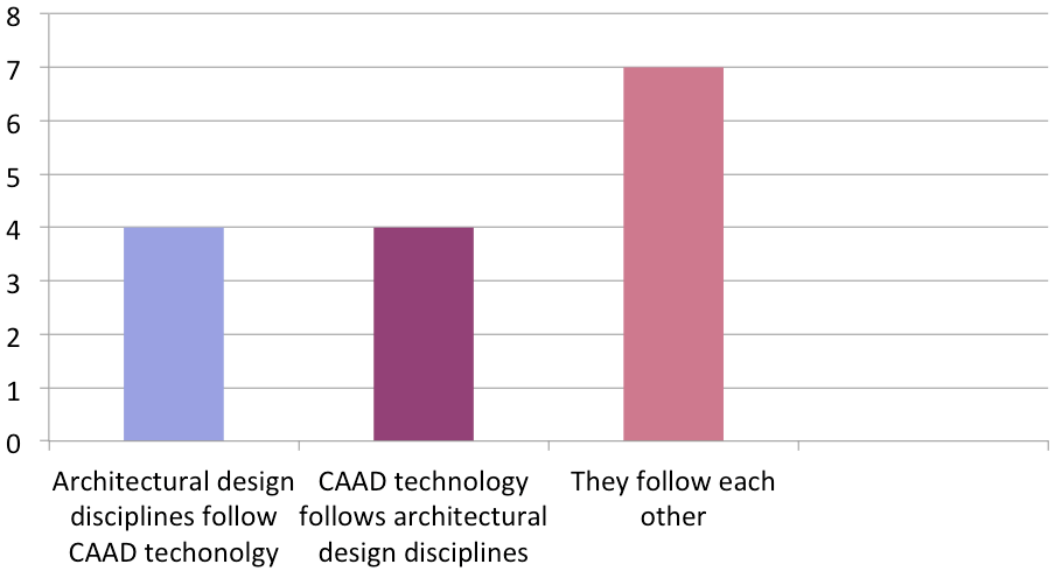

Figure 15. interviewees' view of whether architectural design disciplines follow CAAD technology or on the contrary CAAD technology follows architectural design disciplines

4.3 Discussion of Survey

All architects have used CAAD programs in their profession, and they liked AutoCAD best incorporating into their activities (Figure 16). Transferring hand sketches to CAAD began in the 1990's. The tools used widespread also are V-ray, 3Ds MAX and Sketch up.

However, the research reveals CAAD's are not being merged in the conceptual designing's creation process in architecture, and indicates that CAAD tools have insignificant effect on the conceptual designing stage. The interviewers approved that adopting digital tools had no effect on the creation stage (Figure 17). What causes this could be determined by what the interviewees stated. Creation is an intellectual activity in which the participation of CAAD tools is not needed (60%), or using CAAD tools does not cause creation stage to change (40%). Even now, the most significant and widespread conformed tools employed in architectural designing stage include pencil and freehand sketches, similarly, it is revealed in other researches that drawings are regarded like customary tools used professionally which suggested a means the architects use to explain specifications of the design, negotiate their designing procedure, save ideas and disclose the mechanism mechanics of their thinking procedure in the initial phase having connections with the concealed intentions meaning of images in his/her mind which probably other people cannot comprehend completely. (Lipson and Shpitalni, 2000; Dorner, 1999; Atman et al. 1999; Purcell and Gero, 1998). A significant feature of customary drawing tools in comparison with computer tools, which are presently obtainable, underlies the ability to adapt to briefness that can be confirmed via facts. As the interviewees were requested to determine the hindrance that appeared in the architectural conceptual designing through adjustment of computer tools, their acutest is pleasure was with ambiguous manner of thinking which recently very well-liked CAAD tools obtainable at the market don't tolerate (55%). Common software programs usually require an exact data input ahead of carrying on the work to following stage. However, often over the initial stage of designing, as shown in the previous

paragraphs, the notions created by the designer include some degrees of ambiguity that cannot be easily depicted in an exact and measurable manner.

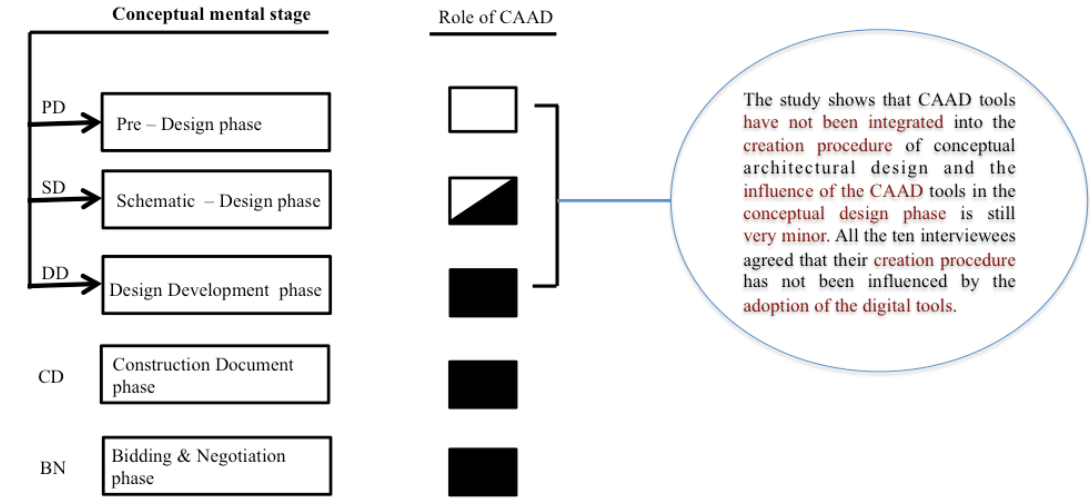

Figure 16. The Role of CAAD Tools in Conceptual Phases

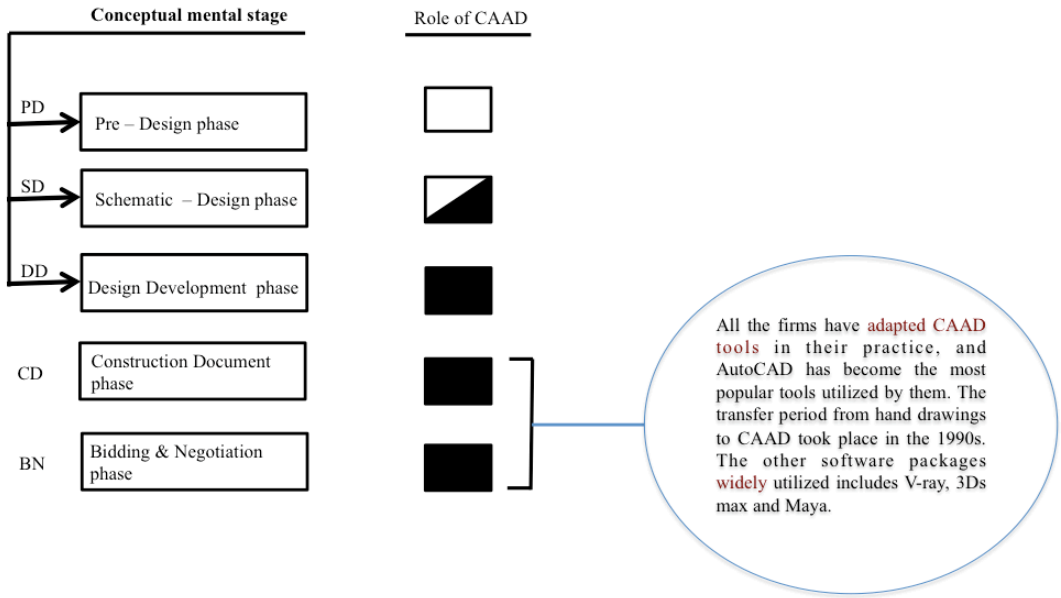

Figure 17. The Role of CAAD Tools in Final Phases

Concerning CAAD's effect on plan cooperation and organization, outcomes gathered were very different. 30% of architects said computer tools had not changed their collaboration and organization. Whereas some others expressed that these tools looked to decrease lively sharing information and ideas during the designing procedure. The designers pay attention mainly to their own design, in place of exchanging the notions and having a glance at other's screens, that somewhat, affect the design's quality. However, remarks about this matter are very different, that infers if CAAD adjustment affect the plan cooperation and organization, mainly relies on the architect's initial plan cooperation and organization samples.

It's apparent that utilizing CAAD tools, the designers like to overlook the worldwide outlook of the entire designing growth process. *They like to accentuate their own piece of the pie*. A few interviewees brought this to attention. To be able to assert a worldwide outlook performs a crucial part in the conceptual stage of designing; this matter needs to be regarded as a critical obstacle on the way of unification of CAAD tools into conceptual stage of designing in architecture.

CAAD tools possess instantaneousness of transferring ideas in comparison with customary freehand sketching that infers freehand sketching is a more effective means of straight transferring notions to paper compared to common CAAD. This can be partly brought about by complicated quality of interface that needs to pursue some rules to deal with. Another reason that may possibly lessen the design quality comes from the general effect of CAAD tools. As the period for innovative designing procedure may not actually lessen, the clients are anticipating less time to be spent on this stage wishing to achieve the outcome sooner, since

they feel getting involved in computer could enable the designers to perform the task more rapidly. This matter resulted straight in shortening the innovative procedure that could finally decline the standard of the conceptual designing.

Regarding 3D digital model, 90% of interviewees believe that computer cannot be as creative as designer's hand; physical models can be more effective especially in advertising. Human kind is sensitive, so he wants to feel the space; it means that the most important factor is feeling. This factor is not strong enough in digital production, even in the 3D models that have_high quality of presentation, in comparison to real physical models. The physical models have soul and they seem alive with which the designer communicate closely because he/she can touch and feel them.

According to 25% of architects, the society forces the architects to present their production digitally. Hand products are not attractive any more, even if you have a perfect hand presentation. However, 75% said that clients did not communicate with digital models of representation, so they preferred physical model. As stated in the previous paragraph, the_customers would like to "feel" the projects, somehow. The more design develops, the more important the role of computer becomes. For experts, however, it will be different. They often prefer digital presentation and more professional products since they can communicate with them easily.

About 58% of architects believe that the CAAD tools do not help them to be more creative considering the fact that initial idea and creativity come from

designer's mind. However, these tools can enhance designer's innovativeness, and help them to represent their idea in more details. On the other hand, some architects still emphasize that drawing and sketching of their idea is more enjoyable and they can interact with their design more effectively.

According to 40% of interviewees, CAAD tools do not have any effective role in creativity and in some cases even may decrease it, and that computer is just a tool that helps you to present your thoughts. They believe that the works of architects in the past, who did not use computer, are more innovative and sophisticated.

Most of the time, CAAD tools are regarded as representation tools, so sometimes the problematic points are not visible and cannot be recognized by the architect unless he/she has a printed copy of the project. Even some architects start to re-examine the project after printing and add some more ideas by hand, because, as mentioned before, they want to "feel" their design even if it is just a line.

Architects can best manipulate the virtual space medium more creatively and effectively by working on their project together as a team where each member works as an architect while having a certain professional skill in particular software.

If the designer has proficiency in certain software, actually he/she can use it more creatively and manipulate that digital medium in a richer and more productive way.

Moreover, for better utilization and more efficiency, architects have to know

which software is more useful to their target. For instance, in 2D plans expert architects suggest AutoCAD whereas for 3D plans V-ray or Rayan will be better than AutoCAD.

All of architects who attended in the interview had the same attitude toward covering the poor design by perfect digital representation. Somehow a project with poor quality of design may be represented with high quality of presentation that even experts cannot realize the problematic points of design. This is not accepted as a positive feature of CAAD tools.

The main question of this study that has been propounded in the initial part is whether architectural design disciplines follow CAAD technology or, on the contrary, CAAD technology follows architectural design disciplines.

This question was asked as a conclusion of interview. Regarding their answers, we should divide these architects in 2 groups: one group believes that technology actually makes changes in the way architectural design is going. As a result, design seems to follow CAAD technology; however today's computer-aided architectural design prepare opportunity for the new architectural styles known as contemporary architecture to appear.

They think if CAAD tools were not helpful to this extent, most of the works of contemporary architects like Frank Gehry or Zaha Hadid might never be constructed or even had never been designed. This important issue may be due to the principles of Zaha Hadid's design office where, contrary to Hadid's early and initial

sketches (Figure 18), they use computer from the very beginning stage of design process to the final representation stage. (Figure 19, Figure 20)

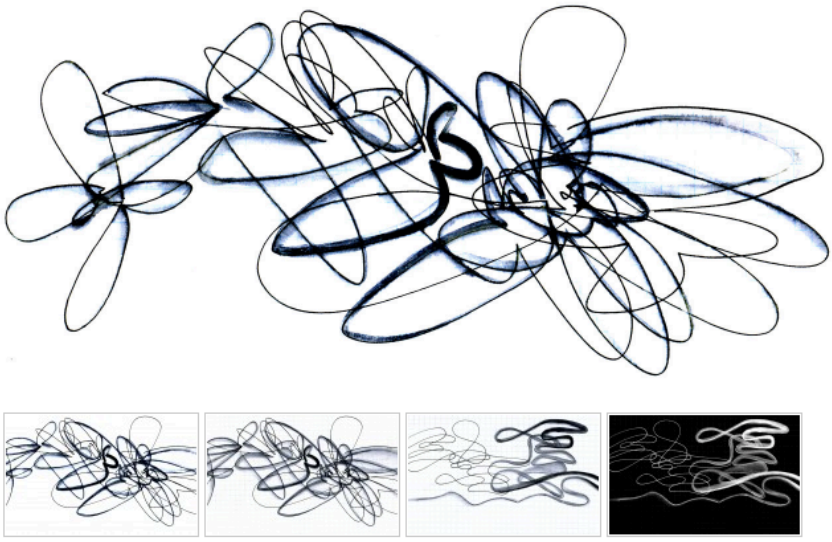

Figure 18. The Edifici Torre Espiral sketches (http://buildipedia.com/aec-pros/featured-architecture/zaha-hadid-architects-edifici-torre-espiral)

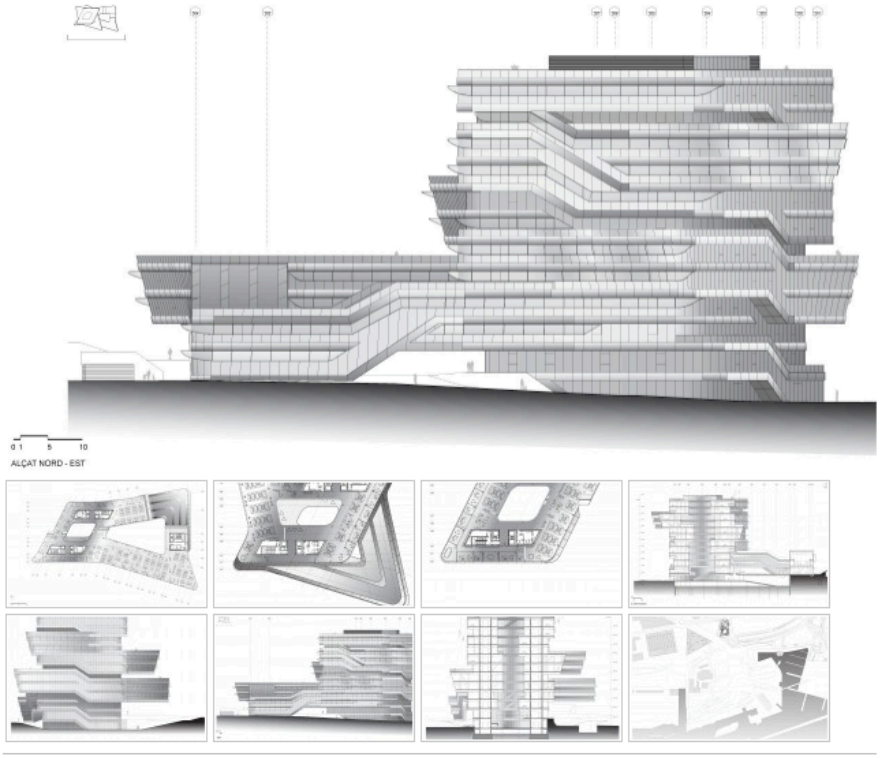

Figure 19. The Edifici Torre Espiral drawings (http://buildipedia.com/aec-pros/featured-architecture/zaha-hadid-architects-edifici-torre-espiral)

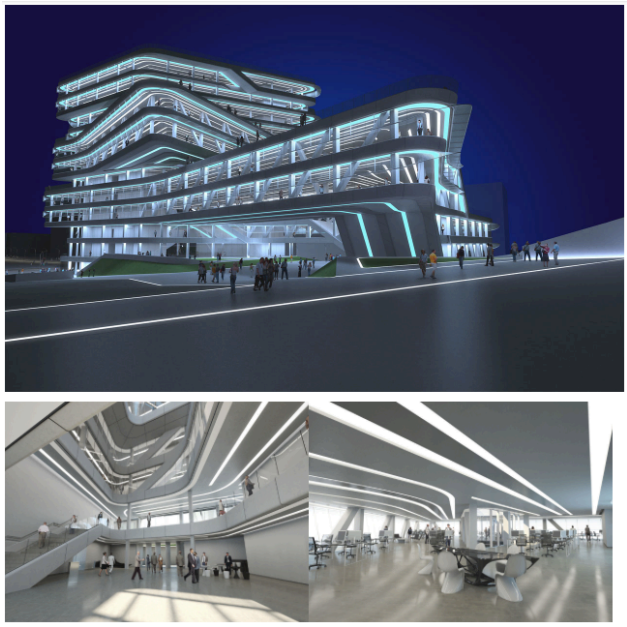

Figure 20. The Edifici Torre Espiral 3D Models (The building is currently under construction),(http://buildipedia.com/aec-pros/featured-architecture/zaha-hadid-architects-edifici-torre-espiral)

They also fix even any smallest changes with the help of computer and in some cases the changes are made by software engineers, and not by an architect. It shows that nowadays modern architecture depends more on high technology and the professions rather than just architecture itself.

The other group believes that architectural discipline is leading the technology, and the computer is just a tool that helps architects in design process. In the other words, the idea that creativity belongs to computer and machine is not true, so, it is the CAAD tool that follows design and still the architecture leads technology.

4.4 Findings of Survey

The main problems related top recently developed CAAD tools that the interviewees offered could be outlined as coming below.

Table 2. The Problem of Current Deployed CAAD tools

	The Problem of currently deployed CAAD tools
1	By the adaptation of current CAAD tools, architects tend to ignore the global view of the whole design development process during their work.
2	The blurring/vague way of design thinking is not tolerated by the currently CAAD tools.
3	With the utilization of the current CAAD tools, the architects are more concentrated on their own screen, instead of communicating with each other once a while during the working process.
4	The CAAD tools hold the immediacy of the transformation of idea
5	Covering the creativity weakness and support the designer by poor quality.

Chapter 5

CONCLUSION

This research involves analyzing the reactions and the actions of designers when interacting with drawings and such studies on how architects interact with their surroundings within the field offer strong clues on what are needed to be developed digitally. Developing facilities and conceptual tools for Computer Aided Architectural Design Systems can be achieved by utilizing the detection on sketching studies, which is an essential part of its development. Such developments also increase the chances that the programs can be incorporated into the earlier stages of design.

Such a methodology enforces the thought that designers outsource their designs through their creativity. Design practice and education successively change which is influenced by the technology.

In order to mature such a requirement, a very clear style of attitude is needed. Such a requirement must ponder the thought of having to ask the question of whether the principal imagination development becomes crucial. In order to answer such an activity, questions such as what sort of cognitive resources are required and how they can be developed must be asked.

Since the beginning of the thesis, the question of whether CAAD should be

used at the initial stages of planning has been asked and has been the reason to the explanation of a more usual topic based on the need for external representation.

It can be answered that the designers may not need sketching for the conceptual phase of the planning phase but it may be necessary to develop CAAD programs according to the stability of mental imagination in conceptual design. The future of CAAD very well may lie in the extension of the perception of imagination capabilities of the human brain and its visual reasoning. This implementation of the future of CAAD may be very different from todays CAAD.

The primary conclusions of analyzing the interview included the issue that current CAAD tools has not been fit for the conceptual stage of design due to the fact that they have not progressed in a proper way to meet the needs of conceptual design reasoning and that the sense of tools cannot yet correspond to the sense of primary paper & pencil. The outcome received from the research with professional designers confirmed this matter in different ways.

1. It was shown by all 15 professional designers that utilizing digital tools had not affected the creation stage of their designing. This means that they preferred common tools as initial tools during the creation stage of designing to digital ones due to the fact that it can be more useful and powerful means in conceptual stage of designing.
2. The interviews with architects showed that they liked traditional tools better during creation stage of designing, being considered as a more effective means.

A few causes resulted in the outcomes that are listed as coming below:

Firstly, architecture is constantly regarded as a complicated and an inconsistent matter. It includes the richness of modern proficiency and the clarity of human proficiency. Thus, particularly in the conceptual phase of designing, it is essential for the architects to realize and agree with this vagueness. Then, it reasonably raises the needs for the tools used in this task that is supposed to allow the vague behavior of notions. Nevertheless, presently common CAAD tools are insufficient in this aspect that considerably had hindered them being adapted in the conceptual phase of designing. All of the architects mentioned this in the interview. Second, most of the interviewees like to employ a single tool more than a variety of tools to manage various types of designing tasks since they're likely will be data loss while transferring between various types of tools. Contrary to the customary tools which can be considered as multifunctional means which meet the needs of nearly all tasks, current CAAD tools can be designed particularly for specific kinds of tasks in designing. Thus, a more extensive package, which could compound various jobs, could substantially increase the usefulness of CAAD tools during the conceptual stage of designing. Finally, the interfaces of recently available CAAD tools are also hindering the architect's from bringing the innovative thinking into focus. The professional designers who were interviewed raised the two matters below:

1.Presently available CAAD tools are capable of transforming the ideas immediately.

2. Designers pay more attention to their own design using common CAAD tools rather than communicate regularly with other designers while working. These two matters were connected to the interface as well as the manner of mutual influence

between human and the common CAAD tools on each other.

Since initial design is a complicated task and computers are potentially capable of supplying help, the digital era will alter designing world more powerfully than before. Usage of computers in designing originates from the computer's ability to enhance the designing procedure and its outcome. We mean the enhancement of the amount of design, particularly during the conceptual stage of designing, as well as the design's quality by the procedure and the outcome. A computer does this by letting us to consume our experience and knowledge about architecture more effectively. Thus, some realities related to the way we perform designing tasks needs to be admitted and respected. It means that CAAD tools have to be capable of including more actions and characteristics engaged in the conceptual stage of designing so that computer tools could merge with the conceptual designing stage. Some important causes that hinder CAAD tools from getting involved in the designing procedure have been discussed in this study. Through bridging these gaps, the designing setting that is suggested by CAAD tools can be more capable of communicating, interacting and being integrated, and having more opportunities to play a more effective part in the conceptual stage of designing and enhance the standard of designing. Follow-up study needs to be dedicated to making these requirements more understandable and to realizing how to carryout the CAAD programs to fulfill these requirements so as to create CAAD tools that are appropriate for the conceptual stage of designing.

n the context of this research, CAAD's representations are the practical methods of encoding data into graphical images to explain a concept via the CAAD

medium. Different visual techniques make visual thinking possible and improvable: each concentrates on ways to free the mind from traditional patterns of thought. Interest in CAAD representations and effects on the early phases of design have increased as designers have reached a different level of awareness in terms of computerized visual appearance and working methods (digital skills). The question of whether CAAD is solely a presentation medium or whether CAAD could be a medium for mixed levels of interactivity that facilitate sudden insights should be addressed. Therefore, new research should look at whether CAAD changes the way designers' reason or changes what designers are representing by analyzing their design methodologies.

Throughout the development of architectural design media, many transitions have occurred, where architects and designers took many years to understand and exploit the potential of a medium in conception. CAAD has passed through this in the final stages of the architectural design process (Dokonal and Knight 2006), in which designers have developed certain strategies to overcome CAAD's potential restrictions. As a conceptual design tool, CAAD seems to be passing through a similar process of exploiting and understanding. However, CAAD restrictions have always been defined in relation to sketching and were evaluated on this basis, thus its claimed restrictions were based on preconceptions or perceptions of sketching as the predominant thinking tool and CAAD must dismiss the former. In the early days of CAAD development, programmers' attention was focused on creating a program to automate the drawing board, not the designing brain, therefore considerable research was undertaken in exploring new trends (in programming) to suit

conceptual design by facilitating a sketchy behavior within a digital environment.

Researchers have explored the traditional design methods in the invention of new conceptual design tools to aid designers in creating architectural designs (Do and Gross 2001). However, similar studies established that differences between sketching and other (digital) tools are the most valued such as Coyne, Park and Wiszniewski's (2002) study.

The differences between the two representations continued to be significant and suggest that looking at the differences between the two is the most interesting theme. Some of these differences are listed in Table 3. Thus the potential of CAAD as a representation and its visual impact has to be examined per se in more depth and not on a comparable basis. More time and effort needs to be spent in exploring CAAD as a new medium for design.

Table 3. Differences between CAAA representation and sketching

CAAD Representation	Traditional Representation
Dynamic reflects on more level while reviewing	Static reflect on the considered level of abstraction
Extra visual effects (Automated effects, color, line weight, texture)	What you draw
Active and passive changes	Active in making a change in representation
Drawing reuse (whether elements or objects and redrawing reuse)	Reuse by tracing over previously drawn-redrawn
Virtually	Reality
No materiality constraints (unlimited)	Materiality constraints (limited)
Storage and display independent	One storage and display-dependency

Has computer influenced the architecture of modern era? Seemingly there is no doubt that it has had a very important role in modern architectural designs so far. However, with regard to the increasing growth of computer science and development of the smart tools, it is time to involve these tools in architectural design procedure more effectively. At the moment, it seems that it is a necessity to do more researches in this field and investigate the deficiency of current CAAD tools in order to improve and enhance them.

This study has attempted to explore the role, which CAAD has played in the development of idea as a representational medium. In order to get the best result from the study, some interviews were carried out with a few architects. What

interviewees have replied to questions and their attitude towards applying computer programs, including CAAD systems in architectural design was analyzed. This attempt was aimed to examine the usage of CAAD as the conceptual tools in addition to find out the weak points of such design soft wares.

The findings of this study could be helpful to those who are interested in this subject matter. However this research is not an end to this topic, and future studies in order to find the solutions and present them as proposals, will certainly improve and develop the systems of CAAD tools. And this will probably result in increase of computer use during conceptual phases of architectural design.

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APPENDICES

Appendix A: INTERVIEW Questionnaire;

1. Do you use CAAD tools in your profession?

   Which software/s do you use more?
2. By considering the 3D digital model, still do you need physical model?
3. What is the most appropriate from of representation for a particular audience and for a particular design stage?
4. Whether CAD has been demonstrated to enhance creativity in architectural design stage?
5. What is the goal of external representation? (Is there need to external representation?)
6. How can designer best manipulate the digital medium in an even richer and more productive, variety of ways?
7. How can contemporary computer visualization techniques be best managed to construct a common visual language and thereby be a key part of a common framework that will facilitate and optimize the performance of lead players in the design process?
8. Do you consider CAAD as an advantage is support of designer in creativity weakness? (Does design softwares cover the creativity weakness and support the design by poor quality?)
9. Whether CAAD technology follows design discipline or design discipline follows CAAD technology? (Does technological development result in contemporary architecture advancement or, on the contrary, progression in contemporary architecture causes technology to develop increasingly?)

Appendix B: List of Interviewees

1. Name: Hamid Reza

   Surname: Ghamsari

   Age: 34

   Telephone number: +98-912-554-3503

   Email address: Ha.ghamsari@yahoo.com

   University of he graduated: Islamic Azad University (Rudehen branch)

2. Name: Mohammad Reza

   Surname: Borumandan

   Age: 46

   Telephone number: +98-912-486-5791

   Email address: Mr.broumandan@yahoo.com

   University of he graduated: Islamic Azad University (Tehran-Markaz Branch)

3. Name: Amir

   Surname: Bahmani

   Age: 43

   Telephone number: +98-912-134-6543

   Email address: Amir.bch@yahoo.com

   University of he graduated: Elm o Sanaat University

4. Name: Abdolkarim

Surname: Qaedi

Age: 45

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Email address: Aqaedi@yahoo.com

University of he graduated: Shahid Beheshti University

5. Name: Alireza

   Surname: Najjari

   Age: 36

   Telephone number: +98-912-287-8326

   Email address: A.najjari@yahoo.com

   University of he graduated: (M.S) Islamic Azad University (Tabriz Branch)

6. Name: Behrouz

   Surname: Marbaghi

   Age: 50

   Telephone number: +98-912-480-5347

   Email address: Bm@om-architects.com

   University of he graduated: (M.S) Shahid Beheshti University

7. Name: Kourosh

   Surname: Hajizadeh

   Age: 39

   Telephone number: +98-912-736-6753

Email address: Kouroshhajizadeh@gmail.com

University of he graduated: (Master, Ph.D. candidate) Islamic Azad University (Tabriz Branch)

8. Name: Mandana

   Surname: Cont

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   Telephone number: +98-912-343-0897

   Email address: M.cont@cont-architects.com

   University of he graduated: (Master) Islamic Azad University (Tehran-Markaz Branch)

9. Name: Shahabeddin

   Surname: Arfaei

   Age: 54

   Email address: Arfaei@bamc.l.ir

   University of he graduated: (Master) Tehran University (Faculty of Fine Arts)

10. Name: Shahriar

    Surname: Yaghini

    Age: 53

    Telephone number: +98-912-102-9643

    Email address: Yaghini_shahriar@yahoo.com

    University of he graduated: (Master) Tehran University (Faculty of Fine Arts)

11. Name: Elnaz

    Surname: Ostad Ahmadi

    Age: 34

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    University of he graduated: (Master) Islamic Azad University (Tabriz Branch)

12. Name: Naiemeh

    Surname: Navidanfar

    Age: 34

    Telephone number: +98-914-114-7279

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    University of he graduated: (Master) Islamic Azad University (Tabriz Branch)

13. Name: Mir Saeed

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