TC

İSTANBUL KÜLTÜR UNIVERSITY

INSTITUTE OF SCIENCES & ENGINEERING

DEPARTMENT OF ARCHITECTURE

INTEGRATING CAAD INTO ARCHITECTURAL EDUCATION

An M.Sc THESIS

By

MAHMOD M. A. ELHARDUDI

Supervised By

Prof. Dr. Koray GÖKAN

İSTANBUL, TURKEY

February 2007

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Approval of the Institute of Research and Graduate Studies

Prof. Dr. Turgut ÜZEL
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I certify that thesis satisfies all the requirements as a thesis for the degree of Master of Architectural Design.

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This is to certify that we have read the thesis named "INTEGRATING CAAD INTO ARCHITECTURAL EDUCATION" which has done by Mr. Mahmoud M. A. ELHARIDI, student no.: 0499930003 and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Architectural Design.

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ÖZET

ABSTRACT (in Turkish)

CAAD, tasarım sürecinde kullanılan bütün programların dahil olduğu (örn. Taslak, tasarım, sunum, iletişim, vs.) Bilgisayar Destekli Mimari Tasarım demektir. Bu tez, CAAD'ın mimari eğitime entegre edilme olasılığını tartışır. Bu tezin temel soruları şunlardır; niye CAAD'ı öğretmek, CAAD eğitime nasıl katkı sağlayabilir? CAAD'ı ne zaman öğretmeye başlamak? Hangi aşamada CAAD öğretilebilir ve ne derecede entegre edilmelidir? Ne öğretilecek, hangi uygulamalar eğitim sürecine yardımcı olabilir? CAAD eğitime nasıl entegre edilebilir?

Tez beş bölüme ayrılmıştır. İlk bölüm, mimaride kullanılan bilgisayar programları konseptini inceler, aynı zamanda bu tezin amaçları ve stratejisi de incelenmektedir. İkinci, üçüncü ve dördüncü bölümler bu tezin yapısını oluşturmaktadır. İkincisi, CAAD'ın gelişim tarihini ve bu aracın faydalarını içerir. Üçüncü bölüm, CAAD'ın hem mimari eğitim hem de araştırmalardaki konumunu inceler. İncelemelere ek olarak CAAD öğretiminde değişen kurallar dahildir. Dördüncüsü, CAAD entegrasyonunun gerekleri ve teorisini tartışır. Son olarak, beşinci bölüm bu çalışmanın temel bulgularını ve gelecekle ilgili bazı önerileri içeren sonuç bölümüdür.

ABSTRACT

CAAD refers to Computer Aided Architectural Design which includes all computer programs that used in design process (e.g. drafting, design, presentation, communication, etc.). At first the concept CAD (Computer Aided Design) was used to refer to all computer programs that used in drawing and design. Quickly, CAD was replaced by CAAD (Computer Aided Architectural Design) which expressing the specific character of computer applications that related to architecture field. By the end of 1980s another concept has appeared that is IT (Information Technology). During 1990s, this concept was replaced by ICT (Information and Communications Technology) which representing the current values of computing and digital technology of our era.

This thesis argues the possibility of integrating CAAD into architectural education. The main questions of this thesis are; why to teach CAAD, what values that CAAD can add to education? When to start teaching CAAD? In which stage should CAAD be taught and to what extent should it being integrated? What to teach, which applications can be helpful to education process? And how CAAD can be integrated into the education?

Thesis divided into five chapters. First chapter reviews the concepts that refer to computer programs used in architecture, also the aims of this thesis and strategy of it. Second, third and fourth chapter form the body of the thesis. Second one includes the history of developing CAAD and utilities of this tool. The third chapter reviews the situation of CAAD in both architectural education and researches. In addition to reviews the changing rules in teaching CAAD. Fourth one discusses the theories and the requirements of integrating CAAD. Finally, the fifth chapter is the conclusion which includes the main findings of this study and some future recommendations.

ACKNOWLEDGMENT

First of all, I wish to express my sincere appreciation to **my father** (God mercifulness is upon him) and **my mother**.

I would like to express my deep appreciation to Prof. Dr. Koray GÖKAN for his assistance.

I wish to express my deep appreciation to:
The General Public Committee, Libya
The General Public Committee for High Education, Libya
The Libyan Public Office "Libyan Embassy", Ankara, Turkey
Fourth and Fifth year's students of Architectural Department, University of Derna
Mr. Ahmed Elmagri, University of Derna

I would like to express my deep appreciation to eCAADe "Education and research in Computer Aided Architectural Design in Europe"

Lastly, I wish to thank my **family**, and all my **relatives** and **friends**.

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CHAPTER ONE
INTRODUCTION

1.1. Concepts of Computer Programs

CAAD was introduced in the 1950s to assist designers in assessing the 'goodness' of their creations. Initially, computers were used to assist in engineering analyses. At first the concept CAD (Computer Aided Design) was used to refer to all graphic computer programs that used in drawing, drafting and design. First graphic system was in mid 1950 the US Air Force's SAGE (Semi Automatic Ground Environment) air defense system. First real drafting program was in 1960, SKETCHPAD by Ivan Sutherland. Quickly, CAD was replaced by CAAD (Computer Aided Architectural Design), in 1980, this is more specific definition for applications that developed for architectural purposes which expressing the specific character of computer applications that related to architecture field.

With the rapid development of computer technologies by the end of 1980s another concept has been added to the CAAD that is IT (Information Technology) which refers to architectural applications and related technologies. By end of 1990s, with the revolution of computers as communications tools the concept IT has been replaced by another one that is ICT (Information and Communications Technology) which representing the current values of computing and digital technology of our era.

From the concept CAD to the final one, ICT, the changing in these concepts which used to refer to computer programs is always related to the development in new technologies. New developed applications caused new definition for computer programs.

The wide use of computers application in architectural practice and the rule that CAAD systems play in design process is affecting the way that architecture is being taught. So, architectural education should provide the right tools to students to be informed and acknowledged about the real practice of their future. As a

result, many researches and concepts have been discussed to achieving the appropriate use of CAAD systems in architectural education. However, still there is no global framework of teaching CAAD in architectural schools and department. They use deferent applications and concepts to teach CAAD to their students.

1.2. Usages of CAAD in Architecture Field

Due to the increased number of CAAD application in the market the use of this tool have become more and more important. Nowadays, using CAAD is not that sample use as a drafting and storage tool instead the use of CAAD applications in architecture field have many fields and generally using CAAD in architecture field can be divided in the following categories:

- **Production and database tool:** this includes the use of CAAD applications as drafting, drawing, presentation and representation tool in addition to the use of computers applications as documentation and database storage.

- **Design tool:** here CAAD acts as a design medium which provide solutions for the design problems and a tool for analysis building and designs elements.

- **Communication tool:** as architectural works have become an collaborative works that requires sharing information and ideas, computers and IT provides powerful advantages to be used as a communication tool that allow architects and designers to share their ideas and projects.

- **Teaching tool:** due to the domination of CAAD systems in architectural professional practice educators and researchers try to integrate this technology in the education process. The aim is to improve students' knowledge in CAAD and develop students' works in collectivity in order to prepare them to their professional future and provide the most updated technologies in architectural practice field to them.

1.3. Thesis Strategy

Architects and designers are still researching for a global system for the use of computers in architecture and to integrate this technology in the architecture education process. With the rapid development of CAAD programs in the architecture field and using CAAD as design tools in the practice field, other issues being set. These issues try to find a framework to integrate CAAD programs with architectural lectures. The aim of these issues is to set rules of teaching CAAD as a design tool and to help students to use CAAD after they graduate in the right way which allow them to use the full features of CAAD programs in there works as can as possible.

The strategy of this thesis is to explore the essence of using CAAD systems and applications in architecture in general, and using this technology in architectural education in particular. The subject presented here argues the possibility of integrating CAAD in architecture education and evaluating the current situation of teaching CAAD in architectural schools with a case study from Libya. In addition to these aims the thesis focus on the latest concepts and theories that argue the problem of how to teach CAAD, when and what is the requirements of this process? This thesis contains five chapters, introduction, body of the thesis which contains three chapters, CAAD and Architecture; CAAD in Education and Researches and CAAD Curriculum, and the last chapter contains the conclusion and recommendations.

First chapter of this thesis includes a general definition of CAAD and description of new technology in architecture field and the use of CAAD and related technologies in architecture field. Second chapter reviews the advantages of CAAD and the added value of CAAD to architecture field in addition to reviews the development process of CAAD by focusing on the history of CAAD development, the generations of CAAD applications and the directions of developing CAAD and finally discussing the future of CAAD in architecture practice and education. Third chapter evaluating the current situation of teaching CAAD by reviews the generations of CAAD usage in education and changing rules of teaching CAAD through the last forty years in addition to reviews the structure of architectural education and the use of CAAD according to this

structure. Also, this chapter contains some world wide case studies about CAAD education in architectural schools in addition to a case study about teaching CAAD in Libya by taking University of Derna as an example.

Fourth chapter discusses the process of integrating CAAD into architectural education by; firstly reviews the categories of digital applications in architecture and the use of multimedia and CAAD applications in architectural education, and then reviews some of the pedagogical issues that have been derived from world wide CAAD conferences and roundtable participants' experiences with CAAD curricula. In addition, this chapter contains the main requirements of integrating CAAD into architectural education and the most important points which must be decided carefully when involving CAAD into the education process. The final chapter includes the conclusion of the thesis and the results of this study in addition to some recommendations which can be guidelines to approaching an ideal CAAD curriculum. Figure 1 shows the structure of the thesis with brief definition about each chapter.

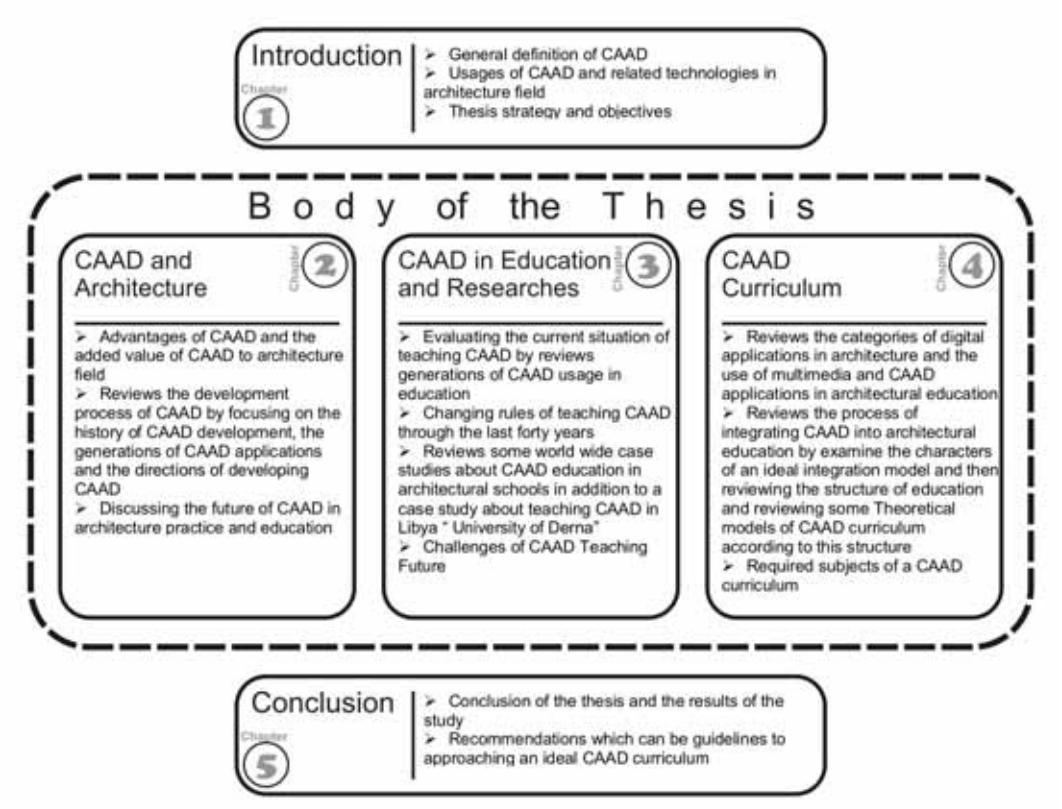

Figure 1: Structure of the Thesis

1.4. Thesis Objectives

The main idea behind this thesis is that the relationship between CAAD programs and education process. It argues the advantages of these tools and how they can help us and mainly how these programs can be integrated to the curriculum process of architecture? The main objectives of this thesis are:

- To present a general description about CAAD systems and the development process of this technology in both practice and education fields of architecture;
- To identify the benefits of CAAD systems in architecture practice field in general and the assistant of these tools in the architectural education particularly;
- To accommodate a prevalent understanding of CAAD integration into the architectural education and review the utilization of this technology;
- To evaluate the current situation of teaching CAAD in architecture schools with regard to the curriculum structure especially in Libya by giving an example from University of Derna;
- To identify the main keys factors that controls the integration of CAAD systems into architectural curriculum;
- To examined how should CAAD be best integrated in the curriculum by looking at where and what subjects in the education should it be integrated with? How that can be done? And when?

CHAPTER TWO
CAAD AND ARCHITECTURE

2.1. Domination of CAAD

Computers are the most powerful tools available in our age and there is no field that not affected by this technology. Architecture is not an exception from this fact. Computers have been involved in architecture field in propose of assist and aid the design and creative process. Nowadays, This tool is not only a great advantage to the design process but also a fundamental necessity for any designer or practice wishing to maintain their position in the highly competitive professions of the built environment due to the great features of this tool and the domination of new technology.

CAAD has great potential for a variety of architectural design process and in the recent forty years computer programs have replaced the traditional ways of drawing and some design activities were able to done with the assistant of computers. New architectural theories have appeared by the assistant of new technologies and the architectural form has been under changing since computer programs were included in the architectural design process. CAAD systems can lead to better representations, and allow architects to models and operations to correspond more closely. The rule of using CAAD systems in architecture has been under changing since the first usage of this technology.

The first generation of CAAD focused on using CAAD as drafting and representation tools which offer tools to make architectural work done faster and easer after that there was an important change in the sue of CAAD which try to involve CAAD in the design process in order to build a virtual environment to the design where it can be developed and experienced by architects on the screen and to enable actions and reaction between them and the form in a virtual world representations. As architectural work have been a collective work which involve a group of participates another use of computers appeared which allow sharing of knowledge between architects, designers and other disciplines to enhance and improve the impact of information technology on architecture. Upcoming

researches and studies focus on the area of using computer as a design, simulation and communication tools.

Since 50s computers have been developing in order to help people to be more efficient and creative and make life easier. In almost every other field of design, the computer has become an important tool in improving both efficiency and quality. Architectural field is not an exception from this. At first, in 1960s, the usage of computers in architectural design process was not paid more attention because of the capacities of the programs and tools available in that time. However, this situation has totally changed in the recent twenty years and the use of CAAD software in architecture field has increased rapidly. Today, CAAD systems are the most powerful tools used in the architectural design process. CAAD Software now is better and more widely used than ever before. It is faster, powerful and its capable of producing drawings and models is very high. These programs provide multi choices which help architects and designers to produce there projects and make it easier to edit and develop the final products.

Nowadays, CAAD software plays a major role in the development of architectural design. CAAD systems and new technologies help architects and designers to develop and create new forms and find new solutions to the technical challenges which they face during the design process. These solutions could not be found without help and assistant of new technologies. It can be seen easily that the change in architecture form that was done by assistant of computers. And the aim of temporary researches and development of CAAD systems is to help architects appreciate and this technology as an everyday tool for their design work and not only for presentation purposes.

Due to the lack of experience and familiarity with computer tools used by architects and designers, CAAD systems are not used to its full capability as a design medium and creative tool. Unfortunately, most of architects are also very traditional in their approach to design and view CAAD systems as a production tool that can only help them in the final stage of the design rather than as another design tool. As a result for this unfamiliarity designers can not draw exactly what they have in mind and CAAD programs are mainly u

Sketching by pencil and paper is the main tool for the designer to transfer their ideas. However, development of information technology has changed this situation and CAAD programs are probably going to change the way of designing, at least computer aided architectural design systems are the main tools that used in architecture field to draw and representation which.

2.2. Advantages of CAAD Systems

CAAD programs have played a major role in architectural design especially after involving these tools in the design process. They have increased and still our abilities in designing, as technologies continuously are improved. In general there are two major field of assistant which CAAD systems provide. First is about drawing by computers and second is the help of computers in the conceptual stage and design assistant provided by CAAD programs.

The assistant of CAAD systems in the drawing and representation and this was the first generation of CAAD usages in architecture field because of the abilities of the technologies which were available in that time. CAAD programs have many advantages that makes this process faster, easer and precise. First advantage is the flexibility of the drawings which made by computers. They can be edited and corrected, and it is easy to have more than one copy of them. For example, to draw three plans for the same building it is needed only to draw one level and then copy it and edit it to be suitable to the other levels or floors. This advantage takes us to another important feature about using CAAD programs that is the time required to the drawing process. By decreasing the time of this process architects can has additional time to think about design it self.

Another advantage is the models and 3D forms which made by computers contain a lot of additional information about the design more than a drawing made by traditional ways. For example, a drawing made by CAAD programs provides all information, such as dimensions, colors, angles, text, etc. at the same time also the ability to be print in different scale. Precision is another important feature of drawing by CAAD programs. In computers measures are always exact and absolute also using computers decrease the possibilities of mistakes. Libraries which available in architectural software contain a lot of symbols, doors,

windows, furniture, cars, etc, they also can be on or off and defreeze or freeze while designing or printing. This is very helpful to users of CAAD system and they do not have to draw every detail themselves. In addition, these elements have the ability to be scaled and edited.

After the rapid development in CAAD packages another usage for CAAD start to appear which is the second generation of assistant of CAAD this assistant is the help of computer programs at the conceptual design stage, in other words, using computers as a design medium. With the rapid development of CAAD software and the capacities they have today, architects and designers have more options and features to reform their design especially in 3D environment and start their concepts by assist of computers. Almost all computer programs contain several commands which allow users to edit, modify and reform the design during the design process.

This process can be done on the same object and users do not have to redraw again and again which allow architects and designers to produce their ideas and drawings in less time. Providing three dimensional objects on the screen allow architects to change colors, materials, textures, etc. and this gives a great view for the design before it be created in the reality which allow architects to change their design easily also using effects such as lighting and natural elements (trees, water, etc.) make the design more efficient. Using 3D models in CAAD systems make a bridge between architects and clients and they do not have to know a lot about architecture, because of using models which can be seen from different points clients have the power to participate in the design process. They can easily see the final project and experience it. In addition to these advantages there are other features of great value to a CAAD system, such as storage of the design in formats which can be used in other CAAD packages, and provide methods for manipulating the geometry. CAAD systems often allow drawings produced from different programs to be used and shown in the same model, that enable compatibility between the software used by the architect and the contractor.

In summary, the main advantages of CAAD systems can be divided into two categories first is the assistant of computers in drawing and representation which

contain the ability to edit, redraw, store and print the final project easily. The second is using computers as design tool where computers are a medium for the design where it can be modified and recreated.

These advantages of CAAD applications and other digital applications can be divided into four categories; reducing time, 3D and presentation capabilities, and precision which are providing in figure 2 below.

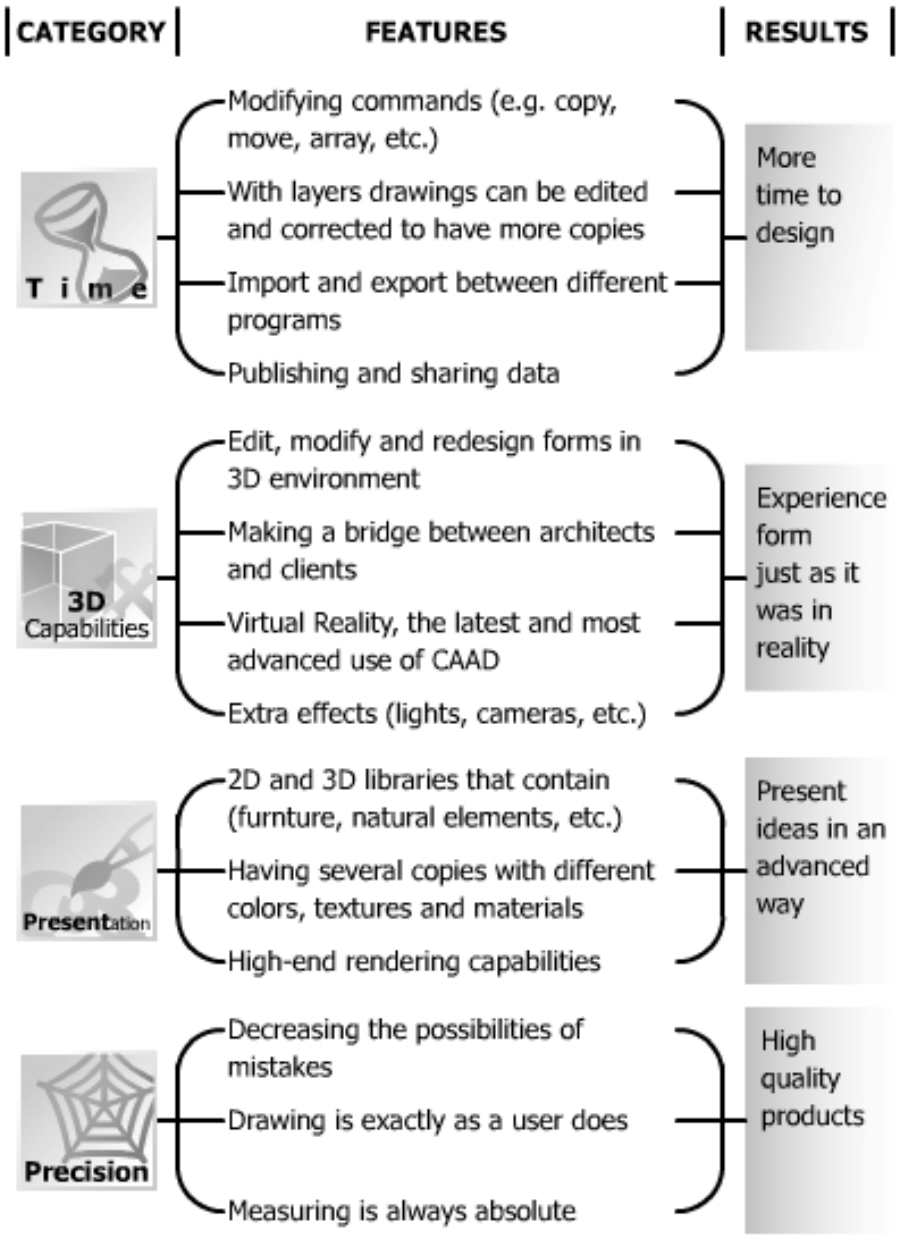

Figure 2: Advantages of CAAD

2.3. Development of CAAD

Developing and improving CAAD applications which lead to full use of computers for architectural design is the essential challenge that CAAD developers face. From the beginnings of the development of CAAD systems the aim was the design process itself. The target is to lead to advanced use of computers in the conceptual design stage not only using computers as a tool for drawing and representation the final products. However, until now there is no well-developed CAAD application yet. Using computers assistant in the conceptual design process has not improved as quickly as what was earlier in the beginning of using computers within the architectural design. Until now there is no CAAD system that provides complete support and gives all requirements for design process in architecture. However, some design activities are done by assistant of computers but they still limited to what it should be. It is obvious that the future of CAAD will not only be as we saw in the last years but there are other concepts in using these systems to approach the aim that make it possible to use CAAD as a creative tool. The recent researches in this field focus on developing more powerful tools design tools and contemporary researchers try to set a framework to how computers can help conceptual design process and exploiting advanced computers techniques.

2.3.1. Historical Approach

The history of using computers in architecture is very short. It is always related to the development of information technology by both hardware and software. In the beginning computer aid was aimed to automate drawing and produce only simple drawings. The use of CAAD systems in architectural design process has increased a lot in recent decades after the rapid development in computer technologies. The first Computer-Aided Design programs used simple algorithms to display patterns of lines at first in two dimensions, and then in 3-D. First articles discussing computer aided design were published in 1961 and 1962. The first true CAD software, a very innovative system called "Sketchpad" was developed by Ivan Sutherland as part of his PhD thesis at MIT in the early 1960s.

In general, the history of CAAD can be set in three major periods, beginning of CAAD software from 50's until the end of 60's when this technology were in the

first steps and the main idea was to help architects to draw and represent their ideas by computers. Second period was in the beginning of 70's after computers abilities become more useful and the third period start from beginning of 80's after personal computers have been used widely. Since 50's number of studies and researches tried to focus on use of computers in design and industrial. These steps were very simple and capacities of the programs were limited and the aim was to create a machine that can produce drawings. Usage of computers was very limited due to the lack of technologies and incomplete of computers programs. In mid of 1950's First graphic system was developed at Massachusetts Institute of Technology's Lincoln Laboratory for USA Air Force's SAGE (Semi Automatic Ground Environment) air defense system. In 1960, Ivan Sutherland produced a project called SKETHPAD, which was the first step to CAD industry. After two years, in 1962, Bill Barnes established Auto-trol and manufactured the first product, a digitizer. The first Computer-Aided Design programs used simple algorithms to display patterns of lines at first in two dimensions, and then in 3-D and to help architects save time instead of drawing their blueprints. At the same time there was another project which was developed at ITEK and general motors. The project was called The Electronic Drafting Machine. While the first production interactive graphics manufacturing system, DAC (Design Automated by Computer), was designed at General Motors Research Laboratory by Dr. Hanratty.

In The second period, 1970, a number of computers programs were available and they done a useful work for architectural design including planning, evaluation of alternatives, cost planning and structural design. In 1971, MCS was founded by Dr. Patrick J. Hanratty. MCS has enjoyed an enviable reputation for technological leadership in mechanical CADD/CAM software. ADAM (Automated Drafting and Machining) which was the first company's product, was released in 1972, ran on 16-bit computers, and was one of the first commercially available mechanical design packages. In the late 1970's the first solid modeling software was produced which taking basic geometric objects such a sphere, block, cylinders and wedges. In 1976, MCS introduced AD-2000, a design and manufacturing system for the first 32-bit computers. By the end of 1970's first modeling software started to appear Taking basic geometric objects such a sphere, block, cylinders and wedges

and combining them using Boolean operations such a remove a cylinder from a block to create a hole. The real start to approach more effective CAAD software was in 80s after the invitation of PC in addition to a number of companies that have been found in addition to the wide use of computers and mini computers with much more power at less cost started to appear. Personal computer led to an explosion of interest as hardware and computers have been used widely in the 1980's. As the computer as drafting systems succeeded, CAAD software has been developed increasingly and personal computers have been used widely which make them the future of the application of computers in architecture and the development of commercial CAAD applications led using computer assistant in architecture to become extensive. The table shows the earlier programs and companies of CAAD.

Year	Company	software	Definition of the Program
1980	T&W Systems	Versa CAD	Creating designs using computers
1981	Computer graphics from Cornell University	3D/Eye Inc.	A pioneered 3D and graphics technology
1981	Unigraphics	UniSolid	First solid modeling system
1982	Avions Marcel Dassault	CATIA Version	Product for 3D design, surface modeling and NC programming
1982	AutoDesk	AutoCAD	The leader of CAAD software in 2D and 3D drawings
1982	P-CAD	CADplan	Later the product was purchased by CalComp and renamed CADVANCE
1983	Applicon	BRAVO	First 32-bit VAX based mechanical design/NC system
1985	MicroStation	PseudoStation	Advanced computer-aided design on PC allowed users to view IGDS drawings files without needing Intergraph's software.
1985	Micro-Control Systems	CADKEY	The first 3D PC CAP product
1986	MCS	ANVIL-5000	A 3-D mechanical CADD/CAM/CAE system
1986	AutoDesk	AutoSketch	
1988	Unigraphics	Shape Data Ltd.	For solids modeling capabilities
1988	Acecad Software	Strucad	A high-end structural CAD program
1989	Graphisoft	ArchiCAD	
1990	AutoDesk	Animator Pro	A 2D painting and animation program for DOS
1991	AutoDesk	ArcCAD	Architectural product
1991	AutoDesk	3D Studio	Can be used to create sophisticated animation of AutoCAD drawings
1992	Visio	Visio Technical	An entry-level 2D drawing program

Table 1: Earlier Programs and Companies of CAAD

Since 1990s CAAD systems have been the most powerful tools have ever been used in architectural design process due to the domination of CAAD programs and the wide use of computers. As CAAD packages become easier to use since 1990, CAAD systems become an important factor in the architectural design process. With the rapid development of hardware and software the use of CAAD in design process increases rapidly. The future of computer aided architectural design development focus on using this technology as a medium for the design process and its target is to replace the traditional tools of designing by computers assistant which are related to the development of new technologies in both hardware and software. By reviewing the development process of CAAD systems through the last forty years it can be seen obviously that the next generation of CAAD systems is looking deeper into the use of computer for the design process and the assistant of computers program at the first stage of design where these tools can be used as the main design tools.

2.3.2. CAAD Associations

In 1980's another important event in history of CAAD was the foundation of the associations and organizations which have been established in idea of researching and developing CAAD programs in addition to sharing ideas and experience in this field. All these associations have played a major rule in education and practice of CAAD. The main CAAD associations are, eCAADe (Education and research in Computer Aided Architectural Design in Europe) which was founded in 1983 with a common interest in promoting good practice and sharing information in relation to the application of computational technologies in research and education for architecture and related professions, ACADIA, the Association for Computer-Aided Design in Architecture which was formed on October 17, 1981. , (SiGraDi) Ibero American Society for Computer Graphics which was established in 1995 also CAAD Future which was founded in 1985, and later in 1996, Computer Aided Architectural Design in Asia (CAADRIA) and The European Association for Architectural Education (EAAE) which is an international, non-profit organization, founded in 1975.

2.3.3. Generations of CAAD Applications

Process of developing CAAD systems has been under changing from the beginning of CAAD applications and the rule of using CAAD in architecture has changed according to these changes. CAAD applications can be divided in three generations according to their use. First is the use of CAAD applications as production tools, second is using CAAD software as a design medium and last one is CAAD applications as a communication tools. First generation of CAAD applications were in the 1950s. Due to the limitation of computers' capacities, the aim was to provide tools to help architects to improve the final products "CAAD was introduced in the 1950s to assist designers in assessing the 'goodness' of their creations. Initially, computers were used to assist in engineering analyses". (Yehuda E. Kalay, 1999) Applications were simple and computers capacities were limited due to the lack of technology at that time.

The second generation of CAAD applications starts at the beginning of 1980s, after computers have been used widely. A large number of CAAD applications were developed and the use of computers came to another advanced level that not only as a drafting and production tool but also involving computers in the first stage of the design. In this period the aim was to develop more advanced systems that can help architects in the conceptual stage. Some CAAD applications could provide very powerful tools that allow designers and architects to edit, develop and change the form in three-dimensional environment. In addition to see the final product as it in the reality by adding colors, textures and materials to it.

After architectural design has become a collaborative work the use of CAAD applications changed to another direction. "The globalization of the building industry in the 1990s, coupled with the increasing capabilities of computers as telecommunication devices due largely to the rise of the Internet, brought about the birth of computer-aided collaboration". (Yehuda E. Kalay, 1999) The globalization of the building industry in the 1990s and the improved capabilities of CAAD applications as communication tools caused the use of CAAD applications as a communication and publishing tool. Since 1990s a number of leader CAAD software companies have involved publishing and viewing tools that allow users to view 2D and 3D drawings, details of the drawings, a list of its

elements and animations. These tools also let users share their designs with other designers and clients via email, Web sites, an intranet, and physical media. Autodesk DWF Viewer is an example for these tools.

2.3.4. Two Directions To Develop CAAD

Using computers assistant in the conceptual design process has not improved as quickly as what was earlier in the beginning of using computers within the architectural design. Until now there is no CAAD system that provides complete support and gives all requirements for design process in architecture. However, some design activities are done by assistant of computers but they still limited to what it should be. It is obvious that the future of CAAD will not be as it was in the last two decades. There are other concepts in using these systems to approach the aim that make it possible to use CAAD as a creative tool. The recent researches in this field focus on developing more powerful tools design and other researchers try to set a framework to achieving more advanced uses of computers programs which can help architects and designers in the conceptual design process and exploiting advanced computers techniques.

Hwa-Ryong Lee, 1999, describes two directions of developing CAAD systems and explained the changes in the CAAD research focus. First is developing CAAD as an intelligent system and the second direction is focus on developing CAAD as a design tool. Focus on developing CAAD as thinking systems tries to find new ways to representation design knowledge and principles in computers to solve the problem of the design. In this category computers are thinking machines that include a database can help in solving design problems. So it is a theoretical view. It argues an academic theory about design knowledge, information and architects' perceptive process. Second direction to develop CAAD aims to help architects and designers by providing new tools which make design process more successes that by improving drafting, representation and rendering tools. In addition, improve computers presentation tools such as 3D modeling and virtual reality. Table 1 shows the differences between viewing computers as an intelligent system and as a design tool according to a paper presented by Hwa-Ryong Lee, 1999.

Category	Intelligent system	Design tool
Computer	As a thinking machine	As a design tool
Concept	Computability of design	Usability of computer
Ideology	Rationalism	Pragmatism
Related fields	Artificial Intelligence	Computer Science
Feature	Academic, Theoretical	Commercial, Practical
Design systems	Knowledge-based systems, Expert systems, case-based systems	CAD drafting or modeling programs, Information-management systems

Table 2: Differences between Viewing Computers as an Intelligent System and a Design System (Lee, 1999)

Focus on these two categories has been changed through the past forty years. According to a paper presented by Hwa-Ryong Lee, 1999, the interest in developing computers as an intelligent system and as a design tool have been changed in the level of the interest over four periods, 1960s, 1970s, 1980s and 1990s. In the first period the focus was on developing computers as an intelligent machine and using them as drafting tools was not pied much attention due to the lack of the capacities of computers. During 1970s number of useful programs was available with abilities for planning, evolution and structural design also simple drafting systems become more developed. That caused more focus on the idea of using computers as a design tool and drafting machine. By 1980s hardware was improved and after using computer as design systems succeeded, academic researchers started developing new theories about using computers as intelligent machines and the interest in this field increased.

Last period, 1990s, developing of CAAD software continues and many drafting and representation tools appeared. At the same time, intelligent systems become more difficult. Despite to develop computer languages and drafting technique the intelligent systems for design field have developed slowly. So the interest in viewing computers as a design tool has been given more attention. Figure 3 shows the shift of CAAD researches focus over the forty last years.

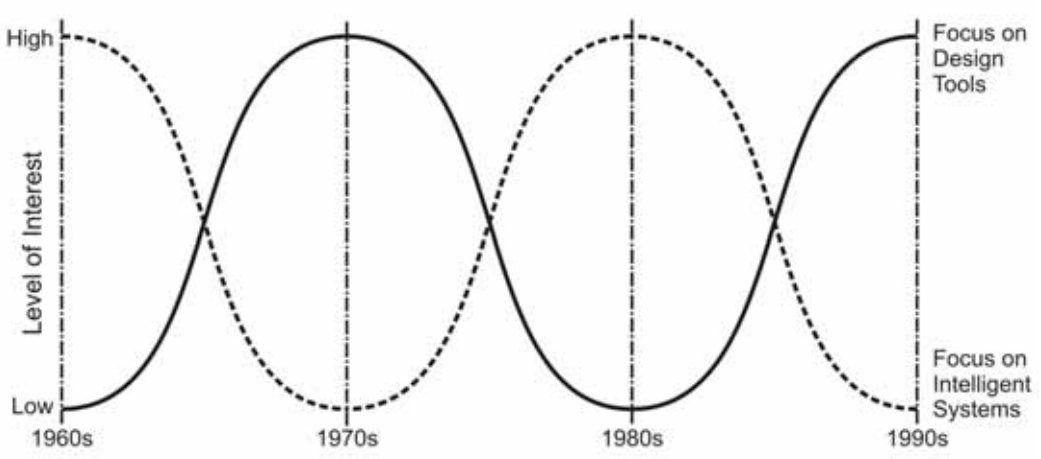

Figure 3: Shift of the CAAD Researches Focus over the Forty Last Years (Lee, 1999)

2.3.5. Purposes of Developing CAAD

Developing of CAAD systems through last five decades has been done according to two purposes. First are scientific purposes and second are commercial purposes.

Scientific Purposes: This includes researches and studies done by CAAD associations such as ACADIA, CAADRIA, eCAADe, SiGraDi, CAAD Futures and EAAE. Also there are the researching centers at computer companies. These associations try to develop CAAD systems and provide suggestions and recommendations to CAAD manufactures to improve CAAD applications.

Commercial Purposes: Regarding to this purposes all hardware and software companies are involving in a competition caused that each company tries to improve its products and provides more advanced productions. Through this continuous competition a number of CAAD applications have been developed.

2.3.6. Future of CAAD Development

Gero, 1987, predicted that intelligent systems would be the core tools in computer-aided design with their ability to automate reasoning through automating inference processes. Other researchers agree with this view and the target of achieving intelligent machines that can think and provide design solutions design was the main aim of CAAD development process. However, most of these researchers have changed their view about using CAAD in

architectural design from only a production and documentation devices to another point of view that argues the use of CAAD as design tools and a medium for the design process and communications tools. Future of CAAD development faces several difficulties which can not solve easily and need a collective work between architects and developers of CAAD systems. Hwa-Ryong Lee mentioned in a paper presented in eCAADe conference 1999 The main difficulties in building a design computational environment result from the combination of many obstacles: the lack of technology; the limitations of computability of design; the incompatible nature between designing and the computer, and so on. Recently, architectural design requires teamwork and the advent of computer networking and the Internet lead to the third generation of using computers in architecture that is using computer networks and internet as a communication tool. One of the most significant issues is the interest of the appropriate design media for supporting the design collaboration, Hwa-Ryong Lee, 1999.

"The important factor about developing CAAD systems is that what we want computers to do for architecture". (Tweed and Carabine, 1999) Answer for this question can be defined by reviewing the possible targets of CAAD developers and researchers which contain several areas of developing CAAD in architecture field which are related to each other strongly. First area is that CAAD as a design medium which focus on developing CAAD application to help architects in the conceptual stage. The second one is developing CAAD as a communication and collaboration tool that allow designers and architects to share their experience and supporting the design collaboration. The other area is the use of computers as automated design machines where CAAD act as an intelligent system that can think and find solutions for the design problems. Final area is that integrating of CAAD systems in architectural education which aim to kept students abreast of constant changes in the new techniques and have the basic knowledge about real world practice which is affected by the new technologies.

2.4. CAAD between Practice and Education

In almost every other field of design, the computer has become an important tool in improving both efficiency and quality. Architectural design has been under changing since using computers software whether as design tools or production

tools. This should be a standpoint in the education process and students should be kept abreast of constant changes in the new techniques and have the basic knowledge about real world practice which is affected by the new technologies. Practice and educate CAAD programs in architectural field has been a common study field which aim to build a foundation for the development of CAAD software. Nowadays, Computer Aided Architectural Design has developed into architectural information and communication technology (ICT), to become commonplace in architectural education. In architectural departments as well as in the professional practice, CAAD is often used just as a drawing tool. Many schools of architecture are using hand made models and hand drawings as a main technique in design education and teaching CAAD as a tool for drawing and representation.

The main aim of the architectural education "is to develop the architect as a generalist able to resolve potential contradictions between different requirements, giving form to the societies and the individual's environmental needs" (UNESCOA, 1996) Architectural education process aims to supports students to understand and know how to deal with architectural problems which they supposed to face in their life. CAAD should be a new tool that used in architectural education to change the traditional ways of teaching depending on the changes in the information technologies in order to improve the abilities of the students in using new technologies and allows them to be in connection with changes in architecture field which has affected by the new technologies. Integration of Information Technology in architectural education is one of the greatest challenges for our professionals and traditional architectural education ways are evolving rapidly and replacing by new technology tools.

The primary uses of computers in architectural practice and education have been changing, over the past four decades, from the evaluation of proposed drawing and drafting, to another proposes which are more advanced use by integrate them in the design process itself, and more recently to facilitating collaboration among the various professionals who are involved in the design process. Architectural educators looking for more advanced CAAD curriculum and upcoming researches focus on use of computers as an environment for the education.

CHAPTER THREE
CAAD IN EDUCATION AND RESEARCHES

3.1. Evaluating CAAD in Architectural Education and Researches

Recently, CAAD and other digital applications have been the most powerful drafting, representation and design tools available to architects and designers. Due to the fact that education and practice are very connected to each other and there is no possible to separate them, each one has its effects on the other, architectural researchers and educators are trying to involve CAAD and other digital media applications in architectural education the aim is to form a fundamental framework to achieving a success integration of computing and CAAD methodology in architectural curriculum.

In recent years, there have been different approaches and experimental developments concerning integration of CAAD and IT in architectural education. Researches and studies presented in conferences held by architectural schools and other architectural platforms, such as ACADIA, CAADRIA, eCAADe, SiGraDi and CAAD Futures, have been made with the purpose of approaching an ideal integration structure of CAAD education. Architectural schools and departments have introduced CAAD in the design studio and some digital applications (e.g. digital communication tools, desktop publishing, Web page publishing, digital presentations tools) in the education schedule. The goal is to develop student's knowledge further in the field of CAAD, improve students' skills in using CAAD and other digital applications in the design activities and inform students of up to date CAAD and digital media applications.

This chapter tries to evaluate the current situation of teaching CAAD and other digital applications in architectural education by; firstly, reviewing the related researches concerning CAAD usage in architectural education and then evaluating the present situation of teaching CAAD in architectural schools.

3.2. CAAD in Architectural Education Researches

Researches and studies in CAAD implementations in architectural education are contingent upon development of CAAD applications. These researches cover all possible usage of CAAD in education. At the beginning of 1980's a number of platforms such as ACADIA, CAADRIA, eCAADe, SiGraDi and CAAD Futures were established to fill the gap of researches and studies in usages of computers in architectural practice and education. Aims of these associations is to promote researches and teaching in CAAD which enhance the use of computers as creative tools rather than production tools and sharing information and experience in relation to the use of computers in research and education in architectural practice and education. Conferences hold by these association aims to developing new theories and concepts in the use of computers in architecture and integrating new technologies in architectural education. Figure 4 shows the categories of CAAD researches and the percentages of papers presented in each category. This figure was presented in study carried by Fevzi Ozersay and Peter Szalapaj in the 17th eCAADe conference, 1999; the study includes 422 selected abstracts from eCAADe, ACADIA and CADRIA.

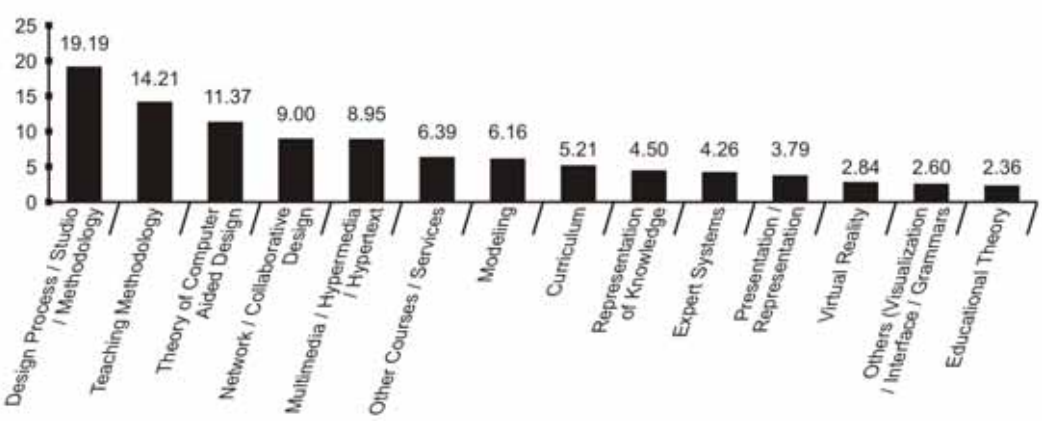

Figure 4: The Categories of CAAD Researches and the Percentages of Papers Presented in Each Category (Ozersay and Szalapaj, 1999)

Table 4 shows a distribution and percentage of researches in the field of computers usage in education (Ozersay and Szalapaj, 1999)

Category	Number of papers	Percentage (%)	Usage Level
Design Process / Studio / Methodology	81	19.19%	Lower
Teaching Methodology	60	14.21%	
Theory of Computer Aided Design	48	11.37%	
Network / Collaborative Design	38	9.00%	
Multimedia / Hypermedia / Hypertext	34	8.05%	
Other Courses / Services	27	6.39%	
Modeling	26	6.16%	
Curriculum	22	5.21%	
Representation of Knowledge	19	4.50%	
Expert Systems	18	4.26%	
Presentation / Representation	16	3.79%	
Virtual Reality	12	2.84%	
Others (Visualization / Interface / Grammars	11	2.60%	
Educational Theory	10	2.36%	Upper
Total	**422**	**100%**	

Table 3: Distribution and Percentage of Researches in Ccomputers Usage in Architectural Education (Ozersay and Szalapaj, 1999)

According to this study about 97% of the researches are about education activities and teaching architecture by the assistant of computers especially in design process which aim to change the traditional ways of teaching in a parallel way with the changes in the information technology; and to improve students' skills in using CAAD programs in such way that help them in the conceptual design stage and kept them abreast of constant changes in the new techniques and to prepare students for their future in the job market. On the other side, only 3% of these researches related directly to education theories which try to make a framework and theoretical concepts for the architectural education process with computers assistant.

"If we are to conclude about the research on computer usage within architectural education, we can say that there is a high tendency of attempting to apply computers to the realization of the aims and objectives of architectural education, but a lower tendency towards exploring the importance of computer technology in defining these aims and objectives" (Ozersay and Szalapaj, 1999).

3.3. Teaching CAAD in Architectural Schools

In almost every other field of design, the computer has become an important tool in improving both efficiency and quality. Computers and new technologies have changed the way of architectural design since using computers software whether as design tools or production tools. Architectural education process has also affected by this fact and new technologies are changing the rules of this process. Teaching architectural design skills and principles have been changed since computers have involved in the architectural education. The influencing of IT and CAAD systems in architecture field are affecting the rules of architectural education. Traditional architectural education tools mainly based on two ways, first is using 2D sketches and second one is using real 3D models. This situation has been changed through the last three decades and computers technologies have been involved in the education process to replace traditional tools of teaching at least in the three last years of the educational schedule.

Recently, integrating complete CAAD system that can support the education of architecture was the main subject of educators and researchers of architecture. The main aim of this process is to use CAAD applications as a tool for design and improve students' skills and abilities in using this technology. Until now there is no framework and fundamental structure for this use of CAAD in architectural education. However, most of architectural schools and departments especially in developed countries have developed there own way of using CAAD in there educational schedules. The perfect CAAD system for education, according to Christopher Tweed and Brendan Carabine, 1999, would facilitate the leap of understanding students must make if they are to relate their imaginings to the physical realization of a building. Such a system would need to be capable of demonstrating the full breadth of experience a design proposal might yield, not just its visual appearance. The main objectives of integrating CAAD in architectural education can be summarized as following:

- Providing a general survey of the essential concepts and applications of computer aided architectural design (CAAD) in architectural education and practice.

- Improving students' knowledge in CAAD and its utilities in architectural design and professional practice and exploring the Information Technology and CAAD Applications.
- Teaching students the use of computers in architectural design and how to use this technology to improve their thoughts.
- Developing students' experience in CAAD and improve their skills practically in using this tool in both design and presentation.
- Improve students' works in collectivity way by using new technology as a communication medium which allows them to share their ideas.

These benefits of CAAD systems to architectural education have been improved through a long term since mid of 1960's. At first the aim was to provide the basic principles of computer application and after the developed systems and application the objectives of teaching and involving CAAD into architectural education have changed and move forwards to another level that aim to allow student to use computers as tools for design and recently more advanced proposes is that using new technologies as communication tools to support the celebrative work and sharing knowledge and experiences.

Through the last four decades teaching CAAD at architectural schools have been under developing and still. The first steps were very sample by providing independent CAAD lectures. After that with assistant of the improved new technologies schools could include more advanced CAAD application and enlarge the use of CAAD in curriculum.

3.4. Changing in Rules of Teaching CAAD

Through the last four decades, teaching CAAD in architectural schools has changed according to the development of new technology and the utilities that CAAD applications provide to support the education process. These changes can be divided into three major periods, first is using CAAD applications as representation tools to support the final products of the students. The second period start around the mid of 1980's when several architectural schools and departments, especially in developed countries, start integrating CAAD

application in design studio as a medium of the design process, since the mid of 1990's another use of CAAD systems and new technologies have been appearance due to the advanced digital applications which were available in the market as a result of the commercial competition of the companies and the new hardware capabilities. This is more advanced and attractive use of CAAD and IT systems which discusses the use of these technologies as tools for the whole education process and using these tools to support the collaborative work.

3.4.1. First CAAD Lectures

The first CAD lectures that introduced in architectural education were in format of small support CAD-courses. In fact the CAD curricula has yet been established and computer programs used in that time were known as CAD not CAAD, "the main difference between them is that CAAD provide the architect's professional needs in architectural design not just computer engineering". (Penttilä. 1996) Due to the limitation of software available at that time and the lack of technologies, CAD lectures were taught in such way that allows students to learn the basic principles of CAD application and the use of this tool in drafting and representation. CAD applications were taught independently without any relation to other courses (Figure 5). The architectural education mainly covers the following subjects:

- Architectural design principles.
- Constructions and materials.
- Public buildings services.
- Housing and urban planning.
- Architectural history and architectural theories.
- Computer programs.
- In addition to support lectures such as art drawings, languages, mathematics and physics, surveying, descriptive geometry.

In this period the influence of CAD education was depends on teachers' personalities and experience in CAD applications. As a result, CAD has yet played any important rule in the architectural education and design activities.

Computers were only helpful in some cases such as drafting and representation and yet has involved in the conceptual stage of the design process.

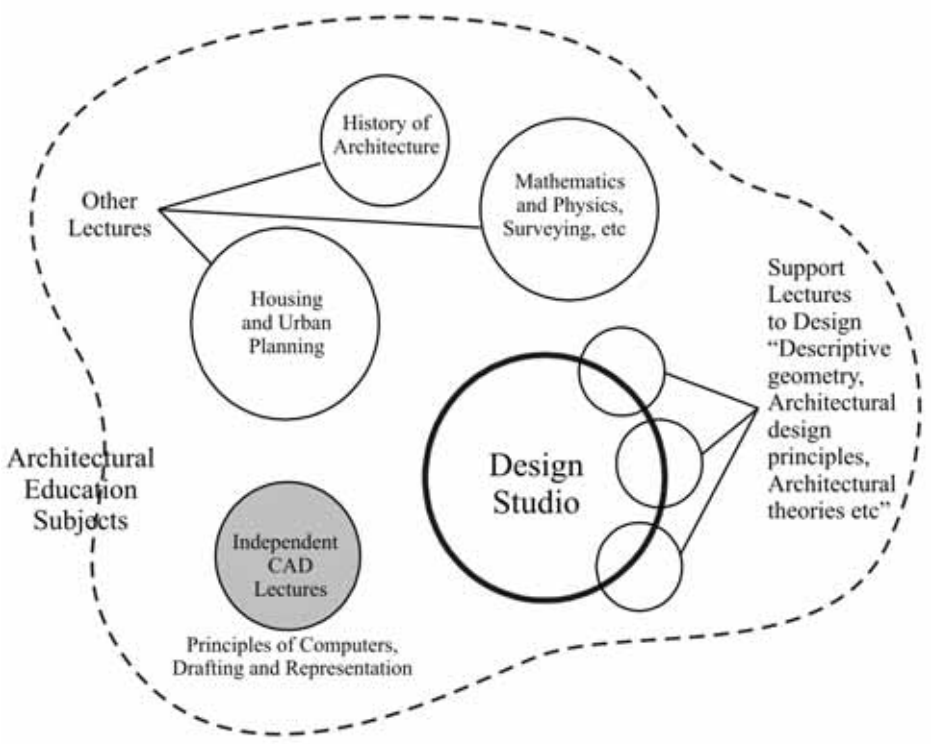

Figure 5: Architectural Education Subjects and CAD Lectures Relation in the First Era of Introducing CAD in Architectural Education

3.4.2. Second Period of Teaching CAAD

Since personal computers (PC) were introduced in the market widely by IBM corporate, in 1981, using CAAD application start to be wider and success in the architectural practice and the evolution of CAD education proceeded too. This is the second period of teaching CAAD in architectural schools which start at the beginning of 1980s. In this period the use of computers in architecture field has become more specialized and CAAD has been regarded as the definition of computer programs that use in architectural practice and education. Characterize to this era, many architectural schools and departments have concentrated into CAAD systems as an architectural medium for the design process rather than only general computing machine.

To approach such aim researchers and educators have introduced CAAD applications in the design studio and CAAD has been taught as a general design tool. Students were supposed to learn CAAD in such way that allows them to use

this tool in the conceptual design stage at different levels. The typical CAAD curriculum that architectural schools and department have included in the education process, as Hannu Penttilä mentioned in a paper presented in eCAADe conference, 1996, mainly consist the following subjects:

- The basic of architectural computing.
- Drawing with CAAD.
- Modeling with CAAD.
- CAAD-based design projects.

Although, the use of CAAD as a design tool has become a basic subject for some architectural schools, the result was limited by hardware, software and operating systems that were available in this period. Figure 6 shows the relationship between architectural education subjects and CAD lectures in this era.

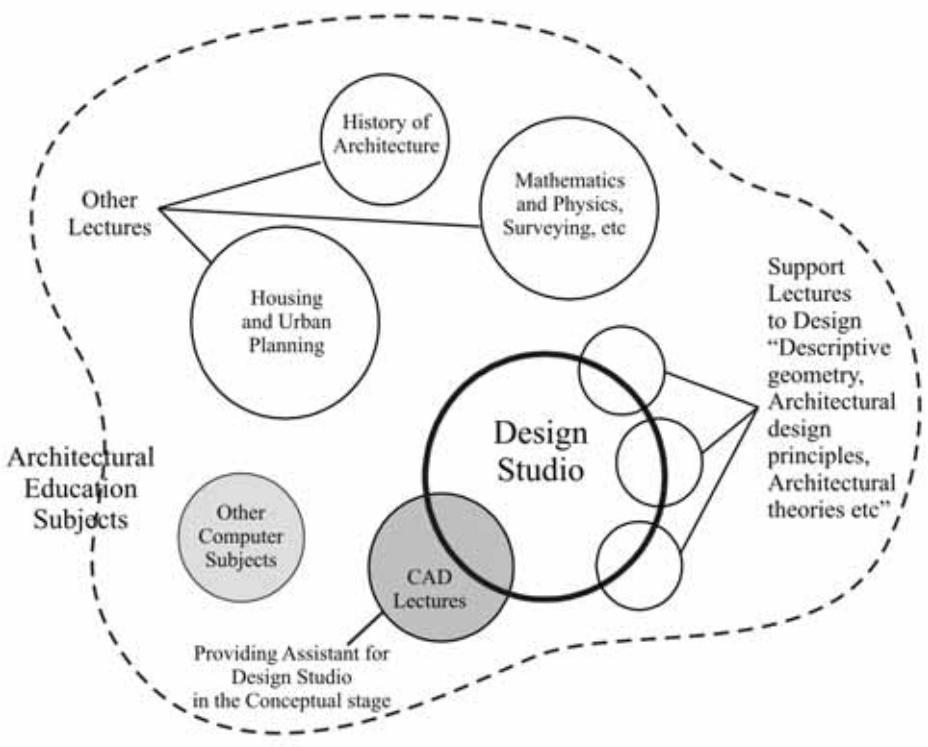

Figure 6: Architectural Education Subjects and Using CAAD as Assistant Tools for Design Studio

3.4.3. Third Period of Teaching CAAD "CAAD Curriculum"

The increasing capabilities of computers as telecommunication devices in the 1990s, coupled with the developed CAAD applications lead to another level of using CAAD in both architectural practice and education not just as drafting and design tools but also as communications tools that support the collaboratively. In this era additional topics related to the new technology have been introduced in the education process such as the general skills of computers, image processing, communications tools, publishing tools etc. The aim was to get the full advantages of digital applications and to inform architectural students of up to date digital applications.

To give more understanding of characterizes of this era here is a world-wide study including 106 universities across curriculum of architecture in seven countries which was done by QaQish and Hanna, 1996. The study tried to evaluate computer utilization by architecture schools with regard to the curriculum structure. The study examines CAD use in architectural education in terms of its utilization across the curriculum in six areas of analysis. First area examined the importance of the role of CAD in architectural curriculum in twenty six areas of architecture; second one examined the use of software in CAD courses. The third area examined whether there are any differences in attitudes and perception between the Gender of CAD tutors towards the importance of CAD labs' proximity to the design studio. Fourth area examines the total hours of training for each course and as a whole. The fifth area investigated the importance of CAD labs' proximity to the design studio. The last area explored the use of software in CAD courses on a scale of low use and high use.

On the role of CAD in the twenty-six areas of architectural education the study indicates that CAD plays an important role in the design courses and in the presentations of projects which presented in figures 7 and 8 shows the most used CAD programs in architectural education.

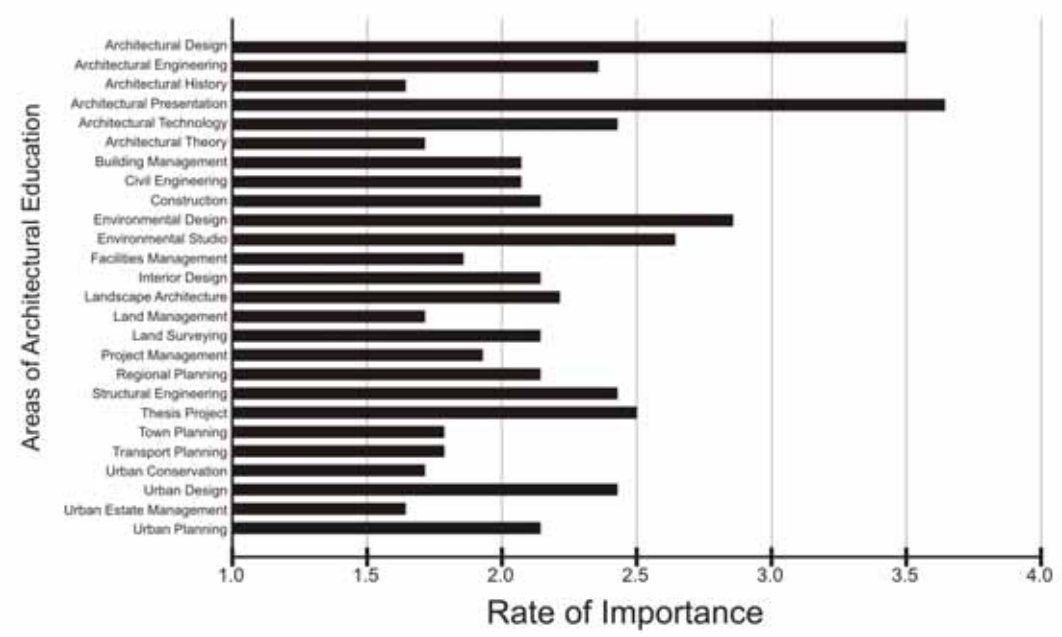

Figure 7: The Mean Rating of the Role of CAD Importance (QaQish and Hanna, 1996)

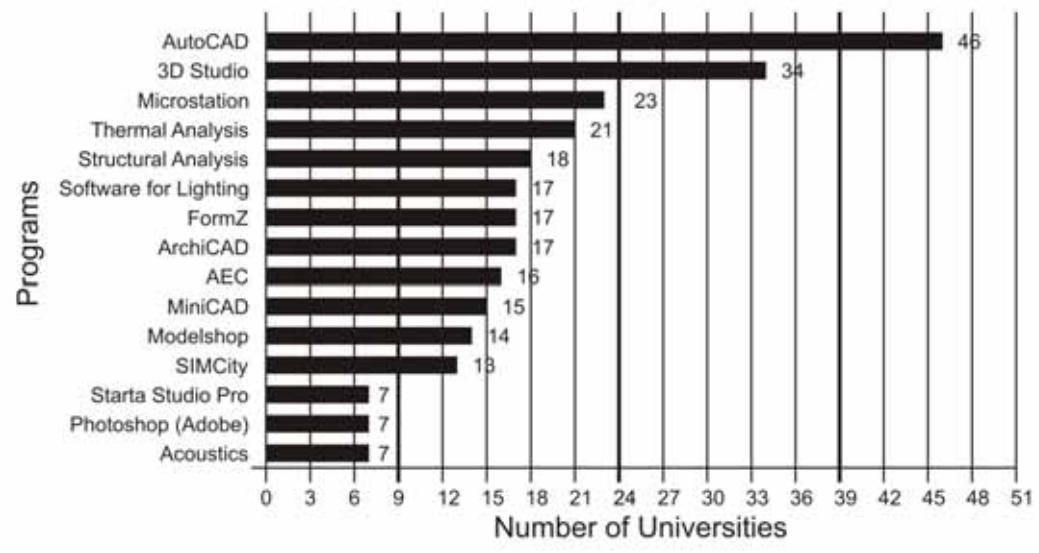

Figure 8: The Highest 15 CAD Software Used World-Wide (QaQish and Hanna, 1996)

In terms of integration CAAD in architectural curriculum the results of this study shows that there is a strong trend to integrate CAAD programs and new technologies in the curriculum and most of the school have future plans to develop CAAD use in architecture education. 92.15% of the architectural schools have introduced CAD course into the curriculum, compared with only 7.9% which have not. Figure 9 shows the count of universities which have introduced CAAD courses in curriculum.

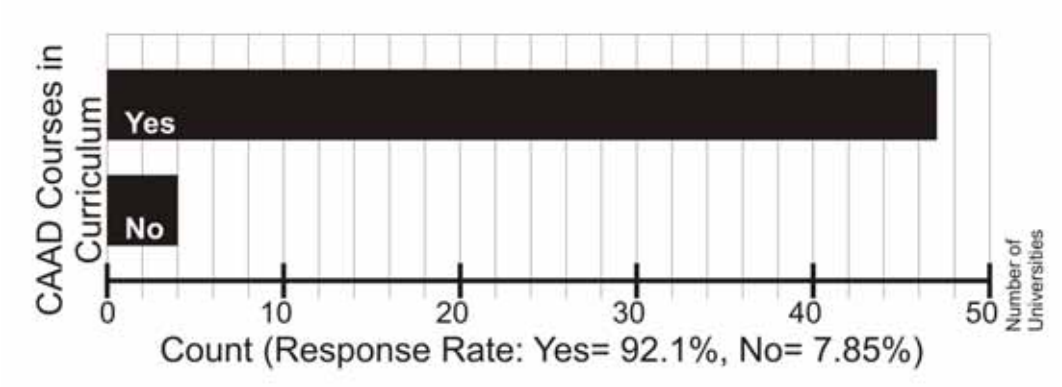

Figure 9: CAD across the Curriculum (QaQish and Hanna, 1996)

With regards to training hours 12 respondents indicated that their students receive an average of 100 hours of training. While 14 respondents offer 59 hours of training to their student, only 5 respondents offer more than 200 hours of training. As shown in figure 10, universities in the USA offer approximately as many training hours as the Sweden. Whereas, some of the UK universities also offer higher training hours but half of that offered by the Sweden.

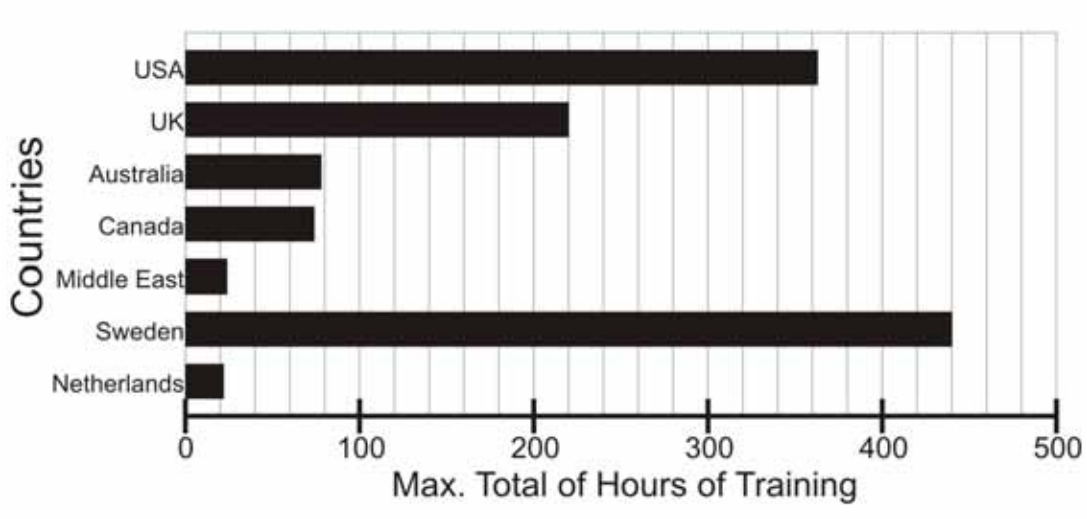

Figure 10: The Max. Distribution of the Total Hours of Training in Architectural Curriculum across Seven Countries (QaQish and Hanna, 1996)

With regards to the importance of CAAD laps in design studio the analysis revealed that 49.0% felt that CAD labs proximity location to the design studio was essential for better CAD integration. While 27.5% felt that it was very important, only 2% felt it was not important to have any relationship between the two. Figure 11 shows the importance of design studio proximity to CAD labs.

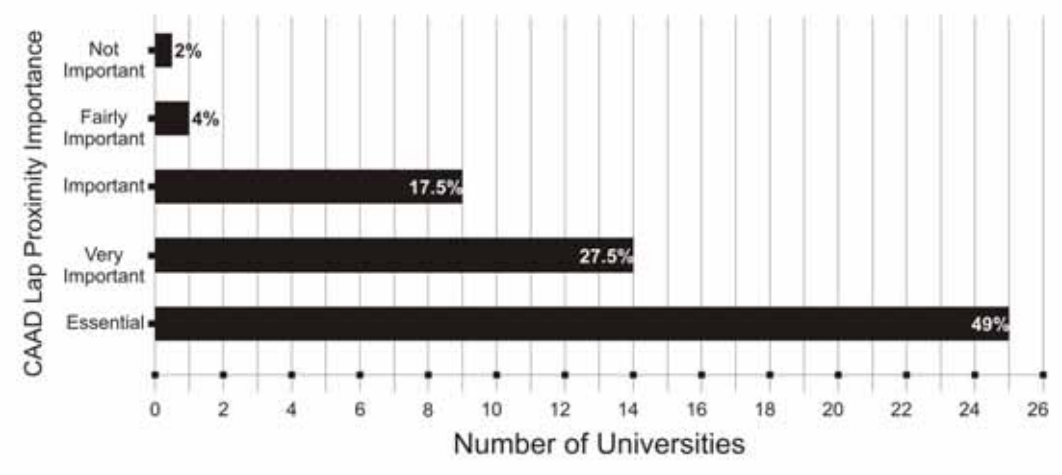

Figure 11: The Importance of Design Studio Proximity to CAD Labs (QaQish and Hanna, 1996)

The most significant findings of this study are:

- CAD users accounted for 42.63% compared with 57.37% who are conventional method users.
- 92.15% of the architectural schools have introduced CAD course into the curriculum, compared with only 7.9% which have not.
- 9.8% indicated interest in introducing and improving CAD in the future compared with 3.9% who have not.
- The Netherlands has the oldest CAD program with a mean age of 34 years compared with both the USA and Israel with 28 years of age. Sweden and Australia have the youngest CAD programs age group amongst the seven countries.
- The age of CAD employment in the curricula of architecture schools ranges between 1 to 34 years old.
- Both architectural design and architectural presentation areas reported the highest mean of approximately 3.4 indicating an important role of CAD in design courses and in the presentation of projects
- The majority of the universities has CAD program aged about 13 years, a slightly more than a decade, with only one university aged 35 years.
- 12 respondents indicated that their students receive an average of 100 hours of training. While 14 respondents offer 59 hours of training to their student, only 5 respondents offer more that 200 hours of training.

- With regard to the CAD platforms in the department, 45.5 % of all the platforms were IBM or Compatible which mark them as the mot widely used platforms. Second one is Macintosh platforms with 22.7%. Power Mackintosh Platforms came in third pace with 14.4% and Workstations ranked fourth with 11.0%.
- With regard to the overall extent of CAD software use world-wide, the use and performance of CAD software under high extent was examined. The results revealed that the highest response rate was reported in Form Z (58.8%), followed by AutoCAD (45.7%), 3DStudio (32.4%), AEC (31.3%), ArchiCAD (29.4%). Once gain, From Z reported high results under above average use with a 35.3%).
- The numbers of CAD tutors or instructors reported by the respondent reached a sum of 55. % for part-time instructors and 45.0% for full-time ones
- The analysis of the results revealed that 49.0% (25 respondents) felt that CAD labs proximity to design studio was essential for better CAD integration. While 27.5% (14 respondents) felt that it was very important only 2% (1 respondent) felt it was not important to have any relationship between the two. It is concluded that the design studio proximity from CAD labs is extremely important to successfully teach CAD.
- With regard to 'virtual-reality', only 31% reported to have employed it in the curriculum, whereas 69% responded that they have not.

This development in CAAD education and the experience through years lead to another advanced CAAD education system. This system includes more success use of CAAD in curriculum which focus on using this tool in the whole education and integrating CAAD into education process.

3.5. Current Situation of Teaching CAAD

The use of CAAD in architecture education has developed rapidly in the recent years. Today, the majority of universities around the world have introduced CAAD systems in their curriculum schedule especially in developed countries. The present use of CAAD in architectural education is mainly focused on,

representation, communication of ideas and final production. However, the primarily method of design in architectural schools is that the use of pencil and paper to assist the early conception of ideas. To evaluate the current situation of teaching CAAD in architecture schools with regard to the curriculum structure here are two studies about teaching CAAD at architectural schools. First one is a study about European universities which was done by Hannu Penttil carried out among 180 European schools of architecture in more than 30 countries during 2002-2003. Second one is a Libyan case study which examines CAAD teaching in University of Derna and contains a questionnaire for students to identify students' components in using CAAD programs and general level of students in CAAD lectures.

3.5.1. European Case

This study was presented by Penttilä Hannu as a post-graduate study carried out among 180 European schools of architecture in more than 30 countries during 2002-2003. The purpose of this study is to describe the role of "modern digital information technology" and to give an overview about ICT and CAAD in European architectural schools.

3.5.1.1. Objectives of the Study

The main questions of this study are "how widely the digital media, tools and methods have been adopted in the education? In what ways information technology is utilized in architectural education of our age, what kind of changes the digital media in fact has caused to the architectural working and educational environments" (Penttilä, 2003). Regarding to these questions the study investigates in which ways information technology is used, the most hardware in use and software in use.

3.5.1.2. Results of the Study

The results of the study are available on the web at http://www.arkit.net. In terms of major hardware platform used in European schools the study indicated that the must used platform is PC/Windows (90-95 %), while Linux and Unix are also used very commonly (25-35 %). Macintoshes are widely used within the architectural discipline (50-55 %) as presented in figure 12.

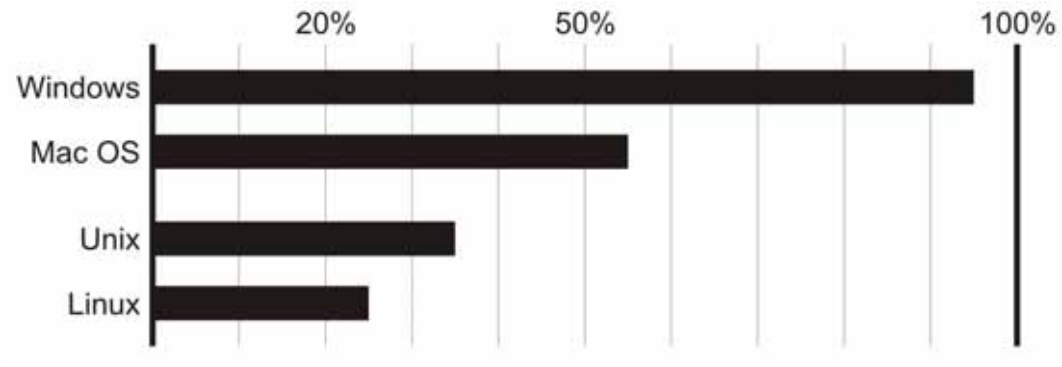

Figure 12: The Major Hardware Platform Used in European Schools (Penttilä, 2003)

The common software platforms used in curriculum is MS/Office (90-95 %) and PhotoShop (85-90 %) while the commonly graphic tools are PageMaker, QuarkXpress, Illustrator and FreeHand with (30-50 %) volume share. Figure 13 shows the percentage of must used platforms in European schools.

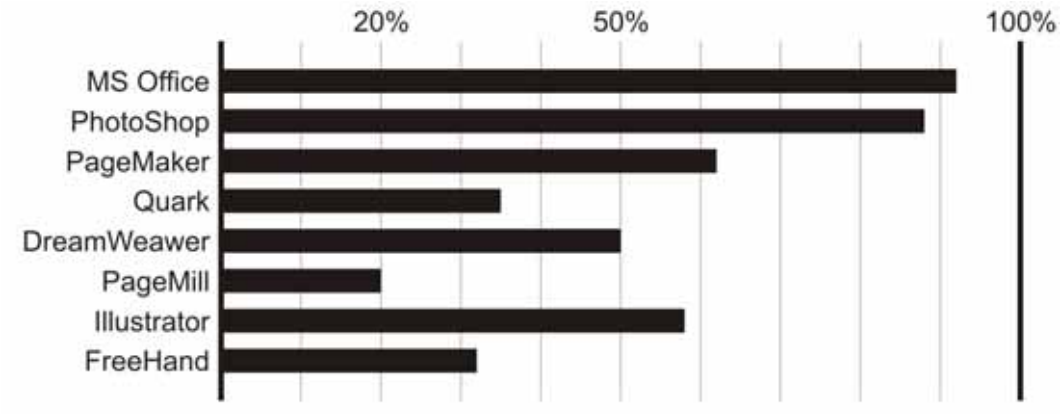

Figure 13: Institutional Software Used in European Schools (Penttilä, 2003)

With regards to the institutional CAAD application the study shows that AutoCAD is the major CAAD application used in education followed by ArchiCAD also MicroStation has a remarkable volume (Figure 14). On the other side the widest 3D modeling application that used in European architectural schools is AutoDesk's 3DStudio with (80-85 %), followed by formZ (35-40 %), then Rhino (15-25 %) and Maya, Alias, Lightscape and Radiance with 15-25 % volume share (Figure 15).

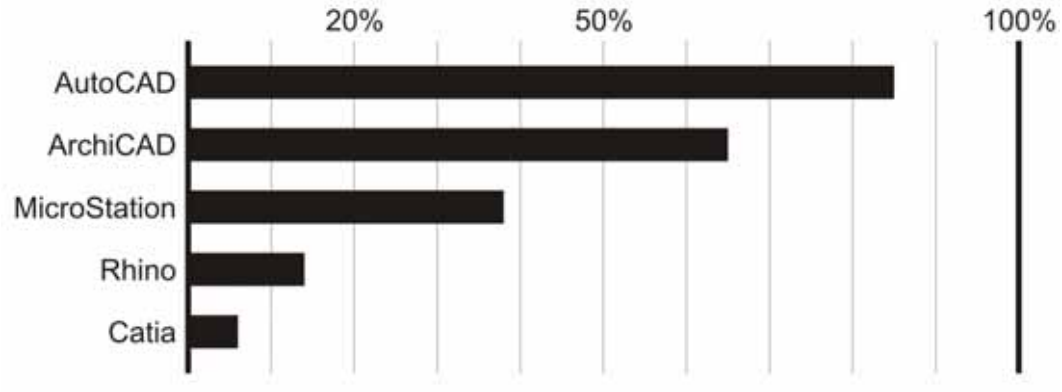

Figure 14: Institutional CAAD Software Used in European Schools (Penttilä, 2003)

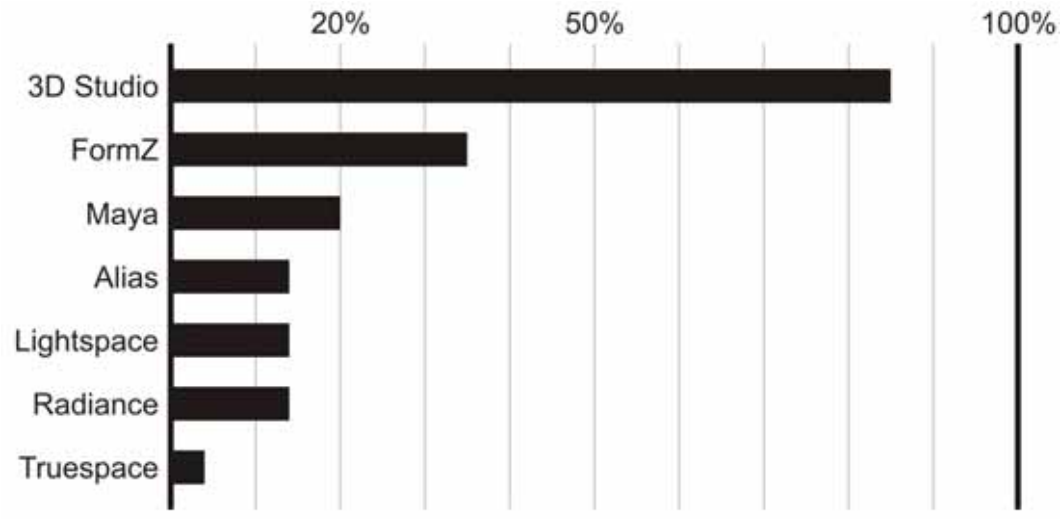

Figure 15: Institutional 3D CAAD Software Used in Education (Penttilä, 2003)

Figure 16 presents a comparison of institutional 2D CAAD software that used in Europe and the World universities. This comparison includes 28 European universities and 16 World universities. In two cases AutoCAD is the most used CAAD software in both Europe and the World. Whereas, in the comparison of 3D CAAD software in Europe and the World the study indicates that the widest used software is 3D Studio in two cases followed by FormZ and Maya (Figure 17)

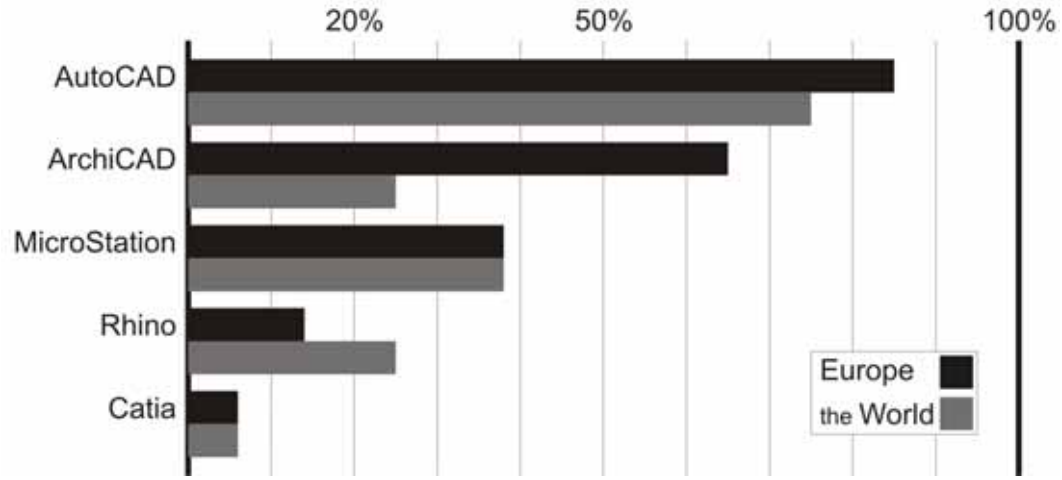

Figure 16: Comparison of Institutional CAAD Software Used in European Schools and the World (Penttilä, 2003)

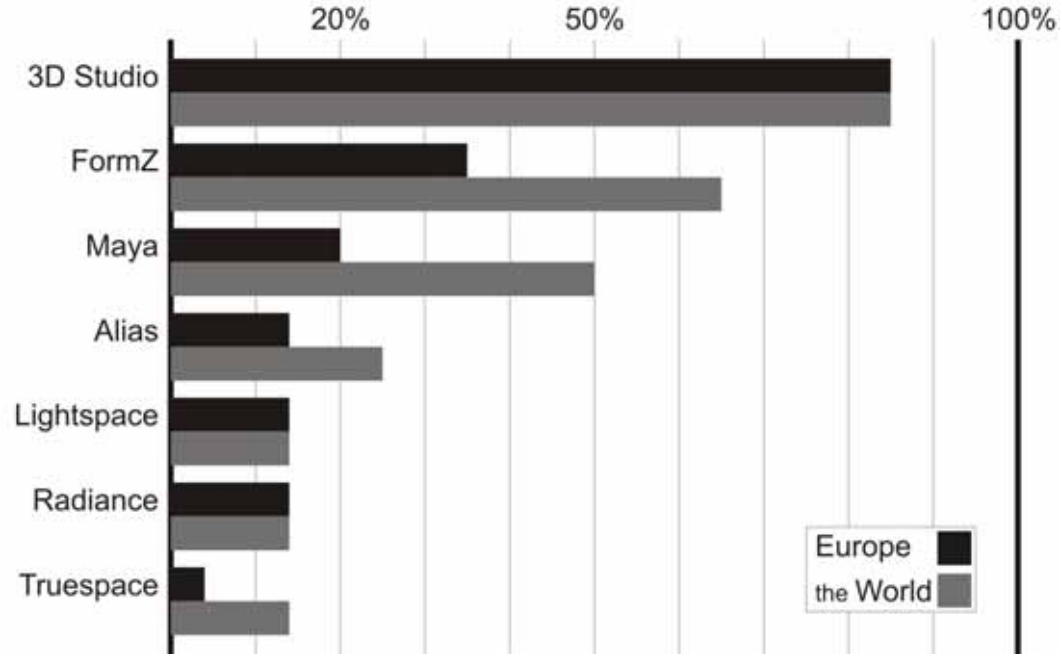

Figure 17: Comparison of Institutional 3D CAAD Software Used in European Schools and the World (Penttilä, 2003)

The other main results from this survey can be concluded in following points:

- Architectural CAD (CAAD) is taught as separate courses and in larger CAAD-curriculums, but based on a web-study, the better integration of CAAD with schools' "traditional" architectural planning and design education should be considered more.

- The invisible ICT-use, “every day use of ICT”, low-level IT-activity – such as writing, emailing and web-browsing - has obviously a lot more volume than documented or expected – and in the future even more so! The every-day ICT-use is usually carried out without any help or instructions, and it is very self-organized. Students teach other students, and it is also done outside the schools: at home, in the libraries, in net-cafes etc.
- A vast majority of the schools (95%) do have a web-site, though some just do have a single page.
- Part-time teaching seems also to be very common (30-40% full-time staff, 70-80% part-time staff). Schools’ IT/CAAD and new media staff is approximately 5% of the staff.

The use of IT and CAAD in European schools has developed rapidly lately, also digital communications such as email, numerous web-based tools, constantly evolving web-sites and logbooks have also improved in use. European architecture schools are technically quite well equipped, but the overall understanding of new media and its integration to schools’ educational curriculums are perhaps not so positive than expected.

3.5.2. Libyan Case “University of Derna”

The aim of this study is to evaluate the way that CAAD software is being taught in Libya and to define the level of the students and their competence in using CAAD programs during the study. This study explored CAAD teaching in architecture schools in Libya by examining the utilization of CAAD across the curriculum of architecture in University of Derna.

3.5.2.1. Background

University of Derna was established in 1991 in Derna city. Art and Architecture faculty is one of the main faculties in the university. In the architecture department the education program for undergraduate students contains five years. In the first year students have to take courses in general education in addition to design bases in the first semester and design studio in the second semester of the first year. The other four years cover both designers and

building engineers. With regards to CAAD courses only AutoCAD is introducing in the education program as an independent lecture in fourth and fifth years.

3.5.2.2. Study Structure

The study contains two parts. First part gathered general information about teaching CAAD in architectural department. This part investigates on some important issues of teaching CAAD which include CAAD software used in courses, platforms, number of tutors, total time of CAAD training and the method of teaching CAAD in the department in addition to relationship between CAAD courses and design studio. Second one contains a questionnaire (see the appendix) for students to identify students' components in using CAAD programs and general level of students in CAAD lectures.

The questionnaire survey divided into three groups of questions, first group explored competence of students in using computer in general and consisted of three questions as following:

- How is your knowledge about using computers?
- How do you can manage files on computers (copy, move, delete, etc)?
- How is your knowledge about installing and uninstalling software?

Second one is about competence of students in using CAAD programs and the level of students in using CAAD in both 2D and 3D drawings in addition to students' experience in CAAD programs and if they have used CAAD in their projects or not neither in design nor representation. This group contains the following questions:

- How do you evaluate your usage of CAAD programs in 2D drawings?
- Your abilities in drawing curved objects in 3D drawings?
- Which programs from followings do you have an experience about?
- Have you ever used CAAD programs to represent your projects?

Last group of the questions aims to define the difficulties of CAAD lectures and how students get advantages from these lectures. The group include following questions:

- Do you think the time of CAAD lecture is enough?
- How do you think CAAD programs are easy to learn?
- How is your level in CAAD lecture?
- What is the best advantage that CAAD software provides?
- Have you improved your abilities by using CAAD software?

3.5.2.3. Results of the study

- **First Part**

The study indicates that CAAD lectures are included in curriculum as separated lectures and no relation between CAAD courses and other lectures especially design studio. Moreover, study shows that Microsoft Windows is the used platform in computer lap and AutoCAD is the only CAAD software that included in curriculum which provided in forth and fifth years. The overall time training that students receive in AutoCAD course is approximately 70 hours (2 hours a week).

With regards to CAAD tutors or instructors the study shows that there is only one teacher in the department and the university does not offer CAAD training to tutors on new software and self taught and on demand were reported to be the most frequently used method in learning CAAD software. Regarding to the method of teaching CAAD in the department the study indicates that in AutoCAD lecture students are asked to draw only in 2D and they learn how to draw sample drawings while 3D drawings are not include in the lectures.

- **Second Part**

The second part of the study which contains a questionnaire aims to define the general level of students and their abilities in using CAAD software. About 26 students have participated in this questionnaire; eight students from the fifth year

and the rest of them are from the fourth year. Table 4 shows the results of the questionnaire.

Group of Questions	Questions	Answers		
Students Competence in Usage of Computer in General				
	How is your knowledge about using computers?	Bad **31%**	Medium **43%**	Good **26%**
	How do you can manage files on computers (copy, move, delete, etc)?	I Cannot **8%**	Hardly **39%**	Easily **53%**
	How is your knowledge about installing and uninstalling software?	Bad **21%**	Medium **27%**	Good **52%**
Competence in CAAD Programs Usage				
	How is your level in using CAAD programs in 2D drawings?	Bad **69%**	Medium **21%**	Good **10%**
	How is your level in using CAAD programs in 3D drawings?	Bad **82%**	Medium **18%**	Good **--**
	Which programs from followings do you have an experience about?	AutoCAD **47%**	3D MAX **--**	No Thing **53%**
	Have you ever used CAAD programs to represent your projects?	Yes **13%**		No **87%**
Difficulties of CAAD Lectures				
	Do you think the time of CAAD lecture is enough?	Not Enough **70%**	Enough **30%**	More Than Required **--**
	How do you think CAAD programs are easy to learn?	Easy **43%**	Medium **40%**	Hard **17%**
	How is your level in CAAD lecture?	Low **47%**	Medium **53%**	High **--**
	What is the best advantage that CAAD software provides?	Precision **58%**	Decreasing Time **21%**	Exp. Form on Screen **21%**
	Have you improved your abilities by using CAAD software?	No **8%**	Not Enough **58%**	Yes **34%**

Table 4: Results of the Questionnaire of Architectural Department's Students at University of Derna

3.5.2.4. Analyses of the Study

The most significant findings of this study which can be concluded from the analysis of this survey are:

- With regard to the CAD platforms in the department the platforms were Microsoft Windows and the only CAAD program that included in the curriculum is AutoCAD.
- Students receive an average of 70 hours of training (two hours a week) through the academic year and students can not have enough practice on CAAD software.
- The numbers of CAD tutors or instructors are not enough at all. In the architectural department there is only one teacher who teaches AutoCAD.
- The method of design and presentation in the department is by traditional ways (pencils and papers). Students do not learn how to use CAAD in design and representation.
- Results from the first group of the questions indicate that most of students can easily deal with computers. About 80% of the students have enough knowledge about using computers and dealing with this technology. Figure 18 shows the mean level of students in using computers in general.

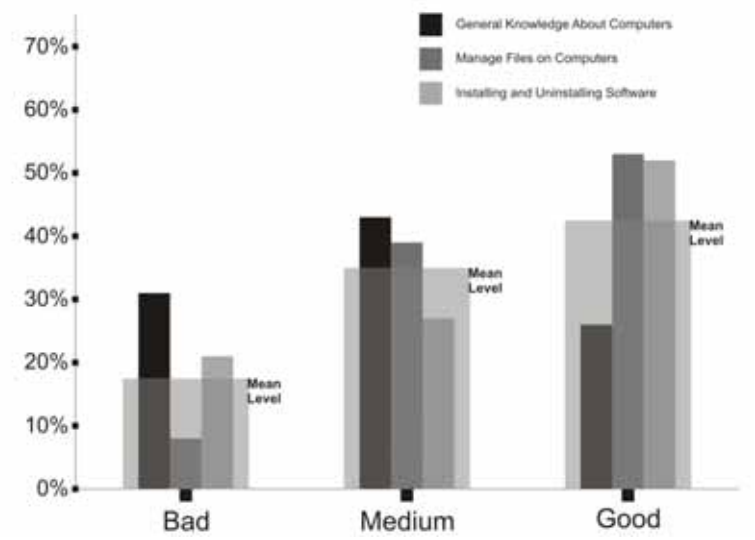

Figure 18: Mean Level of Student's Competence in General Use of Computers

- Figure 19 shows the abilities of Students in using CAAD in both 2D and 3D drawing. Only 10% of the students felt that their level is good in 2D drawings but they do not have experience in 3D drawings. In general, the mean level of students in 2D and 3D is very low.

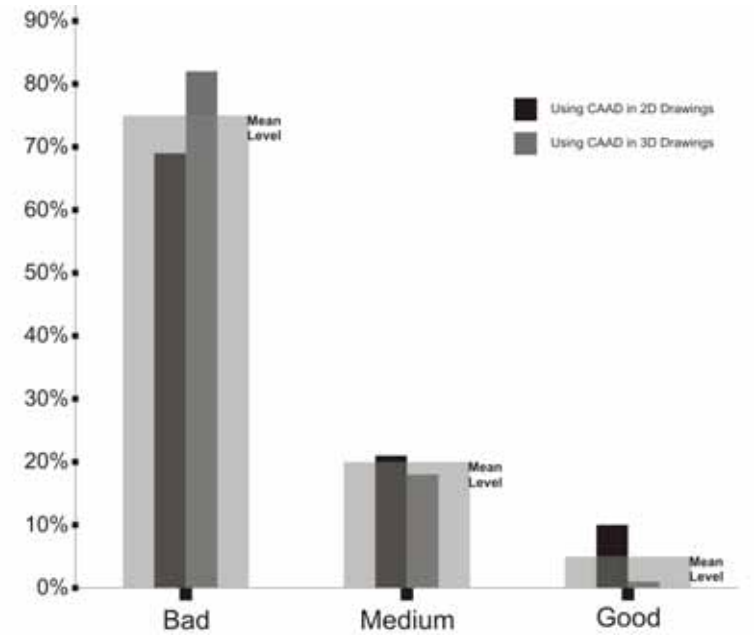

Figure 19: Mean Level of Student's Competence in Using CAAD in 2D and 3D Drawings

- With regard to the time of training most students felt that time was not enough and about 30% said that it is enough as provided in figure 20. However, when they were asked to evaluate their level in CAAD lectures about 55% said that it is medium and the rest of students felt that it is not good. Figure 21 shows the level of students in CAAD lectures.

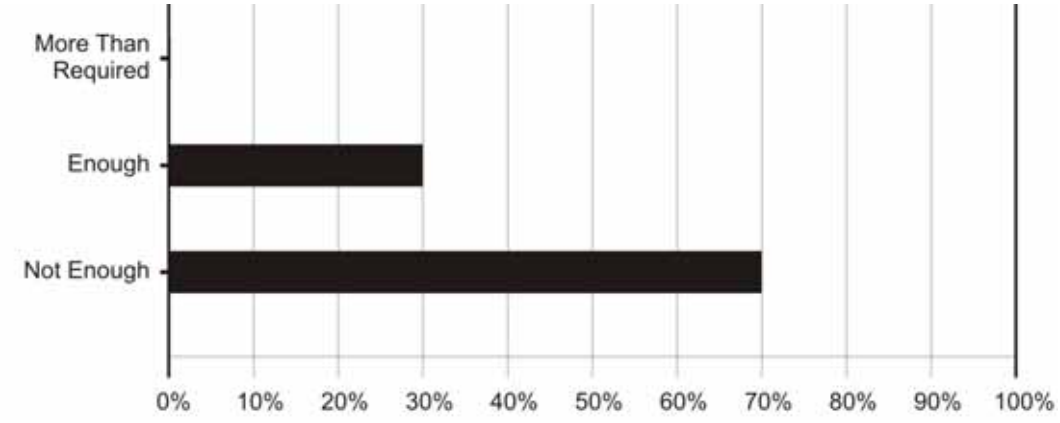

Figure 20: Student's Opinion about Total Hours of Training in CAAD Courses

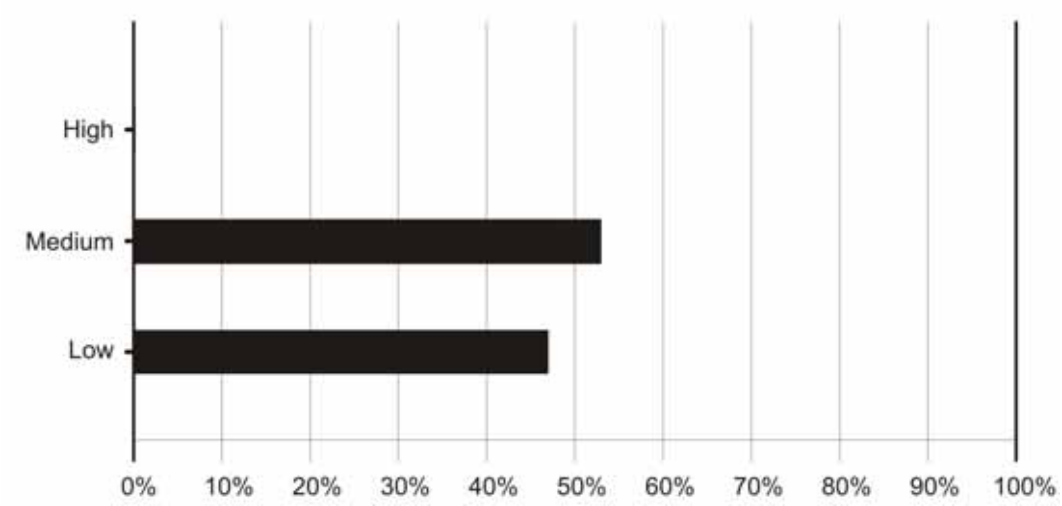

Figure 21: Level of students in CAAD Lectures

In general, the study indicates that teaching CAAD at University of Derna needs more development to achieve more advanced CAAD education as done in most of world universities.

3.5.3. Comparison Between World Wide and Libyan Cases

By comparing CAAD education in University of Derna and world wide universities there are some points can be concluded and these points are:

- With regards to integrating CAAD in education the world wide studies indicate that most of universities have include CAAD in architecture departments as a part of the design process and representation. On the other hand, in Libyan case teaching CAAD still as separated lectures with no connection with other lectures especially design studio.
- At University of Derna only AutoCAD is the involved software in curriculum while in international situation there are at least four or five CAAD programs and the most common programs of them are AutoCAD, 3D Studio, ArchiCAD and FormZ.
- International universities have a full-time CAAD tutors while in University of Derna it is clear that there is lack of tutors which has negative effects on teaching CAAD.
- Regarding to training time in CAAD courses studies shows a big difference between the two cases. In University of Derna the total time

of training is 80-100 hours while in international case the mean time of trainings is about 150 hours.

The other important deference between two cases is that the future plans to integrate CAAD into education. World wide studies show that most of universities have planed to include more advanced system to introduce CAAD in their curriculum. In Derna case the study indicate that the university has no plans on this process.

3.6. Challenges of Teaching CAAD

Architectural Schools are under pressure to provide graduates with the needed skills and principles of design by assistant of computers and new technologies. There is a general agreement among architectural critics and educators that there is a strong requisite to integrate the new technology and CAAD into architectural education. As a result, today the core of researches and studies in CAAD education is to introduce CAAD into education and replace the traditional architectural education tools by new tools.

The future increase of CAAD users and the domination of computers in our age encourage more universities and architectural schools to invest larger sums of money on CAAD labs improvements and seriously evaluate their current curriculum to adapt to the new CAAD trends. However, “The integration of computers in architectural education represents a big challenge for architectural educators. It is necessary to devise appropriate strategies, to create adequate conceptual frameworks within which the application of computers becomes meaningful for architectural education” (Madrazo, 1996) the use of computers in education must add new tools for students which help them to be more creative not only help them in the earlier stage of design.

Using CAAD applications in design studio and in the whole education process should make the balance between basic principles and skills of architects such as freehand sketching, drawing, redrawing, etc. which students have to learn and using computers assistant. In other words, integrating CAAD in architecture

curriculum must not affect the basic skills of architects that students have to learn through their study but must help them in such way that improves their creativity.

In general, there are three important observations must be studied carefully when integrating CAAD in architecture curriculum and these points are:

- How to teach CAAD? CAAD should be taught in such way that does not affect the basic skill those new architectural students must have. In other words, teaching students the basic and essential skills of drawing, designing and presentation then teaching students how to use CAAD programs as creative tools which improve their knowledge and experience in design.
- When to teach CAAD? This point is very important to reach the balance between developing the natural students' skills in design and using new technology assistant.
- What to teach? Nowadays, there are a lot of CAAD programs that available for architects however; educators and researchers have to select the appropriate CAAD programs for education and using the proper computing applications related to design studio work and the whole education process.

CHAPTER FOUR
CAAD CURRICULUM

4.1. The New Tools for Education

CAAD has become an essential tool for architectural practice and education. It is the most powerful designing tools available to architects and designers in our age and it is the future of architecture in both practice and education fields. In the last few years there is a growing consensus among architectural critics and educators that architectural education must get the full added values of CAAD applications to architecture. “Today, it might be more appropriate to speak about the integration of computers in architectural education than to keep postulating the advent of a computer technology that would automatically bring, in it, a revolution in the way we understand and teach architecture”. (Madrazo, 1996) The influence of new technology in architecture education and practice encourages critics and educators to involve CAAD in architectural education in order to improve students’ skills in design with the use of CAAD application. However, very few ideas have been discussed on integrating CAAD into architectural education so far concerning its implementation strategy in a situation where there are very limited access to support a successful integration of CAAD into architectural education.

Nowadays research on architectural computation has been focused more on development of new architectural education system that based on computers technology, especially CAAD applications. These researches try to involve CAAD and other related technologies in architectural education to provide digital design learning tools which improves the capabilities and skills of architectural students and to setting up a fundamental framework to CAAD curriculum. “The integration of computers in architectural education represents a big challenge for architectural educators. It is necessary to devise appropriate strategies, to create adequate conceptual frameworks within which the application of computers becomes meaningful for architectural education”. (Madrazo, 1996) Establishing such a framework is not an easy task due to the rapid development and the increased number of CAAD applications in the market in addition to the high cost

of such educational process which require professional and full-time tutors, hardware, software and facilities to support this operation. CAAD curriculum still need to be more discussed due to some reason; first one is that design education staff that generally lack in experience in CAAD usage, cannot even imagine what design education could be like using CAAD. Second reason, in most cases CAAD is taught as a separated subject without any relation with design education. Third reason is the lack of fundamental and sustainable CAAD curriculum structure that goes parallel with the development of new technologies.

This chapter reviews some of the pedagogical issues that have been derived from world wide CAAD conferences and roundtable participants' experiences with CAAD curricula. It reflects discussions that were held at the eCAADe conferences by; firstly, reviewing the categories of digital applications in architecture and the use of multimedia and CAAD applications in architectural education, then reviews some selected researches and papers from the worldwide CAAD conferences which discussing the main aspects and experiences in integrating CAAD into curriculum.

4.2. CAAD Applications

CAAD applications are the repository of accurate and comprehensive records of buildings and are used by architects and architectural companies. In the last four decades CAAD applications have become important tools in architectural education. Currently, CAAD applications are used at the later stages of the design process after the crucial decisions of creating design artifacts have been considered. Moreover, must of CAAD applications developers are deal with the problem of presentation rather than developing applications that support the design process itself. However, due to the developed CAAD applications that available in these days there are a number of applications that contain good features to help architects in the design stage and the use of CAAD in earlier stage of the design process are becoming more common. To understand the main advantages provided by CAAD applications it is useful to have a general idea about categories of CAAD software and the classification of these tools in architectural education.

4.2.1. Digital Applications Categories

In the last two decades CAAD applications have been increased rapidly and nowadays there are a huge number of CAAD applications in the market. However, only some of them are developed enough to be used in both architectural practice and education. In order to approach to the proper applications that can used in the architectural education it is important to understand the use of each CAAD application and having enough knowledge about the most common CAAD software that used in architecture field. In general, CAAD applications can be divided in several categories according to their features and usages in architectural design activities and these categories are:

- **2D Drafting Applications**

These applications are easy to use and contain simple tools and commands which used in 2D drawings such as AutoCAD LT from Autodesk, IntelliCAD PE and RealCAD Draft. However, these applications are not commonly used in the professional practice.

- **Essential CAAD Applications**

These applications are the essential tools of the architectural design and drawing. They contain commands and tools which allow designers and architects to create objects in 2 and 3 dimensions in addition to representation drawings such as plans, sections and elevations and rendering 3D objects. These programs use primitive entities such as lines, plotlines, circles, arcs, and text as the foundation for more complex objects. The most common CAAD application in the market is AutoCAD. And there are also other common applications such as Autodesk Architectural Desktop, Microstation, Revit and ArchiCAD.

- **Advanced 3D Modeling**

Advanced 3D CAAD modeling applications are used to create complex objects in three dimensional environment. They contain advanced surface and solid modeling capabilities and they includes materials library. A 3d modeling application includes several features that used to presentation and render such as material libraries, lighting tools and animations tools also they have a very plugin-

oriented architecture, and high-end plugins. The most known 3D CAAD applications are 3D Studio, Maya and Form-Z.

- **Landscape and Interior Design Applications**

Landscape and interior design application differ from other CAAD application in that they are have larger libraries which contain more details such as materials, furniture and natural elements. Examples for these applications are: AutoCAD Landscape and Home Designer Pro.

- **Viewers and Tools**

Software to convert CAAD files view and print them, markup CAAD drawings, render 3D models and add symbols libraries in addition to convert CAAD files to images and vise versa. The most common viewer tools are Voloview from Autodesk, CADViewer and ScanPro which used to convert scanned images to a vector format.

- **Structural Analysis Applications**

These applications are used to account, analysis and drawing structures details (e.g. steel, concrete) in addition to testing structures in virtual environment such as StrucPLUS for AutoCAD and StrucPLUS for IntelliCAD.

- **Digital Communication Tools**

Digital communications refers to the field of study concerned with the transmission of digital data. This is in contrast with analog communications. While analog communications use a continuously varying signal, a digital transmission can be broken down into discrete messages. Transmitting data in discrete messages allows for greater signal processing capability.

- **Image Processing Software**

In the broadest sense, image processing is any form of information processing for which both the input and output are images, such as photographs or frames of video. Digital image processing has become the most common form of image

processing. Examples for these applications are: Photoshop, Paint Shop Pro and Corel PHOTO-PAINT.

- **Desktop Publishing (DTP)**

These tools allow an individual to combine text, numerical data, and graphic elements in a document that can be output on a printer or a phototypesetter. The most common desktop publishing applications are Microsoft Publisher, Print Shop Deluxe, Adobe InDesign, Print Explosion Deluxe and Scribus.

- **Web Page Publishing**

Web Page Publishing tools allow designers to create, edit and publish their pages or documents on the internet such as Microsoft Office Publisher, Web Publisher, SWING DocPublisher and AutoWebBuilder.

- **Digital Presentations**

Digital presentations are tools used to present and publish documents such as Microsoft Office PowerPoint and Macromedia Flash.

Table 5 in next page shows the categories of CAAD applications according to their usages and gives the most common applications of each category.

Category	Usage	Examples for Applications
2D Drafting Applications	Drawing sample 2D drafting and representation drawings such as plans, sections and elevations.	AutoCAD LT IntelliCAD PE RealCAD Draft
Essential CAAD Applications	Create objects in 2 and 3 dimensions and representation drawings such as plans, sections and elevations and rendering 3D objects.	AutoCAD Autodesk Architectural Desktop Microstation Revit and ArchiCAD
Advanced 3D Modeling	Create complex objects in 3-dimensional environment and more advanced render levels.	3D Studio Maya Form-Z
Landscape and Interior Design	Help designers and architects to create landscape and interior designs in more details.	AutoCAD Landscape Home Designer Pro
Viewers and Tools	View and print CAAD files, render 3D models; add symbols libraries, convert CAAD files to images and vice versa.	Voloview CADViewer ScanPro
Structural Analysis Applications	Account, analysis and drawing structures details (e.g. steel, concrete) in addition to testing structures.	StrucPLUS for AutoCAD StrucPLUS for IntelliCAD
Digital Communication Tools	Allow users to communicate by computers.	
Image Processing Software	Create, edit, print and convert images and graphics.	Photoshop Paint Shop Pro Corel PHOTO-PAINT
Desktop Publishing (DTP)	Allow an individual to combine text, numerical data, and graphic elements in a document that can be output on a printer or a phototypesetter.	Microsoft Publisher Print Shop Deluxe Adobe InDesign Print Explosion Deluxe Scribus
Web Page Publishing	Create, edit and publish their pages or documents on the internet.	Microsoft Office Publisher Web Publisher SWING DocPublisher AutoWebBuilder
Digital Presentations	Present and publish documents.	MS Office PowerPoint

Table 5: Digital Applications Categories

4.2.2. Classification of CAAD Usages in Architectural Education

During the last forty years computers programs have been used in architectural education and practice in different contexts. This domination of computers in architecture has encouraged educators and researchers to redefine the use of CAAD application in architecture repeatedly. The aim of this classification it that to defined the meaning of CAAD, and more significantly, the importance of implementation of the technology in architectural education as it is today. The first classification of computers usages in architecture was in 1995 by Maver and Petric. As CAAD application are becoming more and more important in architectural education and practice, new classification of these tools appeared

in a parallel way with the development of new technology. The classification provided here are mainly depends on a paper presented by Anetta Kepczynska-Walczak, 2002, in the 20th eCAADe conference which seeks the meaning of multimedia, and more significantly, the importance of implementation of the technology in architectural education and practice. According to this paper the new classification of CAAD applications in architectural education contains the following categories:

- **Teaching/Learning support**

In the recent years CAAD systems have become powerful tools in the education. Mainly these tools provide the following package:

  - Computer based teaching packages;
  - Multimedia coursework;
  - On-line education (distance and life-long learning via Internet);
  - Libraries of reference material and case libraries.

- **Presentation and Representation**

Using computers in architectural presentation was one of the main usages of this tool in architectural design. It is a powerful tool especially in presenting design schemes, conference papers and live demonstrations. This category includes Rendering, Building Information Modeling (BIM), Animation and Virtual Reality.

- **Urban Representation and GIS**

New technology proved to be a powerful tool in dealing with representation of urban environments for example in projects based on GIS (Geographic Information System) or 3D city model.

- **Explanation of Technical Issues**

Technical issues have always been strongly related to architectural design studio. The use of CAAD systems increases the understanding of these aspects.

- **Virtual Heritage and Virtual Museums of Architecture**

The areas of research and development, academic institutions pursue include virtual world, virtual museums and virtual heritage. This has recently become one of the most spectacular and fast development in multimedia applications (e. g. Dießenbacher, Rank, 1995; Maver, Petric, 1999; Lee, Paterson, Maver, 2000).

- **Multimedia Software Design and Interfaces to CAAD**

As it was predicted by the authors of the first classification, the number of multimedia-based software and interfaces to CAAD has been increasing significantly with each year (e. g. Donath, Petzold, 1997; Gu, J. et al., 2000).

- **Remote Co-operation and Collaborative Work**

In this fast developing area of architectural education and practice, the computer-mediated communication that employ multimedia and Internet can empower designers by providing them with new ways of working together (e. g. Park, 1997; Andia, 2001).

- **Planning and Building Control and Management**

CAAD systems have effected on the decision-making process, improved communication and collaboration error reduction in planning and building control.

- **Documentation**

Computers provide very powerful and useful tools for archiving and there is a number of examples of multimedia archives can be cited.

- **Experimentation**

Despite such enormous diversity of multimedia applications there is still a place for experimentations, which can lay foundations for new developments in the near future (e. g. Han, Turner, 2001; Levy, 2001).

4.3. Approaching to an Ideal CAAD Curriculum

Recent researches on architectural computation have been focused more on the role of CAAD software in facilitating process in early design stages. The aim

of these researches is to integrate CAAD in architectural curriculum from the first steps in order to allow students to use the full period of their studies to reach a reasonable level of computer skill. Students should see the relevance of computing to their design process, and to ensure that it is utilized properly. In the practice field the use of computers and CAAD applications has been the main tools in architectural design and the educational process must not be an exception. Moreover, most of building projects are just huge masses of information that have to be handled in digital form which mean architects must work in a digital environment. So it is important that students should be able to use the full period of their studies to reach a reasonable level of skill that improve the abilities of them in the use of new technologies and allow architectural students to be in connection with changes in architecture field. The advantages of CAAD knowledge as Chiu-Shui Chan mentioned, 2006, are:

- The ability to handle design information and images more efficiently;
- To catch the future direction of information science in the 21st century;
- To be equipped with CAD research ability;
- To accumulate assets for conducting CAD research.

The process of integration CAAD into architectural education has two part, first is the philosophical and theoretical and the second is particular part. The first one discussing the objectives and aims of education within CAAD and IT and form those targets in a theoretical and sustainable structure in addition to clarify the characters of CAAD curriculum. Also, this section aims to establish the tools needed to achieve these objectives, test them and replace any failed by another proper one. This section is covered by educators and researches who try to develop a sustainable structure for CAAD curriculum which has the ability to be changed with the changes in education objectives. Second part is the tools and components of CAAD education which are required to complete the integration process. This part includes CAAD staff and tutors, laboratories, hardware and contents of CAAD subjects (CAAD software and other digital applications). Next pages review the concepts and studies that discuss this process. These researches

were published in CAAD conferences that held by international CAAD associations.

4.3.1. Characters of an Ideal CAAD Curriculum

Recently, integrating CAAD into architectural education has become the core of architectural education researches. In architectural schools there is a discussion about the use of computers and integrating CAAD into architectural curriculum and how students can move easily between manual techniques and computers. The aim of these researches is to set a fundamental framework for CAAD curriculum and to find out how to manage CAAD curses to have more efficient and progressive CAAD education. There are several researches try to present an ideal CAAD curriculum that can help education process to become more efficient and keep student in connection with the professional practice field of architecture and inform them of up to date CAAD applications that available in the market. Recent CAAD research has attempted to use computers to aid architectural education these researches try to construct a suitable format of CAAD implementation in architectural education. During the last 30 years, an impressive amount of research effort has been made in order to set a fundamental structure for an ideal and sustainable CAAD education system. Characters of an ideal CAAD curriculum can be summarized in the following points:

- An ideal CAAD curriculum should clarify the extent that CAAD can be integrated to the architectural curriculum; in other words, where to use CAAD? In which subjects it can be introduced?
- It should not affect the traditional techniques and the essential skills that new architects should have instead it must be in a parallel way with them and support them;
- Teaching CAAD in such way that does not seek to replace creativity but rather inform it;
- Ensure that “students are informed of up to date CAAD applications so they now can choose for themselves which equipment, software and training is most suitable for their needs”. (Loy, 1999)

Achieving such ideal model of CAAD curriculum requires a sustainable CAAD integration model into architectural education. To do so, it is useful to review the structure of education in order to form an ideal model of CAAD curriculum that can not be interrupted and can be changed according to the rapid development of CAAD applications and IT.

4.3.2. Structure of Education

The structure of architectural education can be understood within the structure of education. Ozersay and Szalapaj, 1999, explain this structure in a paper presented in the 17th eCAADe conference. This explanation reviews the general education structure as Moore defined it in 1974 and then defines the structure of architectural education within the whole structure of the education. In general, structure of education contains three levels, philosophy of education, educational theory and educational activities, it is just like a multi-store building which has three levels. "On the ground floor there are various 'educational activities'. At the next higher level, say at the first floor level, there is educational theory, which may be understood as a body of connected principles, guidelines and recommendations. At a higher level still, there is a philosophy of education, which has for its main tasks the clarification of the concepts used at lower levels" (Moore, 1974).

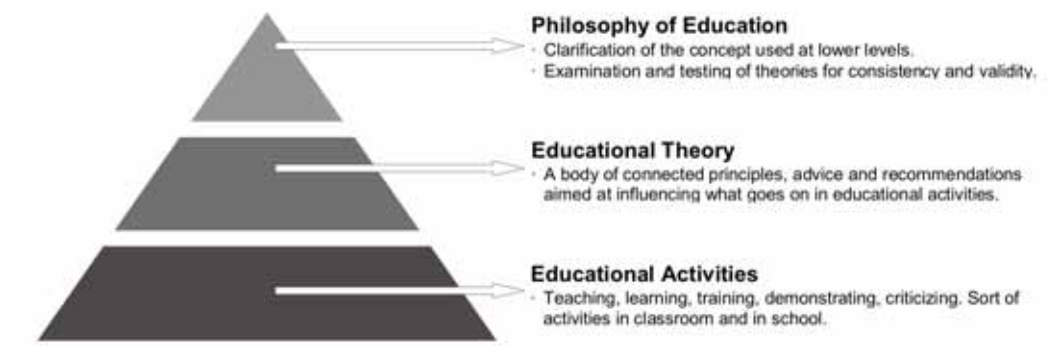

Figure 22: The Structure of Education and its Levels (Ozersay and Szalapaj, 1999)

Figure 22 shows the structure of education and its levels with a brief definition of each one. At the top of this structure there is the philosophy of the education which aims to define and examine the educational theory. Every elements of the education process such teaching and learning, training, knowledge, students, etc.

are emphasized and philosophized with their relation. The theory of the education can be exist only by a clear understand to each concepts of the education. The philosophy of the education is the upper level of the educational structure where the educational theory is examined and all concepts of educational theory are tested for consistency and validity. This examination gives the way to define and redefine the educational theory.

The second level in this structure is the educational theory. The general definition of a theory is "A set of statements or principles devised to explain a group of facts or phenomena, especially one that has been repeatedly tested or is widely accepted and can be used to make predictions about natural phenomena".

Discussion of concepts of education in the philosophy of education level forms the educational theory. This theory is not a descriptive theory; it's a practical theory not just a theoretical theory which is more prescriptive and recommendatory. The educational theory uses a group of principles and recommendations that used to practice of theory which forms the educational activities. The objective of the educational theory is to set a framework for the way of teaching including all conceptual questions such, way to teach, how and what to teach. All these questions are discussed and answered in the educational theory. The educational theory is the body and the guidelines of what is going on in the classroom and related activities of the education process. In the lower level of the structure of education there are the educational activities. These activities such, teaching, learning, training, demonstrating, evaluating , etc. are formed in the educational theory in order to achieve the aims and objectives of education. In other words, prescriptions of a pedagogical of the most effective ways of teaching, learning and producing a certain type of person come from the educational theory and converted into the educational activates which lead to test them in a particular way.

4.3.3. Theoretical Approach to an ideal CAAD Curriculum Model

In the recent years educators and researches in architecture have focused on developing a new architectural education system that depends on CAAD and other digital applications. The subject of these researches tries to find an answer to

the question “To what extent can CAAD be integrated to the architectural curriculum?” (Asanowicz, 1998) To approach to such system it is important to understand the education process and in what subjects that CAAD can be integrated in.

A paper carried by Aleksander Asanowicz in the 16th eCAADe conference, 1998, discusses the possibilities of setting an ideal integrated model where education is completely depends on new technology. The paper starts with the traditional education model and tries to develop it according to the use of CAAD and IT in architecture. As mentioned previously, the first model is the traditional education model, second one shows the integrating of CAAD in design studio, third model present the integration of CAAD and IT in other education subjects, fourth model is a developed model according to the previous model where education subjects are connected to each other by CAAD and IT and finally the study arrives at an advanced and more developed model where the education process is wholly depends on new technology.

The first model (figure 23) was used at the beginning of introducing CAAD applications in architectural education; however, it is still used in some architectural schools especially in developing countries. In this model CAAD is introduced in the education schedule as a separated subject “CAAD is being considered as a typical element (discipline) of architectural curriculum, the same as history, construction or urban planning”. (Asanowicz, 1998) All subjects are not connected to each other. In fact, this model shows the traditional architectural education where the use of CAAD is primarily focused on learning some basic skills of CAAD applications and the design studio activities are done by traditional analogical tools (hand sketches and modeling).

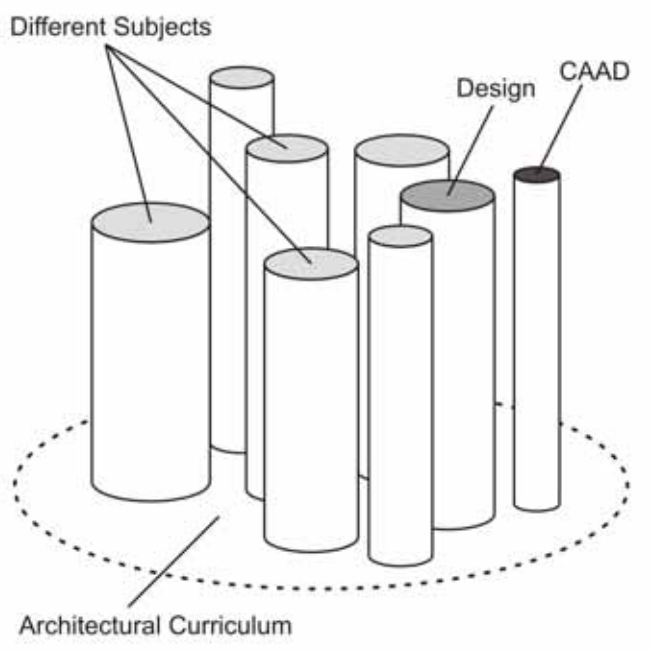

Figure 23: Traditional Architectural Curriculum - CAAD as a Separate Subject of Architectural Curriculum (Asanowicz, 1998)

A developed model to the previous one is presented in figure 24 where CAAD is integrated in design studio. The aim of involving CAAD into design studio is that "to teach CAAD usage as tools for design thinking and alternative exploring in addition to conventional use as tools for attractive presentation". (MOROZUMI) Introducing CAAD in design studio does not aim to replace the traditional methods but to provide another designing tool for students. In this model "Computer is treated as a medium, which lets students explore different spaces of architectural design". (Asanowicz, 1998) With the success in using CAAD and other digital media applications in architectural practice coupled with the developed hardware and software lead to another level of integrating CAAD in architectural education that aim to allow students to explore the advantages of new technologies and inform them of the up to date CAAD applications. And more advanced goal of this model is supporting design studio activities at the conceptual stage. The added value of CAAD to the design process as Aleksander Asanowicz, 1998, mentioned is that computers give students access to the processes and sources of creative activity. They could use it at early design stages for searching of idea.

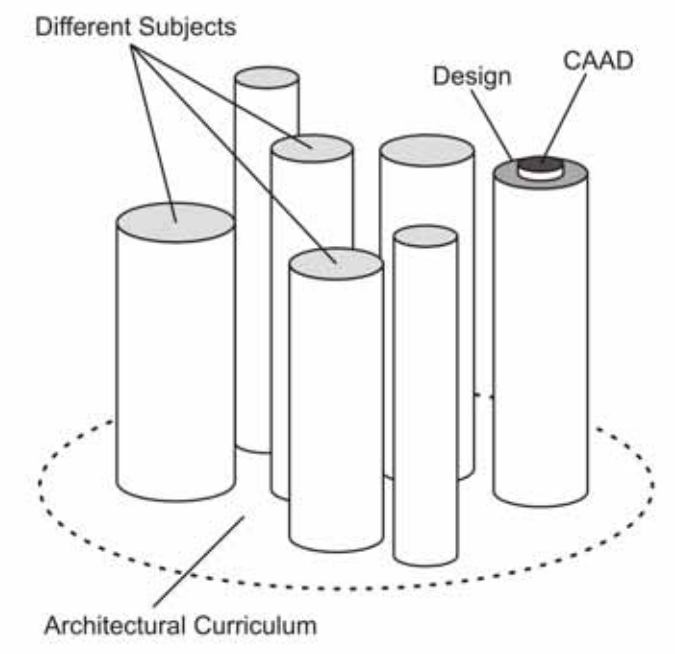

Figure 24: CAAD Integrate with Design (Asanowicz, 1998)

Even though this is an advanced use of CAAD in design studio, the other subjects of the curriculum are still separated and not jointed to each other. The success of integrating CAAD in designs gives the possibilities to integrate CAAD and IT in other curriculum subjects.

In addition to using CAAD in the whole designing process computers have various usages in architecture field such as urban design, analysis and presentation of towns' development, analysis of architectural styles (CAAD-Assisted Architectural-Historical Researches) and engineering construction where computers can be used to simulation of construction deformation in different conditions. The result of this analyzing is the third model (figure 25) where each education subject contains some element of Information Technology.

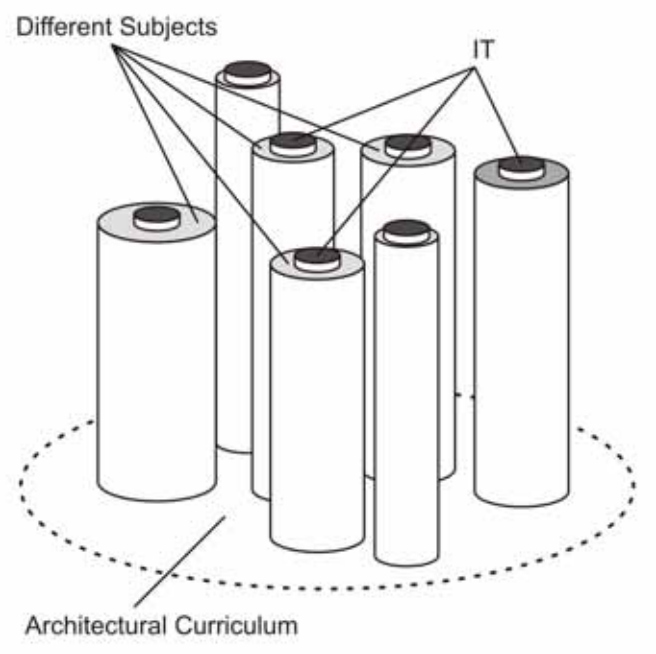

Figure 25: IT (Information Technology) in Different Subjects of Curriculum (Asanowicz, 1998)

Although CAAD and IT is involved in each subjects in the third model, "this kind of using of computers does not change the curriculum as a whole, because the situation in this model is the same as in the first two models-no connection between separate subjects of curriculum". (Asanowicz, 1998) Fourth model (figure 26) is a theoretical devolved model of third one where IT play main rule in the curriculum. However, IT can not play such rule because they still attached to separate subjects, and are not treated as a whole. "If Technology could be an environment for all subjects; it will be possible to create more appropriate model to requirements of new architectural curriculum" (figure 27).

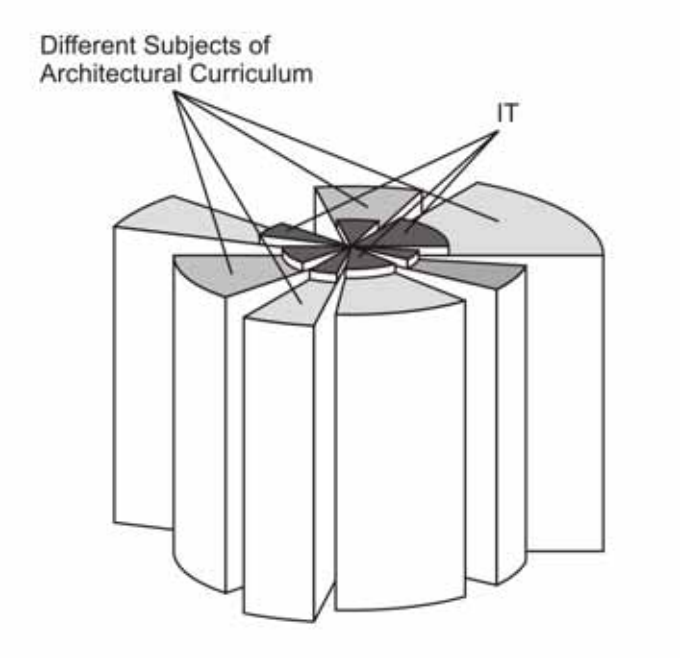

Figure 26: IT (Information Technology) as an Axis for Architectural Curriculum Integration (Asanowicz, 1998)

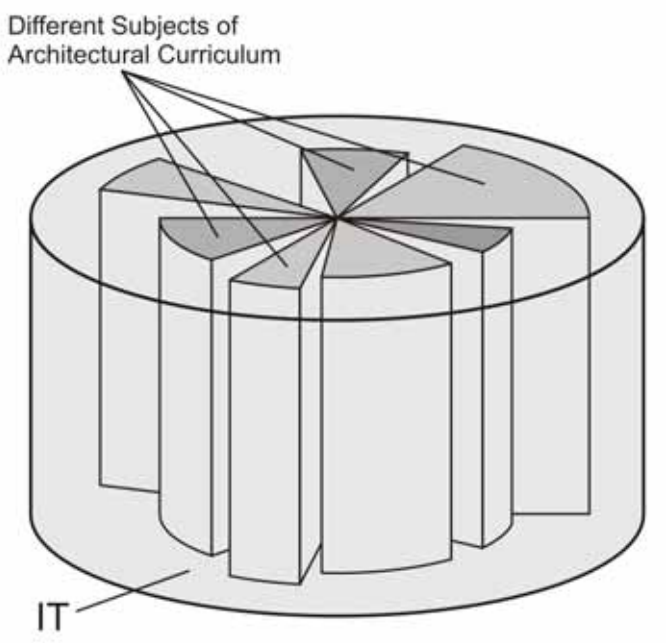

Figure 27: IT (Information Technology) and Full Architectural Curriculum Integrating (Asanowicz, 1998)

The last model presented above can be the key of an advanced integration of CAAD and IT in architectural education where they act as a medium for education activities. Achieving to such model require a sustainable architectural education structure which can be changed according to the rapid development of CAAD applications and IT. This sustainability comes from the theory of education itself

where “The sustainability of the theory comes from the concept of its being consistent as changes occur in the definitions of the concepts that defined the theory”. (Ozersay and Szalapaj, 1999)

4.3.4. A Sustainable Architectural Education Structure

A sustainable CAAD curriculum model can does not exist without the structure of architectural education. As mentioned previously any education structure contains three levels, philosophy of education in the upper level, educational theory and in the lower level there is the educational activities. However, the present structure of architectural education has some missed parts according to the structure of the education explained by Moore, 1974. “At the philosophical levels, the concepts that are related to architectural education are more taken for granted or accepted as existing more than being discussed and updated. Although these concepts, such as education, training, student, knowledge, information, technology, etc. are discussed by individuals and go round within the discourse of architectural education”. (Ozersay and Szalapaj, 1999)

Figure 28 present the current structure of architectural education which full of myths. The relations between levels are not as it should be. Instead of starting discussing the philosophy of the education at the upper level to form a theory which later set up the activities of the education, the process is done just in the opposite way; it is made at the button of the education structure. This is explained by Teymur as “Architectural Education can justifiably be called a practice without a theory. The discourse on Architectural Education is full of myths and unarticulated assumptions which cannot of course be substitutes for theory”. (Teymur, 1996)

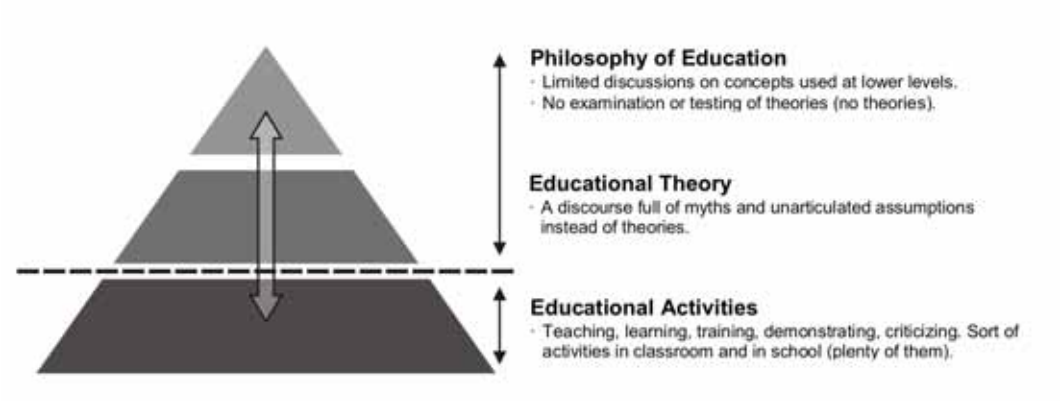

Figure 28: The Split Structure of Architectural Education (Ozersay and Szalapaj, 1999)

The appearance of computers in architecture has added a great value to it in both practice and education. According to structure of education CAAD and IT can be used in education in two categories; the first one is towards the education activities in the lower level, the second is the use of CAAD and IT in the upper level, that to say, defining the aims and objectives of education within the use of computers. At the upper level, philosophy of education, all aims and objectives of the education process must be defined clearly according to CAAD and IT, "Education, knowledge, training, learning as well as feedback from psychology and sociology must all deal with the effect of computer technology". (Ozersay and Szalapaj, 1999)

The next step is forming the theory in the second level of the structure; here the theory is come from upper level and formatted according to CAAD and IT. The practical theory of the education must start with the aims and objectives of the education which contain the use of computers that defined by the philosophy of the education. The theory should set clearly the way of introducing CAAD and IT into education process with recommendations and reasons. Then, the activities of the architectural education will be set according to these recommendations which define what is going on in the lower level.

Methods and models of teaching, learning, pedagogy, etc. are formed by the theory which "does not only consist of the presentation of the ends to be achieved, but also recommends the various means as ways of realizing them". (Ozersay and Szalapaj, 1999) Any changes in the aims and objectives of the education process

will change the philosophical definitions which will test the theory for consistency and validity with these new changes. The modified or changed theories according to this testing will return to the activities to see if they still consist with the education's aims and objectives which have been defined in the upper level (the philosophy of the education). This cycle from top to bottom and then up again will form the sustainability of the structure (figure 29) of architectural education. Any changes will affect the assumptions and recommendations formed in the theory not the structure itself. Any part of this process failed will be replaced by more appropriate one.

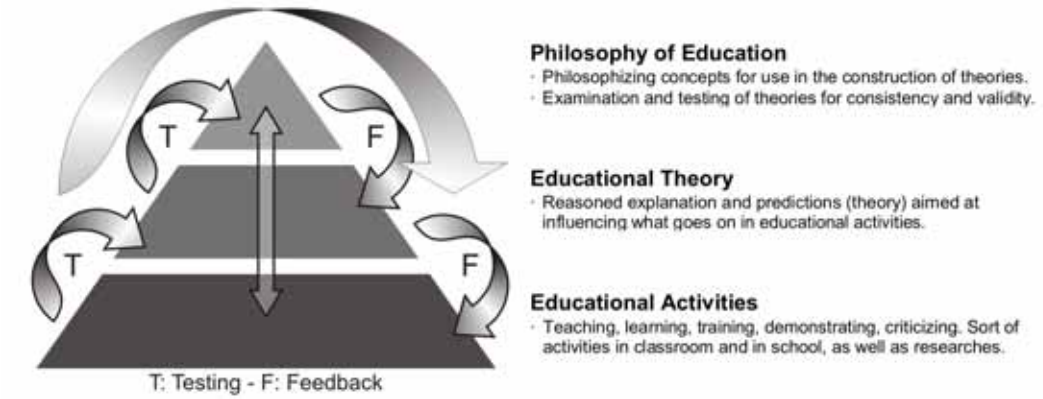

Figure 29: A Sustainable Structure for Architectural Education (Ozersay and Szalapaj, 1999)

Such structure of architectural education presented above will lead to an ideal architectural education through in fully technological environment. The next step is to identify the requirements and essential parts of CAAD education to complement the education process within CAAD and other digital applications.

4.4. Components of CAAD Curriculum

To achieve an ideal CAAD integration in the architectural education there are some essential requirements. These parts with each other form the practical part of the process of integrating CAAD in architectural education to achieve to the appropriate structure of the education. These components are; CAAD tutors and staff, laboratories and hardware and the contents of CAAD subjects. Another important point regarding to CAAD subjects is the time and training hours required to achieving the essential level of CAAD and digital applications skills.

4.4.1. CAAD Education Staff and Tutors

CAAD education staff and tutors are one of the must important factors to upgrade the level of CAAD education. It is due to that their "ability indicators are to deliver, explain, interpret, use, design, adjust to differences in the learning styles, observe classroom pasterns, produce different methods of teaching, and interact with learners". (Louden, 1991) If the knowledge and experience of CAAD education staff in CAAD and other digital applications is not enough the result will be poor education process due to the fact that "The design education staff that generally lack in experience in CAAD usage, cannot even imagine what design education could be like using CAAD". (MOROZUMI) In order to have a good CAAD education staff and tutors it is important to architectural schools to:

- "Provide the means for CAAD staff to prompt effective changes". (QaQish, 1998);
- Inform them of the up to date CAAD and digital applications.
- Employ full-time professional CAAD education staff, a common mistake is that some architectural departments have part-time tutors which affect the education process negatively.
- Provide a proper training for them to accommodate all CAAD courses in the curricula;
- Organize separate workshops for new media essentials, CAD-basics, web-publishing, etc. to design teachers. (MARK et. al, 2002)

4.4.2. Laboratories and Hardware

Another important component in the process of introducing CAAD in the architectural education is the computer laps and hardware. They are integral part of a proper CAAD education. This part includes PCs, notebooks, scanners, printers and plotters in addition to other requirements related to these devices such as wireless or high-speed network connections. Today computers capacities are developed rapidly so it is important to be in connection with the latest update in computers and hardware. The new packages of CAAD applications require high performance and high featured computers so the capacity of a computer is very important to install such applications in. In addition to providing the required

hardware and other related devices the relation between laboratories and design studio is very important. A world wide survey about CAAD in architectural schools carried by Ra'Ed QaQish and Raid Hanna, 1996, shows that CAAD laboratories proximity to design studio was essential for better CAAD integration.

4.4.3. Contents of CAAD Subjects

The contents of CAAD subjects meant the digital applications and CAAD software that provided to students in the lectures. The influencing of CAAD and digital applications in architecture field shows that architects should be educated in a more wide-ranging. Having a superior characteristics and effective CAAD education requires choosing the appropriate subjects that its contents (CAAD and digital applications) improve the quality of the education. "CAAD-courses have to stimulate the interest in architectural design and, more important, establish a mechanism to control and enhance the quality of the architectural design produced with the help of digital media". (MARK et. al, 2002) Architectural design process contains several activities to be done starting from establishing the idea of the design to publishing it. These activities need a set of programs to be done in the proper way. The applications are the tools of CAAD education; they form, with other components of CAAD curriculum, the particular way for achieving the objectives of education. It is important to provide the relevant CAAD tools to support education objectives established in the theory of the education. In general, the applications that CAAD subjects should contain are:

- **General computer applications:** Word processing, spreadsheets and database management systems.
- **Programming:** Data structures, algorithms, control structures, structured programming, object-oriented programming and event-based programming.
- **Image processing:** analyzing, enhancing, compressing, and reconstructing images.
- **CAAD management and practice:** Archiving, purchasing, field issues, training, budgeting and project management.

- **2D modeling applications:** Drafting, point line drawing, region modeling, blocks and dimensioning.
- **3D modeling applications:** Constructive solid geometry, boundary representations, rendering, lighting and materials.
- **Animation:** Key frames, tweening, moving objects.
- **Communication tools:** Internet, E-mail, telecommunications technology, web publishing and collaborative design tools.

The importance of these contents depends on the level of students in computer skills and CAAD experience. For example, if the students come to university with enough experience in using internet then the subjects that contain internet browsing will be not required. However, the subjects presented above must be set in an order starting from elementary level to an advanced one through the whole study period.

4.5. Hierarchy of CAAD Subjects

The hierarchy of CAAD subjects contains three levels; these levels are developed from selected papers which were presented in the 20th eCAADe conference. These levels are; introductory CAAD curriculum, intermediate and advanced level. The introductory level includes the essential subjects that students must start with in dealing with computers. Second level comprise more specified subjects about using CAAD and digital applications in architecture. The final level is an advanced level contains more complex applications and implementation of CAAD in architecture such as 3D modeling, rendering and animation software.

4.5.1. Introductory CAAD Curriculum

First year students usually come to the university with a wide range of backgrounds, skills and expectations but also there is a limited or non existing computer software experience. “It is necessary for students to have a chance, in early stages of design education, to use different media and instruments of both conventional and newly developing. They may then find suitable tools for themselves and for different type of design studies”. (MOROZUMI)

An introductory CAAD curriculum should cover a set of digital design media subjects “including interactive communications, basic geometrical modeling, digital image processing, and mixed media productions that involve the use of digital video, scanning and output media”. (MARK et. al, 2002)

4.5.1.1. Objectives of an Introductory CAAD Curriculum

According to MARK Earl, MARTENS Bob and OXMAN Rivka, 2002, an introductory CAAD curriculum should allow students to achieve a basic level of computing skills and knowledge, by:

- Ensuring a basic level of computing skill;
- Replacing bad computing practices with good ones;
- Demonstrating the potential of computing tools for design;
- Encouraging a considered approach to the use of computing tools;
- Providing an appreciation and understanding of the benefits and difficulties in using the computer in conjunction with or instead of non digital methods.
- Computer uses should be engrained in the student’s everyday working patterns. This includes: design exploration; presentation (e.g. image processing, word processing, web, paper) and communication (e.g. email, discussion boards, assignment submission).

4.5.1.2. Subjects of an Introductory CAAD Curriculum

The most important factor in teaching incoming students is to ensure that they have a basic level of computing skills. Usually, Students enter universities with some computing experience, but they are often still lacking certain basic IT skills. So the first year students must have enough information about IT and learn the basic principals of multimedia applications. The introductory CAAD subjects for first-year students should contain:

- **Introduction of computer skills**

First year students come to university with deferent skills and levels in computer knowledge. This subject is very important because it allows students to

get familiar with computers and give them some essential skills. The introduction to basic usage of computers covers the followings:

- General information about hardware and software;
- Operating systems and mange files (storage, organize, etc.);
- Word processor and spreadsheets;
- Web browsing and e-mail software;
- Using internet as a searching tool;
- Input and output skills;
- Raster graphics and vector graphics applications.

- **Introduction of CAAD Application**

An introductory CAAD Curriculum should introduce students to basic 2D drawing skills. This course should mix computer techniques with manual ones which can help students to create more interesting images. The most common 2D applications are AutoCAD, AutoCAD LT and Microstation. This subject includes:

- CAAD programs interface and commands line;
- Essential skills of 2D drawings such as drawing lines, objects, line weights, hatching libraries, copying and moving objects;
- Scaled charts of people, cars, trees and text;
- Print with specific scales.

4.5.2. Intermediate Level of CAAD Subjects

The aim of increasing the level of CAAD curriculum through architectural education is to achieve an educational pyramid with a large based computer technology. The next level of CAAD applications in this hierarchy is the intermediate level. This level contains more specific application in architecture field. It mainly includes the following subjects:

- **3D Modeling**

This subject area focuses on three-dimensional drawing applications and the use of computers to produce architectural forms. The most used 3D CAAD

applications in schools are; AutoCAD, ArchiCAD and Microstation, also, Rhino and Catia are used in some cases. In general the subject should contain:

- Introduction to computer modeling;
- Clarifies the importance of three dimensional models to students by giving examples;
- Creating 3D models from 2D elevations and plans;
- Creating and editing objects in 3D environment;
- Introduction for 3D shading and lighting and rendering forms;
- Dealing with 3D blocks and library materials.
- Saving files in several formats to be transferred between applications.

- **Digital Photo Processing**

Digital photo editing applications are very essential for an architect to edit and create special effects on digital photos; they can produce advanced and high-end pictures. The common applications used in schools are; Photoshop, Corel PHOTO-PAINT and Paint Shop Pro. The objective of this subject is teaching students how to:

- "Resolution characteristics;
- Calculating color depth;
- Choosing graphic file extensions according to intended use;
- Compositing a photo montage"; (MARK et. al, 2002)
- "Converting vector models to pixel images;
- Applying color and textures to CAAD models;
- Creating materials and properties of textures;
- Rendering time consumption;
- Sunlight simulation studies". (Loy, 1999)

- **Digital Presentation Tools**

This subject contains presentation software such as Microsoft PowerPoint, the most common presentation program, and Macromedia Flash. These tools have become the most powerful tools for design schemes, conferences papers and live

presentations of projects and ideas. This subject aims to improve skills of student in creating presentation for specific purposes.

- **CAAD-Support Collaboration**

Since the internet has become the most powerful searching, sharing and publishing tool it is very important to enhance students' abilities in the use of internet as a communication tools and explain its rules in collaborative design. This subjects digital communication, desktop publishing and web page publishing applications. The main objective of this subject is improving students' skills in:

- Using internet as a communication;
- Sharing knowledge and experience via internet;
- Publishing on the internet;
- On line interactive communication;
- Other sharing tools.

4.5.3. Advanced CAAD subjects

This level contains the most advanced CAAD and digital applications such as the 3D rendering offering full features to control the design from the first steps especially in the presentation. In addition this level other applications needed for professionals. The main subjects in this level are:

- **Advanced 3D Rendering**

This subject explains the full spectrum of three-dimensional rendering applications from a beginning to an advanced level. Applications such as 3D Studio, Form-Z and Maya are widely used in architectural schools under this subject. This subject contains:

- Demonstrate rendered models;
- Exporting files formats;
- Three dimensional montage;
- Lighting skills;
- Dealing with 3D blocks;
- Creating materials and textures;

- Dealing with cameras;
- Using simulations tools such as wind plugins;
- Import and export data.

- **Animation**

The subject explains the use of multimedia applications in automating the movement and supplying the in-between drawings for full animation. High rendering applications such as 3D Studio, Form-Z and Maya contain tools for animations and creating moving.

- **Programming**

"The subject provides Data structures, algorithms, control structures, structured programming, object-oriented programming and event-based programming". (Clayton and de Velasco, 1999) C++ is the most known and high-level programming language, it also contains low-level commands to beginners.

- **Computation of Construction**

"Subject explores the computational relationship between structural engineering and architectural design. The use of infinite elements is a topic that could be explored at an advanced level". (MARK et. al, 2002)

- **Surveying and GIS**

The subjects describe the use of computer applications to be constructed from field data and sites to be built in 3D models and the implementations of computers in Geographic Information System.

- **Structural Analysis**

This subject describes the full spectrum of structural analysis tools, including advanced simulation and experimentations techniques.

- **Virtual Reality**

Virtual reality (See Appendix) is the most advanced applications have been introduced in architecture field to improve the design process. This subject

describes the benefits of virtual reality in simulation and the use of VR applications to create interactive three-dimensional environment. The tools of this subject contain some required devices in addition to the VR application such as Superscape VRT.

This hierarchy does not mean that it is necessary to have all the mentioned subjects above in the education process but it sets guidelines for educator and decision-makers to choose the proper subjects according to the requirements of the education process and students' experience in computer skills. It is significant to adapt CAAD and other digital applications in the traditional education subjects by; firstly, include the larger part of these in the existing architectural education courses as can as possible. Secondly, put them in an order according to their importance and "offering some of the higher level courses as optional courses". (SEEBOHM, 2002) Educators should choose the subjects of CAAD and digital applications according to their importance to architectural education. The main points that should be the guidelines in choosing CAAD subjects are:

- Level of students in dealing with computers and their experience in CAAD and digital applications. For example, if they have good experience in 2D CAAD applications it is possible to start with 3D applications;
- Difficulty of the applications. It is not possible to begin teaching 3D CAAD applications while student do not have enough experience in 2D one;
- Timetable and study schedule. The amount of subjects required to have complete CAAD education through architectural education need to draw up a possible schedule that can be done in the available time. So educators should choose the subjects of CAAD and digital applications according to their importance.

4.6. A Suggested Model for Integrating CAAD

This model is a suggestion for integrating CAAD applications in the education which depends on the hierarchy of CAAD applications and the relations between CAAD and other digital applications in one side, and design studio in the other side. The model includes a structure that contains two circles; first is general

computer applications and the other includes CAAD applications. Two circles related to each others and one has a reflection on the other. For examples, using image processing applications, from the first circle, to create materials that can be used in CAAD applications, in the other circle. At the same time a plan drawn by CAAD application can be imported to image processing application to be illustrated.

The subjects in this model are organized in a hierarchy that begin with traditional tools and end with full advanced CAAD applications. First circle begins with general computer skills and through the study period it will be improved by using another digital applications such as images processing, presentation and publishing tools. The second one starts from the traditional methods of architectural design to the full rendered designs through a progressive process. The full subjects are presented in table 6. And figure 30 in next page shows the structure of this model. The main idea behind this can be summarized as following:

- The model depends on a progressive process, start from traditional methods which are not changeable to the advanced use of CAAD and other digital applications. Also, the structure itself is not changeable but the subjects can be changed according to the latest developments in new technologies.
- At the end of this process the knowledge will have some added values from the experience, and this will has a reflection on the process and develops it according to this added experience (circle of experience and knowledge).
- Other digital applications such as programming, simulation and construction analysis applications are not involve here. The reason is that they can be adapted to the other subjects that have a relation with them.

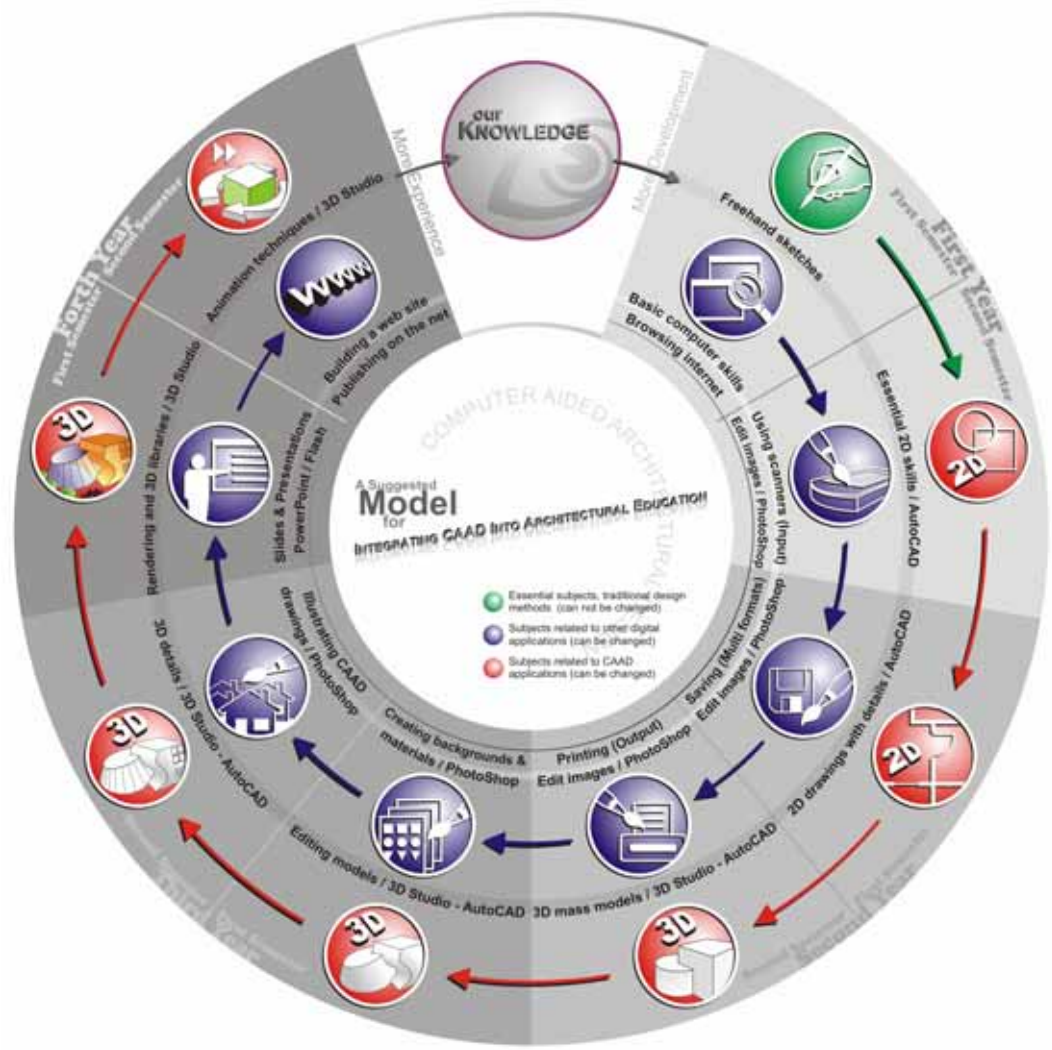

Figure 30: Structure of a Suggested Model for Integrating CAAD

Y.	S.	Subject	Tools	Aims
First Year	1	**C**omputer Literacy **B**rowsing Internet	**O**ffice Word **I**nternet	General computer skills, word proceeding, browsing and download from the internet.
		Design studio	**F**ree Hand **S**ketches	Basic of design and hand sketches skills.
	2	**I**nput Skills **I**mage Processing	**S**canners **P**hotoShop	Scan images and texts and edit images.
		Introduction of 2D	**A**utoCAD	Draw sample objects and to modifying commands (copy, move, scale, etc.).
Second Year	1	**I**mage Processing	**P**hotoShop	Improve the use of image processing applications and save images in different formats.
		2D Drawings with Details	**A**utoCAD	Develop the previous 2D drawings by adding details to them (wall depth, doors, windows, 2D libraries).
	2	**O**utput skills **I**mage Processing	**P**rinters **P**hotoShop **A**utoCAD	Print images (Output skills) and print 2D CAAD drawings in different scales.
		3D Drawings	**3**D Studio	Introduction for 3D drawings and creating solid models without details.
Third Year	1	**I**mage Processing	**P**hotoShop	Creating backgrounds, different material and textures to be use in CAAD rendering.
		3D Models Editing	**A**utoCAD **3**D Studio	Editing 3D objects (union, subtract, intersect, etc.) to create more complex objects.
	2	**I**mage Processing	**P**hotoShop	Import drawings from CAAD applications to image processing applications and illustrate them.
		3D Models with Details	**A**utoCAD **3**D Studio	Adding details to the 3D edited models and dealing with 3D commands and libraries.
Forth Year	1	**P**resentations	**P**owerPoint **F**lash	Making presentations, slides and the basic skills of 2D animation.
		Rendering	**3**D Studio	Adding backgrounds, textures and other elements such as figures, cars and trees, etc.
	2	**P**ublishing	**I**nternet	Building personal web site, publishing designs and productions and transferring data to the internet.
		Animation	**3**D Studio	Basic skills of animation, setting frames, time and other skills of creating moving by CAAD.

Table 6: Subjects of a Suggested Model for Integrating CAAD

CHAPTER FIVE
CONCLUSION

5.1. Conclusion

This thesis has focused on the process of integrating and requirements of this process. The main questions of this thesis are; why to teach CAAD, what value that CAAD can add to education? When to start teaching CAAD? In which stage should CAAD be taught and to what extent should it being integrated? What to teach, which applications can be helpful to education process? And how CAAD can be integrated in the education?

First Chapter reviews the general definition of CAAD and the changing in concepts that refer to computer programs used in architecture. At first, CAD (Computer Aided Design) was used to refer to all programs that used in drawing and design then it was replaced by CAAD (Computer Aided Architectural Design). Then IT (Information Technology) and recently this has been replaced by ICT (Information and Computing Technology). This changing is always related to the development in new technologies.

Chapter two includes a historical review about CAAD applications. The aim was to understand the history of this tool when it started and where it has arrived, also reviewing the advantages of CAAD in architecture. The result was that through the last five decades CAAD has mainly three generations; first is CAD/CAAD as a drafting tool, CAAD as design medium and last generation is using CAAD as communication tools due to the globalization of building industry at the beginning of 1990s. Also, the study shows that CAAD and ICT applications can be very helpful to architecture education due to their benefits and the success of them in practice field.

Third chapter reviews changing in rules of teaching CAAD and the interest of CAAD researches. The study shows that CAAD was taught as a separated lecture and then with more developed applications it has become more important in the education especially in developed countries. These results show that education is

always related to practice. However, analyzing of cases studies shows that there is a gap between developed countries and developing countries. In developing countries, teaching CAAD still need more development, it just still taught as separated subject as shown in Libyan case. Regarding to topics of CAAD, the result was that majority of them are discussing the practical ways of teaching CAAD with fewer studies about theory of education within new technologies.

Chapter four focus on the process of integrating CAAD into education. It starts with the categories of digital applications and its implementations in education and practice. Also, it reviews some theoretical models of integrating CAAD and the proper structure of education within CAAD which aims to provide an understanding of the possible ways of integrating CAAD. Regarding to CAAD applications the study shows that these applications are divided in three levels; introductory, intermediate and advanced level. These applications should be taught in a hierarchy starting from introductory level to the advanced one. Also, they should be formed in a structure that can be changed to fit the new developments in CAAD and ICT applications.

5.2. Future Suggestions

- The theory of education within CAAD and other digital applications should be discussed further. Such a discussion should clarify the extent of integrating CAAD into education and identifies the aims and objectives of this integration.
- It could be helpful to develop a global structure for CAAD education to be a guide for architectural schools in teaching this tool especially for architectural schools in developing countries.
- It is useful to evaluate and revaluate the education process to ensure that it goes in a parallel way with the practice field and to be informed of up to date CAAD and ICT applications.
- It is important to share experience and latest concepts in CAAD implementations and integrating of CAAD in architectural education.

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ELECTRONIC RESOURCES

- http://www.acadia.org
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- http://desktop-publishing-software-review.toptenreviews.com
- http://www.eaae.be
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- http://mbinfo.mbdesign.net/CAD1960.htm
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- http://www.wikipedia.org

APPENDIX

-A-

1. **ACADIA:** The Association for Computer-Aided Design in Architecture. Formed in the early 1980's for the purpose of facilitating communication and critical thinking regarding the use of computers in architecture, planning and building science. A particular focus is education and the software, hardware and pedagogy involved in education (http://www.acadia.org).
2. **ADDA:** The American Design Drafting Association. A non-profit professional membership organization was born in Bartlesville, Oklahoma in 1948. The original philosophy of the organization is to support all drafting people, those on the board as well as supervisory personnel. (http://www.adda.org).

-C-

3. **CAADRIA:** Computer Aided Architectural Design in Asia. Founded in 1996 with a conference at The University of Hong Kong that was organized with significant support from Japan. The association took root and has flourished with annual conferences in nine different countries all around Asia. (http://www.caadria.org).

-D-

4. **Derna (or Darnah)** is one of the municipalities of Libya. It is in the northeast of the country. Its capital is Darnah. The city of Darnah is the location of the historical city of Derna. Its population is approximately 80.000 people.

-E-

5. **EAAE:** The European Association for Architectural Education. An international, non-profit organization founded in 1975 and committed to promoting the exchange of ideas and people within the field of architectural education and research, and to encouraging the development of the subject throughout Europe. (http://www.eaae.be).
6. **ECAADE:** Education and research in Computer Aided Architectural Design in Europe. A non-profit making association of institutions and individuals with a common interest in promoting good practice and sharing information in relation to the use of computers in research and education in architecture and related professions. eCAADe was founded in 1983 (http://www.ecaade.org).

7. **Existing CAD software** companies and their products (CAD Chronology, Marian Bozdoc, http://mbinfo.mbdesign.net/CAD1960.htm).

Note: The list is far from complete or representative as the CAD business landscape is very dynamic: almost every month new companies appear, old companies go out of business, and companies split and merge. Sometimes some names disappear and reappear again.

Company	Programs
AeroHydro, Inc.	MultiSurf SurfaceWorks
Alibre, Inc.	Alibre Design Alibre Design Xpress
Apperson & Daughters - official website	CadStd Lite CadStd Pro
ASCON	KOMPAS 3D LOODSMAN:PLM
Autodesk	AutoCAD and Architectural Desktop Mechanical Desktop and other components Revit (originally of Revit Technology Corporation) Alias StudioTools
Bentley Systems	Microstation Powerdraft
Cadsoft Corporation	Envisioneer Cadsoft Build APDesign (AutoCAD add-on)
CAD Schroer GmbH	MEDUSA (originally of Cambridge Interactive Systems (CIS) - later a subsidiary Computervision) Stheno
CoCreate (formerly subsidiary of Hewlett-Packard)	OneSpace Designer Modeling (originally called SolidDesigner) OneSpace Designer Drafting (originally called ME10) OneSpace.net (for Internet-based collaboration) Model Manager
DATACAD LLC	DataCAD DataCAD LT o2c_Interactive!
Dassault Systèmes	CATIA COSMOS SolidWorks (originally of SolidWorks Corporation) ACIS 3D Modeler (originally of Spatial Corp.) Euclid-IS (originally of Matra DataVision) Open CASCADE (originally of Matra DataVision) STRIM (originally of Matra DataVision) SmartTeam (originally of Smart Solutions) ENOVIA Delmia (originally of Deneb Robotics Inc.) Abaqus
Gehry Technologies - official website	Digital Project™ - 2004 press release Version R2 (based on CATIA) - 2005 press release
General CADD Products, Inc.	General CADD Pro
Graphisoft	ArchiCAD Graphisoft Constructor Graphisoft Estimator Graphisoft Change Manager
Ing.-Buero FRIEDRICH	TARGET 3001!
Informatix	MicroGDS Piranesi
Intergraph	GeoMedia IGDS Intergraph InterAct SmartPlant SmartSketch
IRONCAD	IronCAD
Nemetschek	AllPlan FT
Nemetschek North America (formerly Diehl Graphsoft)	VectorWorks (formerly MiniCAD)
Parametric Technology Corporation	Pro/ENGINEER CADDS 5i (originally of Computervision)

	Pro/DESKTOP Pro/MECHANICA Pro/Concept (originally called CDRS) Windchill Granite ProductView (Division)
Sigma Design	ARRIS - official website Architect's Studio and other components
SOFTTECH GmbH	SPIRIT AVA NTi PRO NTo
STI International, Inc.	SPIRIT AVA NTi PRO NTo
UGS (Formerly Unigraphics Solutions)	NX NX Nastran Parasolid SolidEdge FEMAP EMS (originally of Intergraph) BRAVO (originally of Applicon) I-DEAS (Origianlly of SDRC) Teamcenter
VariCAD s. r. o.	VariCAD
Vero International	VISI-Series (Integrated CAD/CAM) machining STRATEGIST ("Shop Floor" CAM)

-I-

8. **IBM:** (International Business Machines Corporation) Leading U.S. computer manufacturer, headquartered in Armonk, N.Y. It was incorporated in 1911 as the Computing-Tabulating-Recording Co., a consolidation of three office-products companies. In the early 1950s it entered the computer industry, investing heavily in development, and in the 1960s it produced 70% of the world's computers. In 1981 it produced its first personal computer, the IBM PC.
9. **IT:** (Information Technology) general name for methods of calculating and processing information and data communications.

10. Questionnaire presented to fourth and fifth year's students at University of Derna-Libya:

إستبيان عن برامج الرسم بإستخدام الحاسوبCAAD Questionnaire

هذا الإستبيان هو جزء من بحث ماجستير عن مناهج وطرق تدريس برامج الرسم المعماري بإستخدام الحاسوب (CAAD). والشريحة المستهدفة في هذا البحث هي طلبة السنتين الأخيرتين في قسم الهندسة المعمارية. والهدف من البحث هو معرفة وتقييم مستوى الطلبة وكيفية إستفادتهم من المنهج المقرر خلال فترة دراستهم عن برامج الرسم المعماري بإستخدام الحاسوب (CAAD).

This questionnaire is a part of a thesis about CAAD education. The Sampling Group which this questionnaire is interested in is the students of the last two years of the architectural department. The purpose of this questionnaire is to define the level of the students and their competence in using CAAD programs.

T H E Q U E S T I O N N A I R E أســـــــــــــــــــألة الإستبيـــــــــــــــــان

General Information about the Participants معلومات عن المشترك في الإستبيان

Name الإسم: …….…… Age العمر: …… Academic Year السنة الدراسية: ……

Students Competence in Usage of Computer in General قدرة الطلبة على الإستخدام العام للحاسوب

- How is your knowledge about using computers?
- كيف هي معرفتك بإستخدام الحاسوب؟

□Very Bad ضعيفة جداً □Bad ضعيفة □ Medium متوسطة □Good جيدة □Very Good جيدة جداً

……

- How do you can manage files on computers (copy, move, delete, etc)?
- كيف تستطيع تنظيم الملفات على الحاسوب (تحريك, نسخ, حذف ... إلخ)؟

□I Cannot لا أستطيع □Hardly أستطيع بصعوبة □Easily بكل سهولة

……

- How is your knowledge about installing and uninstalling software?
- كيف هي قدرتك على تخزين وحذف البرامج؟

□Very Bad ضعيفة جداً □Bad ضعيفة □ Medium متوسطة □Good جيدة □Very Good جيدة جداً

……

Competence in CAAD Programs Usage قدرة الطلبة على إستخدام برامج الرسم بواسطة الحاسوب

- How do you evaluate your usage of CAAD programs in 2D drawings?
- كيف تقيم مستواك في الرسم ثنائي الأبعاد بإستخدام برامج الرسم الهندسي بإستخدام الحاسوب؟

□Very Bad ضعيفة جداً □Bad ضعيفة □ Medium متوسطة □Good جيدة □Very Good جيدة جداً

……

- Your abilities in drawing curved objects in 3D drawings?
- كيف تقيم مستواك في الرسم ثلاثي الأبعاد بإستخدام برامج الرسم الهندسي بإستخدام الحاسوب؟

□Very Bad ضعيفة جداً □Bad ضعيفة □ Medium متوسطة □Good جيدة □Very Good جيدة جداً

……

- Which programs from followings do you have an experience about?
- أي من البرامج التالية لديك خبرة عليها؟

□AutoCAD □3D MAX □ ArchiCAD Other أخرى: ……

……

- Have you ever used CAAD programs to represent your projects?
- هل إستخدمت برامج الرسم الهندسي بإستخدام الحاسوب في مشاريعك؟

□ Yes نعم □ No لا

……

CAAD Lectures محاظرات برامج الرسم بالحاسوب

- Do you think the time of CAAD lecture is enough?
- هل تعتقد أن الزمن المخصص لمحاظرات برامج الرسم بالحاسوب؟

□Not Enough ليست كافية □Enough كافية □Much Than Required أكثر من الحاجة

……

- How do you think CAAD programs are easy to learn?
- كيف تقيم سهولة تعلم وفهم برامج الرسم الهندسي بإستخدام الحاسوب؟

□Very Easy سهلة جداً □Easy سهلة □ Medium متوسطة □Hard صعبة □Very Hard صعبة جداً

……

- How is your level in CAAD lecture?
- كيف هو مستواك في مادة الرسم بواسطة الحاسوب؟

□ Low منخفض □ Medium متوسط □ High مرتفع

……

- What is the best advantage that CAAD software provides?
- ما هي أهم المميزات التي تقدمها برامج الرسم بواسطة الحاسوب؟

□ Precision الدقة المتناهية □ Decreasing Time تقليص الوقت □ Experience the Form on the Screen معاينة التصميم

……

- Have you improved your abilities by using CAAD software?
- هل ساعدتك الدروس والمحاظرات عن برامج الحاسوب في تطوير قدراتك على إستخدام هذه البرامج؟

□No لا □Not Enough ليس بالدرجة الكافية □ Yes نعم

……

Finish and thank you for your time إنتهى وشكراً على تخصيص وقتك لإملاء الإستبيان

-S-

11. **SiGraDi:** Ibero American Society for Computer Graphics. The largest Latin-American association of computer graphics in design (http://www.datarq.fadu.uba.ar/sigradi/).

-V-

12. **Virtual Reality (VR):** A computer-generated environment simulates reality by means of interactive devices that send and receive information and are worn as goggles, headsets, gloves, or body suits. The illusion of being in the created environment (telepresence) is accomplished by motion sensors that pick up the user's movements and adjust his or her view accordingly, usually in real time. The basis of the technology emerged in the 1960s in simulators that taught how to fly planes, drive tanks, shoot artillery, and generally perform in combat. It came of commercial age in the 1980s and is now used in games, exhibits, and aerospace simulators. It has potential for use in many fields, including entertainment, medicine and biotechnology, engineering, design, and marketing. (Britannica Concise Encyclopedia, Oxford University Press, 2004)