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Effects of the Use of Computer Aided Design (CAD) on Architecture: A Quantitative Approach

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Abstract

Over the last few years, literature has vehemently advocated the negative effects of the use of CAD in architectural practice and education. It was discussed to have a retrogressive effect on the mental efficacy of contemporary students in institutions and largely, architects in practice. Meanwhile, the older methodology of drafting was position in a better light, against the status quo of the use of Computer - Aided Design (CAD) in design process. Therefore, this research is a moralist polemics voice against such blanket assertions. It purports to examine the validity of the objectives of existing literature before positing a curative remedial. In that vein, the aim of this study is objectively on binary stances; primarily, to quantitatively compare and contrast the benefits and limitations of the use of Computer - Aided Design (CAD) and traditional methods in architectural practice and education. Secondarily, it aims to vehemently aggrandize, if the use of Computer - Aided Design (CAD) should be encouraged in continuity or should be ended on the accounts of the synopsis of identified CAD users. Hence, to attain the full phenomena of this vast aim, an array of interdependent schemata was developed to organise the boundaries of the scope. The typology of methodology peddled is the quantitative stereotype. Secondary data for theoretical framework was collected from the professionals' perspective - via journals, books and data bases. The scope of this study looks into the perspectives of twenty students and lecturers within the Department of Architecture - Cyprus International University that use Computer - Aided Design (CAD) for their day to day architectural drafting and presentations. The accounts of the interview of twenty (20) Computer-Aided Design (CAD) users in the Department are being used as the yardstick for the progressive summation. This was achieved by evaluation of respondents' CAD works as well as intensive interviews with individuals in context. This study posits that the successful analysis of this vast purpose will fill the void which exists in the contemporary literature. Furthermore, it postulates that more innovations should be encouraged to produce more enhanced architectural designs. The identified benefits and limitations of Computer-Aided Design (CAD) on users will be a kernel for the furtherance of similar academic research in the future.

Keywords

Architectural Practice, Architectural Education, Computer-Aided Design (CAD), Computer-Aided Drafting, Computer Software, Two-dimensional (2D) Space, Three-dimensional (3D)

1. Introduction

Ever since the advent of Information Technology (IT) over the last few decades, architecture professional practice and architectural education have been at the fore front of fervent consumption of the digital prowess in their various unique rights. Invigoratingly, it was being argued by Andia [1] that architectural school has provided the vehement spring board for reshaping the scope of the profession. Architectural schools have been the experimental laboratory for the perpetuation of new experimental architectural imagination and further an avenue to extend architectural realms to the cyberspace.

However, according to Dunn [2], Architecture has been overtime regarded as a jurisdiction with dual interdependent core activities, namely: designing and making. These binary pivotal activities moreover, are dependently transitive in a persistent dialog as ventures advancement from ideas, through configuration improvement, to last idea - normally, the realization of a building. The capacity to successfully convey imaginative thoughts remains a focal part of

Architecture. With the advancement of various Computer-Aided Design (CAD) and other programming bundles, the mixture of configuration procedures accessible to planners, which may impact the fabrication of architecture and its components, is greater than ever.

Moreover, Computer-Aided Design (CAD) is used in many design fields such as Architectural, Mechanical and Engineering fields in the design of all kinds of machinery. CAD is being employed in the drafting/design of all types of buildings such as residential buildings as well as industrial structures as it substitutes tedious manual drafting with an automated development. Computer-Aided Design (CAD) is more resourceful and accurate because the software records lines as vectors based on mathematical calculations [3]. CAD software includes Auto CAD (typical Auto CAD drawing is shown in figure 3), Revit Architecture (typical AutoCAD drawing is shown in figure 5) by Autodesk, DataCAD by DATACAD LLC, Free CAD by Juergen Riegel, Chief Architect Software and ArchiCAD (typical AutoCAD drawing is shown in figure 6-7) by Graphisoft.

1.1. Problem Definition

Over the last few years, literature has vehemently advocated the negative effects of the use of CAD in architectural practice and education. It was discussed to have a retrogressive effect on the mental efficacy of contemporary students in institutions and largely, architects in practice. In the professional practice however, paradoxical arguments exists in literature as to whether information technology has a bearing on increasing efficacy of the user or it is a mere compulsive tool compelled on the contemporary generation by this era of advancement [4], [5], [6]. It was argued that the efficacy of computer instructor has been significantly low ever since the advent of technology and it is negative in relation to that of the students [7]. Meanwhile, the older methodology of drafting (see figure 1-2) was position in a better light, against the status quo of the use of Computer-Aided Design (CAD) in design process.

1.2. Aims of Study

Therefore, this research aims to be moralist polemics voice against such blanket assertions with the intent of filling the void that exist in literature today. It purports to examine the validity of the objectives of existing literature before positing a remedial. In that vein, the aim of this study is objectively on binary stances; primarily, to quantitatively compare and contrast the benefits and limitations of the use of Computer-Aided Design (CAD) and traditional methods in architectural practice and education. Secondarily, it aims to vehemently aggrandize, if the use of Computer-Aided Design (CAD) should be encouraged in continuity or should be ended on the accounts of the synopsis of identified CAD users.

1.3. Methodology of Study

Hence, to attain the full phenomena of this vast aim, an array of interdependent schemata was developed to organise the boundaries of the scope. The typology of methodology peddled is the quantitative stereotype. Secondary data for theoretical framework was collected from the professionals' perspective-via journals, books, Open Science data base, Elsevier Science Direct and School libraries and data bases. The scope of this study looks into the perspectives of twenty students and lecturers within the Department of Architecture-Cyprus International University that use Computer-Aided Design (CAD) for their day to day architectural drafting, teaching and presentations. The accounts of the interview of twenty (20) Computer-Aided Design (CAD) users in the Department are being used as the yardstick for the progressive summation. This was achieved by evaluation of respondents' CAD works as well as intensive interviews with individuals in context.

2. The Theoretical Framework

"Computer-aided design (CAD) refers to the process of using computers and specialist software to create virtual three-dimensional models and two dimensional drawings of products. Various different types of CAD software have been developed for use across a range of applications and industries" [3]. Invigoratingly, Computer-Aided Design (CAD) in this context is generally computer software used by computer systems to generate, alter or optimize a design and to support in precision drawing [8]. According to Sapidis [9], it is also known as Computer-Aided Drafting. Computer-Aided Design (CAD) is either in two dimensional (2D) or three dimensional (3D) formats and used to design curvatures and figures or curves, surfaces, and solids in in two-dimensional-2D (see figure 7) space or three-dimensional (3D) space (see figure 6).

Computer-Aided Design (CAD) can be separated into three different types: 2D drafting (as graphically shown in figure 4) systems like Auto CAD LT (also known as Auto CAD Light); 3D solid feature modellers like Chief Architect, Archi CAD (as palpable in figure 6), Vari CAD, SolidWorks and SolidEdge; and high-end 3D hybrid systems like Pro/ENGINEER and NX (Unigraphics). On the other hand, visualisation as explained by Pilkaite [10], is a contemporary design tool which aids the representation of different types of infrastructure. However, visualisation became an important 3D object for presentation and advertising purposes (as shown in figure 6). With Visualisations, objects are simulated with exactness of how they will look in real life without the need for expensive external resources.

2.1. The Emergence of Computer Aided Designs (CAD) Software

Computer-Aided Design (CAD) is a design / drafting tool that has been in existence for a long period of time as an innovation for designers using drafting table and drawing instruments. The interface for the use of CAD software is usually a mouse or trackball or pen and tablet. It was explained by Andia [2] that the use of CAD emerged in the mid-1970 and mid-1980 owing to the widespread of personal

computers (PC) and commercial scaled CAD that came into existence. However, not until early 90's that the use of CAD attained full recognition and became a rudiment in the curriculum of architectural education. Also, in this early 90's CAD proficiency became a prerequisite for the acquisition of employments by graduates. The ratio of computer per student surged from 1:50 to 1:10 in the 90's [5]. Contemporarily, with the advent of advancement, student can afford individual computers as the ratio is now of the vehement rise.

Generally, Computer-Aided Design (CAD) is not only used in the field of architecture but also to produce technical drawings for a wide range of industries. However, this research focuses on Architecture. According to Dong & Gibson [4], CAD technological development in three dimensional drawings, three dimensional digital model and computer simulation can provide new approach for designers to find more solution in schematic design process. Architectural design is described by Sanders [6] and Demirkan [11] as a repetitive process where the process scheme is until the best solution is achieved.

CAD systems generally used to represent the ultimate result of the design initially but later, the era of faster computers and 3D modelling emerged and took CAD to the next level. The recent developments in computer technology allow CAD technology to be used in decision making during the design process and not only for producing drawings [12].

2.2. Effects of Computer-Aided Designs (CAD) On Architecture

"The machine is the architect's tool -whether he likes it or not. Unless he masters it, the machine has mastered him" Arc. Frank Lloyd Wright.

No matter how much CAD has helped in producing designs, the designer will encounter limitations in the use of CAD. As he or she tackles these limitations, more knowledge of computer programming is required. Computer-Aided Design (CAD) has had a radical impact upon the teaching, learning and practice of design [13]. One can create conceptual detailed designs of 2-D and 3-D drawings, environmental impact reports, manipulate the shape of images and tackle more complex design problems in faster time with the aid of CAD. CAD technology existence in architecture has two primary objectives which are to be applied in human cognitive design process through the computing smart technology and to become an idea representative media in architectural design process [14, 15]. Therefore, the effects of the use of Computer-Aided Design (CAD) will be discussed under the following aegis.

2.2.1. Effects of Computer-Aided Designs (CAD) On Architectural Practice

As opined by Andia [16], the architectural practices have followed the lead of technology as also exemplified by other industries. Generally, professional architects use CAD on only binary stances which include; at the level of work procedure and professional ethos, secondly, at the prowess level. According to Dong and Gibson [4], the digital model in this context gives chances for the architect to think, picture, connect and make assumptions in designing process. CAD software is very interactive and most advanced software is loaded with various simulations to assist in producing better visual concepts of designs.

Andia [1] also explained that CAD transforms traditional methodologies of design construct employed in drawing, reports and documentation. More so, Novitski [15] explained that as regards the architectural institutions like Frank Gehry & Associate suggested that a more technological friendly system does not only facilitate design efficiency but also disgraces traditional design procedures.

2.2.2. The Effects of Computer-Aided Designs (CAD) On Architectural Education

Architectural schools have overtime provided the kernel for the experimenting of various architectural imaginations. Hence, according to Salama &Wilkinson [17], the advancements of digital technology and design have grotesque bearings on the approaches of architectural education in recent times. The evolution of information technology (IT) however, is known to be redefining the ethos of the construct of architectural education. Moreover, there were argumentative responses by Reffat [18] that the use of CAD in architectural drawing is robbing the traditional method of hand drafting and craft modelling of its very significance in the development of rationalisation of design ethics. Brown [13] also opined that that the influx of CAD into architectural education have overridden the traditional methods of drafting by emasculating the advantages of the relationships which should exist between student to student and student to instructor, which is a canonical interaction in architectural education.

Lawson [5] and Robertson, Walther & Radcliffe [19] claimed that CAD does not improve designing to anywhere near the extent of the opposed publicity of CAD vendors that claim CAD improves designing or how we were meant to believe. Also, Dutch architect Herman Hertzberger in his book stated that CAD is not a creative design tool as it is the real depiction of real creativity rather a fake one as the software suggests how the outcome of the design would be. He greatly criticised the use of CAD as drafting tool in his book "Lessons for Students of Architecture".

As regards the negative impacts of the use of the CAD softwares, Lawson [20] claimed that "before computers, the student architect had to learn to draw in order to design and also in order to see and record. It was of course possible that very poor architecture could be presented so beautifully that one was deceived… We are in danger of creating a generation of young architects who are highly skilled with computer software and yet have little visual sensibility" (p.385). Robertson and Radcliffe [21] also claims that the most vital aspect of design education is the student to student or face to face social interaction which CAD has taken away.

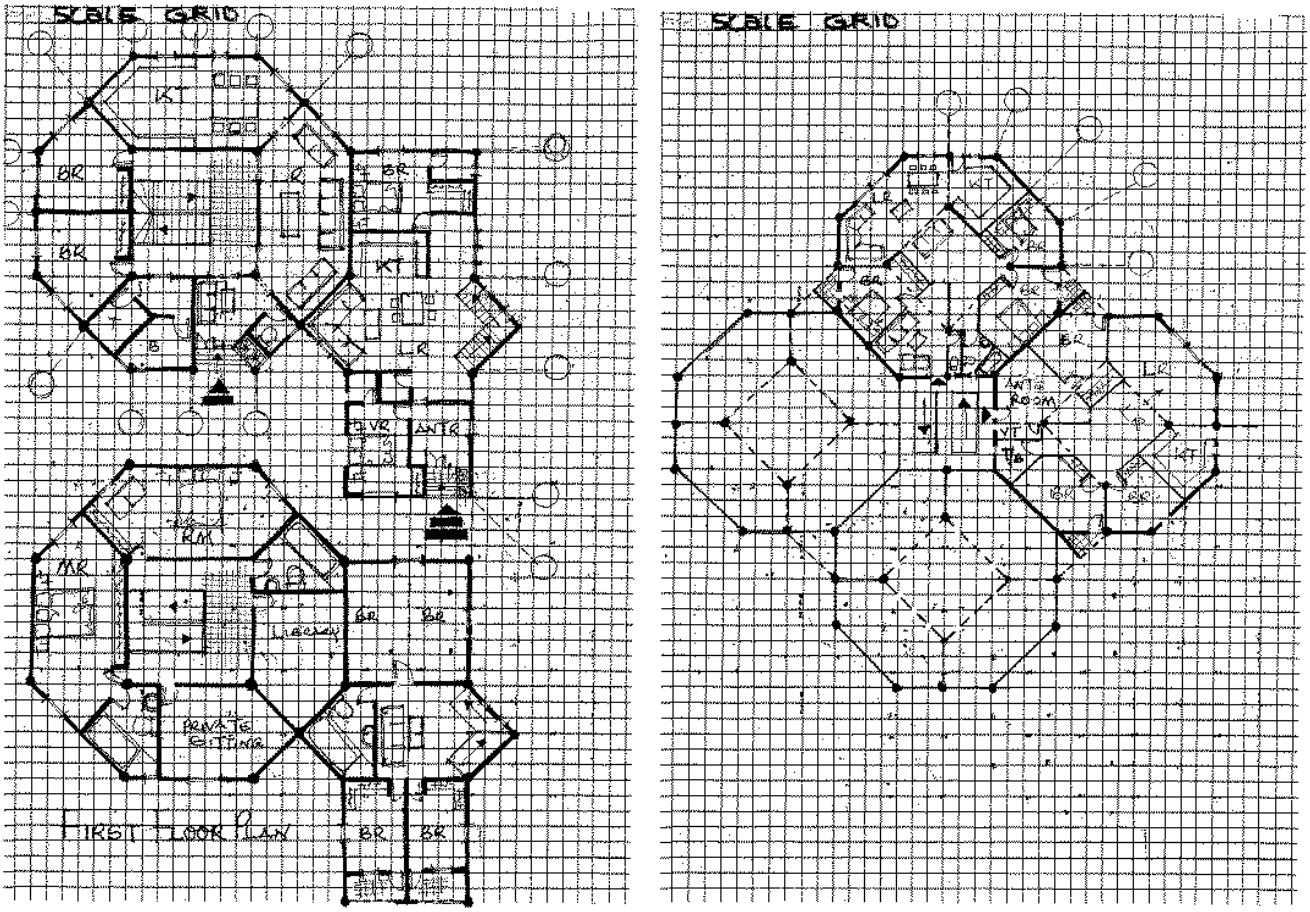


Figure 1. *Typical 2D floor tessellation plan done using traditional method (source: by Author).*

Figure 2. *Typical 3D using traditional method (source: Moustafa Elshindidy, 2006).*

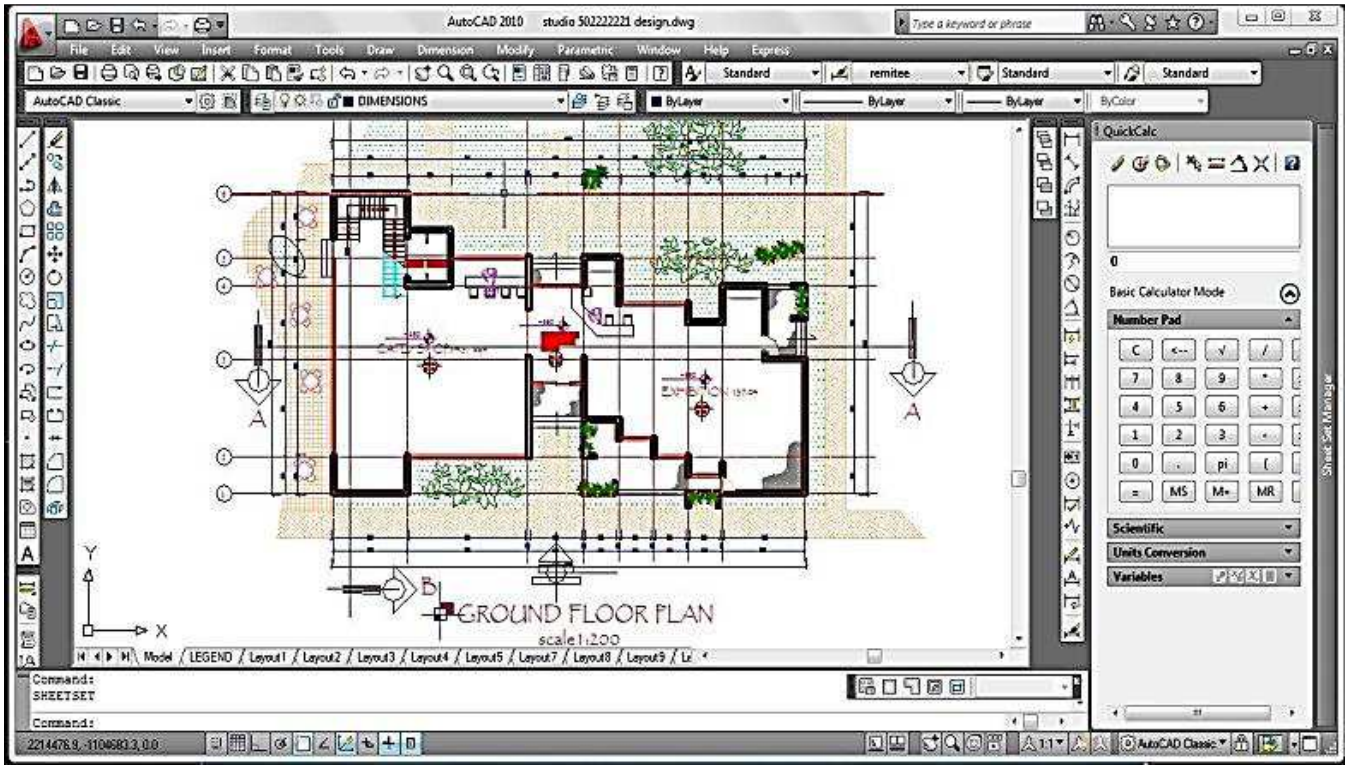


Figure 3. *Typical 2D drawing (floor plan) done with AutoCAD 2010 interface (Source: by author).*

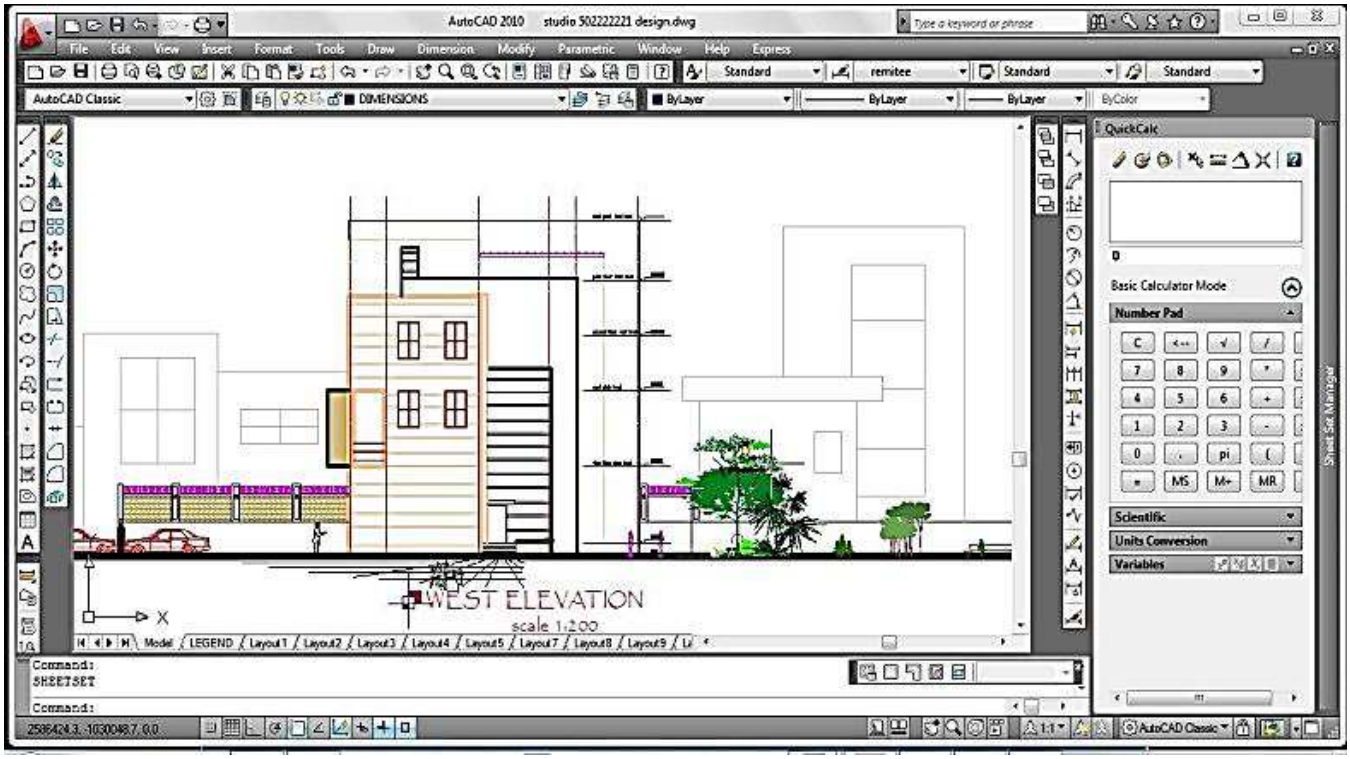


Figure 4. *Typical 2D drawing (elevation) done with AutoCAD 2010 interface (Source: by author).*

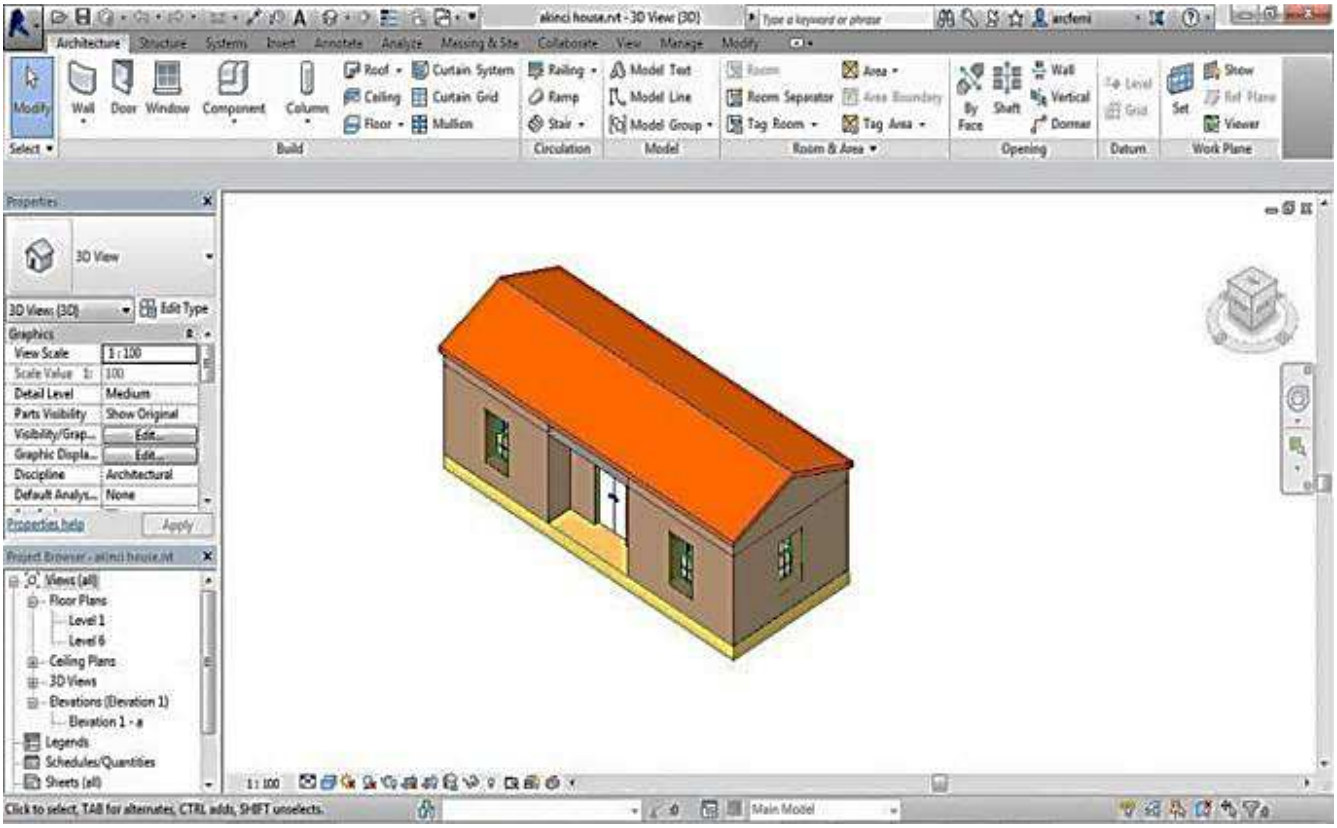


Figure 5. *Typical simple 3D drawing done using Revit Architecture software (source: author).*

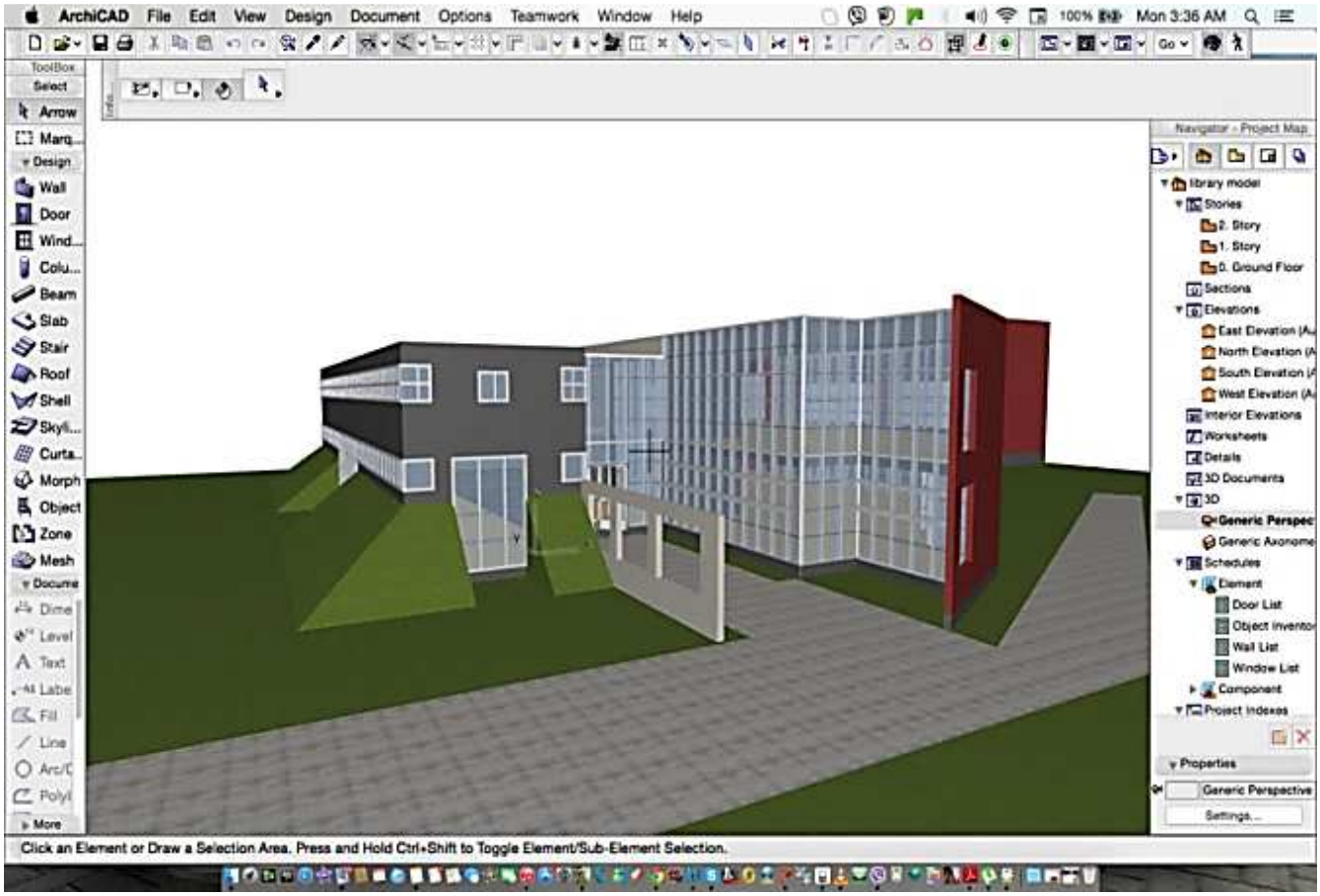


Figure 6. *Typical simple 3D drawing done using ArchiCAD software (source: author).*

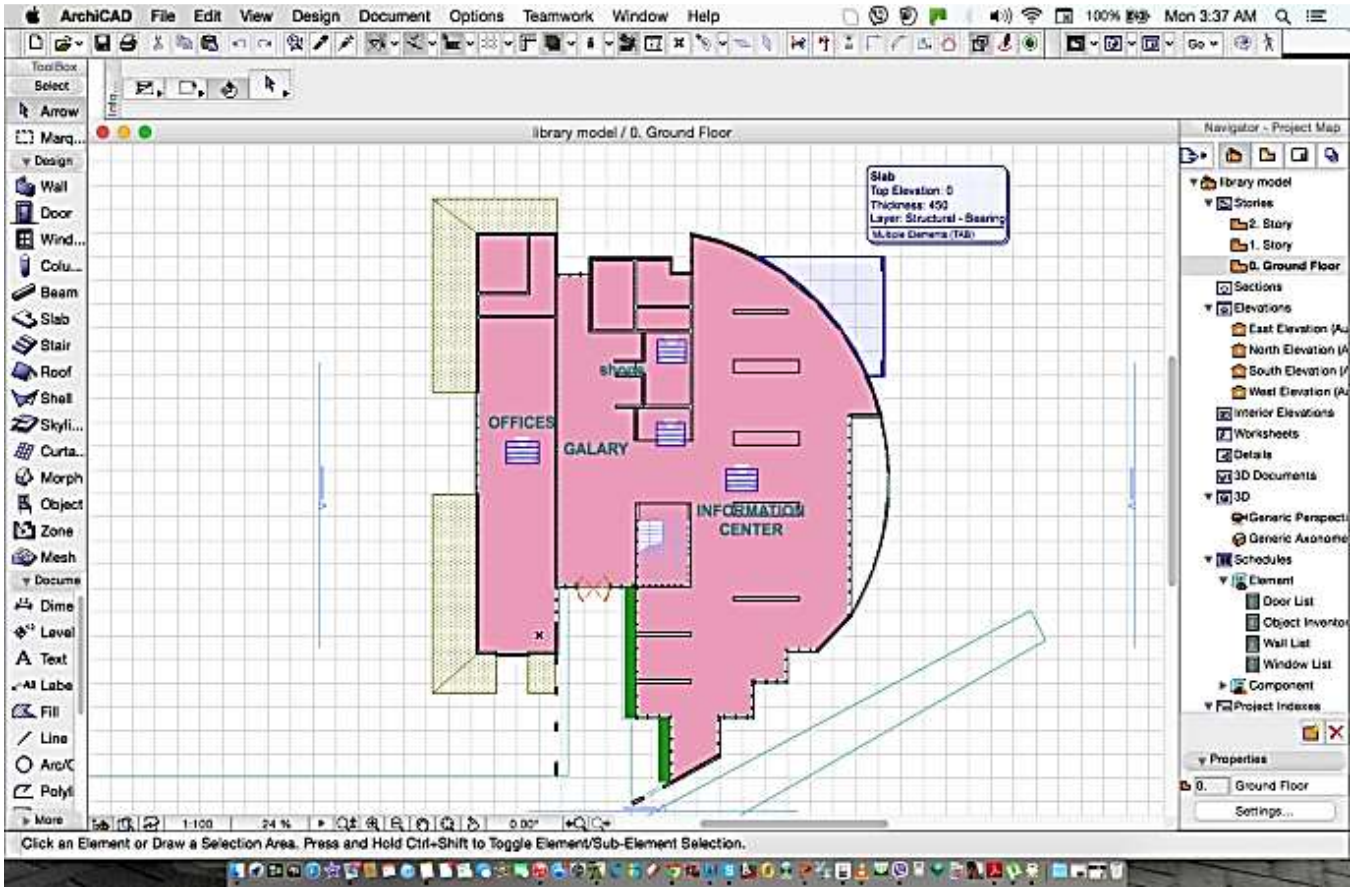


Figure 7. *Typical simple 2D drawing (floor layout) done using ArchiCad software (source: author).*

3. Methodology

Methodologically, this paper peddles a unique credo which primarily entails systematic collection of date through a transitive and inter-dependent array of schemata. This schema however, aims at identifying, examining, determining specific canonical summations. It is worth stressing however, that this methodology is a quantitative research approach. The empirical data garnered from the interview would be analysed (pictorial and chart analyses) quantitatively and processed using SPSS 12.0 for windows.

3.1. Study Area

The study area is the Department of Architecture of Cyprus International University, Nicosia in North Cyprus. The university was established in 1997 and is one of the few universities on the Island - Cyprus.

3.2. Participants' Selections

Interviews were conducted with twenty (20) respondents of the Department of Architecture. The respondents include Professors, Associate professors, Assistant Professors, Instructors, Research Assistants and students of the department. Office hierarchy of the respondents also included the Dean to the students in the department. The interview was conducted with both men and women randomly in no ratio. However, it was palpable that the participants were already aware of the research problems, hence, they participated voluntarily.

3.3. Data Collection Procedures

Owing to the typology of methodology adopted in this research process, the primary data were collected via the intensive open ended interview with lecturers and students of the Department of Architecture, Cyprus International University. Secondary data for theoretical framework was collected from professionals' perspective-via journals, books.

3.4. The Open Ended Interview

The open ended interview was conducted with the respondents to ascertain their responses to certain parameters. The questions were therefore structured in four phases which includes the following:

- Part one: Bio data (sex, designation, level)
- Part two: questions determining preference of CAD and traditional method
- Part three: questions about time and cost efficiency of the use of CAD in comparison to traditional method
- Part four: Questions about their preference of CAD software and the quality of the design done using the Computer-Aided Design (CAD) in comparison to traditional methods.

3.5. Data Presentations

The findings include the following data gathered from the interviews with the twenty respondents (lecturers and students) within the department of Architecture in Cyprus International University.

Part one: Collection of the bio data of the respondents. This is to determine the frequency of the respondents.

I Question: Sex of respondents

As palpable in table 1 above, 60% of the respondents are male while 8% are females.

Table 1. *Sex of respondents.*

S/N	Sex	Frequency	Percentage (%)
1	Male	12	60%
2	Female	8	40%
	Total	20	100%

As palpable in table 1 above, 60% of the respondents are male while 8% are females.

II Question: Occupation of respondents

As seen in table 2, 60% of the respondents were lecturers with designation ranging from Prof. Dr. to Research Assistants in the department of Architecture while 40% of the respondents are students.

Table 2. *Distribution of respondent's Occupation.*

S/N	Occupation/ Designation	Frequency	Percentage
1	Lecturer	12	60%
2	Students	8	40%
	Total	20	100%

Part two: Questions about their preferences and attitudes of the lecturers and students of the department towards the use of Computer-Aided Design (CAD) in comparison to traditional methods.

1 Question: *What is your attitude towards Computer-Aided Design (CAD) compared to traditional methods?*

As shown in Figure 8, majority (90%) of the respondents have positive attitudes to the use of CAD over the use of traditional methods. However, 5% of the respondents were indifferent and 5% also had negative attitudes to the use of CAD.

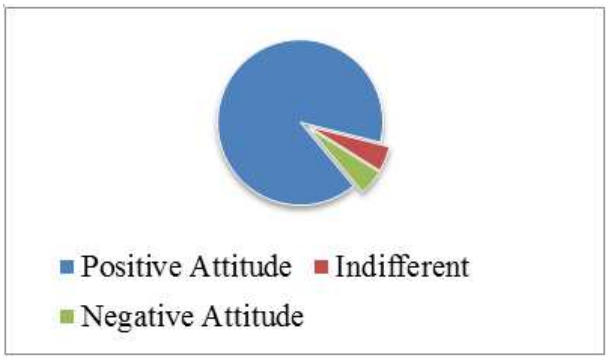


Figure 8. *Responses to questions pertaining to attitude towards the use of CAD.*

2 Question: *What is your preference between Computer-Aided Design (CAD) and traditional methods?*

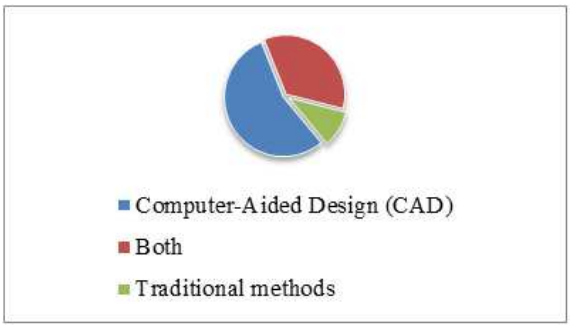


Figure 9. *Responses to questions pertaining to preference towards the use of CAD.*

As shown in Figure 9, bulk (55%) of the respondents prefers to use Computer Aided Design over traditional method of drafting. However, 35% of the respondents prefer the combination of both traditional method and CAD methodology while 10% prefer the use of traditional drafting process in architectural practice and education over the use of CAD.

Part three: Questions about the time and cost efficiency of the use of Computer-Aided Design (CAD) in comparison to traditional methods.

3 Question: *What is the Design time frame for Computer-Aided Design (CAD) compared to traditional methods?*

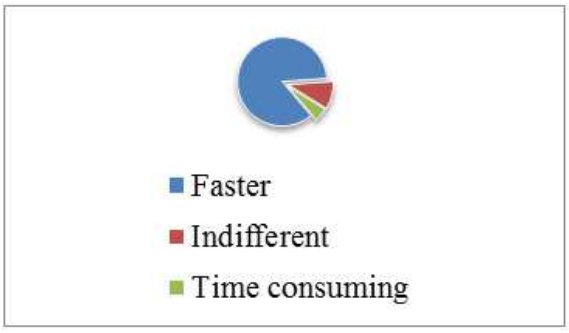


Figure 10. *Responses to questions pertaining to design time frame of the use of CAD.*

As shown in Figure 10, bulk (85%) of the respondents attests to the fact that use of Computer Aided Design (CAD) is more time efficient than traditional method of drafting. However, 10% of the respondents are indifferent while 5% thinks the use of CAD is slower than traditional drafting process in architectural practice and education.

4 Question: *What is the Cost efficiency for Computer-Aided Design (CAD) compared to traditional methods*

As shown in Figure 11, majority (85%) of the respondents attests to the fact that use of Computer Aided Design (CAD) as being more cost efficient than traditional method of drafting. However, 5% of the respondents are indifferent while 5% thinks the use of CAD is less cost efficient than traditional drafting process in architectural practice and education.

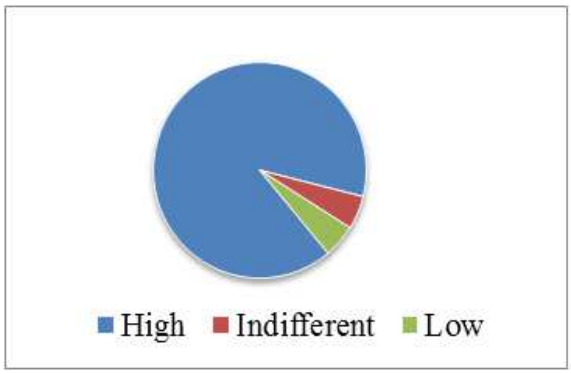


Figure 11. *Responses to questions pertaining to cost efficiency of the use of CAD.*

Part four: Questions about their preferences of CAD software and the quality of the design done using the Computer-Aided Design (CAD) in comparison to traditional methods.

5 Question: Quality of design between Computer-Aided Design (CAD) and traditional methods

Figure 12 explains that the majority (90%) of the respondents says the quality of projects done using Computer Aided Design (CAD) are usually of higher quality than traditional method of drafting. However, 5% of the respondents are indifferent while 5% thinks the designs done using CAD is of lesser quality than that of the traditional drafting process in architectural practice and education.

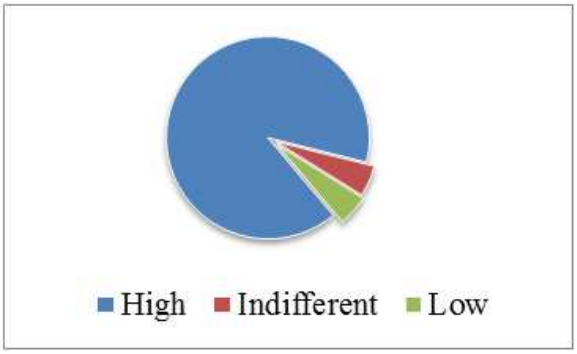


Figure 12. *Responses to questions pertaining to quality of designs done by the use of CAD.*

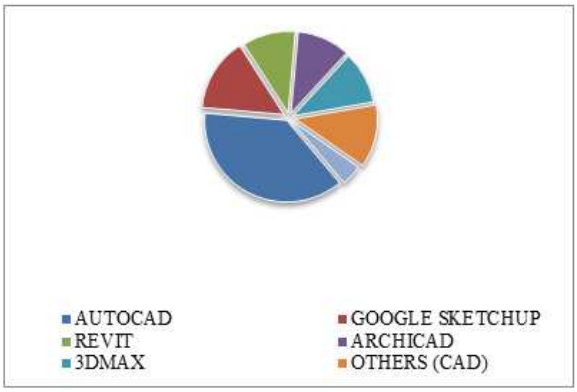


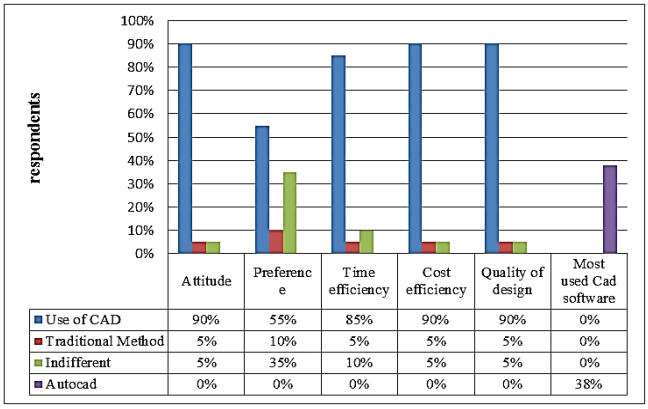
Figure 13. *Responses to questions pertaining to cost efficiency of the use of CAD.*

6 Most Computer-Aided Design (CAD) used for designs

As palpable in Figure 13, the majority (38%) of the respondents are users of AutoCAD software, while 15% of the respondents are users of Google Sketch Up. Moreover, 10% of the respondents use ArchiCAD, 10% use 3D max as 13% use other unconventional CAD softwares while 4% of the respondents still use the traditional method for the drafting process in architectural practice and education.

3.6. Discussions of Empirical Data

Owing to the empirical data garnered from the interviews and as summarised in Figure 14, it can be seen that majority of the respondents use the Computer-Aided Design (CAD) for their daily design executions as it is known to be faster, more cost efficient, of higher quality and has better presentation as it provides various ways to execute a design project that visual representation / realization.



	Attitude	Preference	Time efficiency	Cost efficiency	Quality of design	Most used Cad software
Use of CAD	90%	55%	85%	90%	90%	0%
Traditional Method	5%	10%	5%	5%	5%	0%
Indifferent	5%	35%	10%	5%	5%	0%
Autocad	0%	0%	0%	0%	0%	38%

Figure 14. *Summative chat for the analysis.*

However, for the indifferences and referencing to traditional methods of designing in some of the data retrieved from the interviews, it can be deduced that such respondents are either compelled to the use of these software due to the technology era we are in or were trained in Architectural schools as at the period before the innovations of Computer-Aided Design (CAD) and technology evolution.

4. Conclusions

At this point, it will be considered peddling the wad of a tired gum to further attempt to panegyrize the benefits of the use of Computer-Aided Design (CAD) in Architecture. As proven by the respondents, the use Computer-Aided Design (CAD) has overriding advantages over the traditional design construct. Such merits includes, improved level of productivity, improved design quality, lower design development costs and enormous time efficiency to meet up deadlines.

Generally, Computer-Aided Design (CAD) is a mere tool that assists the drafting procedure. It has no place in the thinking process and has very little influence on the initial stages of design. It is only a physical tangible tool which transforms the abstraction of the user into reality on the paperless board just like the old traditional methodology of

drafting does too. Therefore, there is no vehement reason to seek an opposing ground to the continuity of the use of Computer-Aided Design (CAD) in architectural practice and education in this era of technological ease and advancements.

As much as contemporary world is compelled to form conformism with the dictate of technological advancements, the place of traditional history as the kernel of progress should be fervently protected. History is the connecting bridge which provides synthesis between the past and the "to-come".

The practice of drawing is the central to the design development in Architecture. Therefore, without forgetting the subject at hand, as a recommendation, the contemporary architecture practice should use the traditional way of sketching before drafting as the canon of the design process. Furthermore, the architectural school's instructors should encourage the students to imbibe the practices of traditional sketching as the basics of the design process. This study posits that the successful fusion of traditional design constructs and technological use of Computer-Aided Design (CAD) will produce excellent amalgam products as finished designs. Thus, in the Architectural trainings as well as practices, there should be a balance in the use of traditional methods as well as the Computer-Aided Design (CAD) as a complete architect that has mastered various techniques to proffer design solutions.

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