

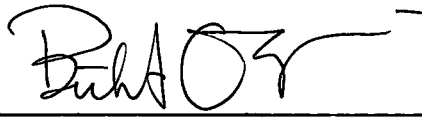
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**PROPOSAL FOR IMPROVING COMPUTER AID TO INTERIOR
ARCHITECTURAL DESIGN**

**A THESIS
SUBMITTED TO THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN
AND THE INSTITUTE OF FINE ARTS
OF BILKENT UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF FINE ARTS**

**By
Burcu Şenyapılı
February, 1993**

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts.



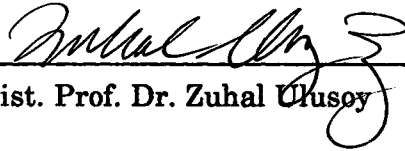
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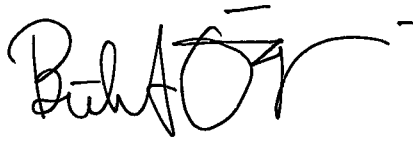
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ABSTRACT

PROPOSAL FOR IMPROVING COMPUTER AID TO INTERIOR ARCHITECTURAL DESIGN

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M.F.A. in Fine Arts

Supervisor: Prof. Dr. Bülent Özgüç

1993

In this work, several proposals are put forth in order to render computer-aid to interior architecture more efficient and easy-to-use. Considering the role of computer in architecture as a design assistant, the factors establishing this position have been discussed. Based on these factors and aspects of interior architecture, proposals are introduced. The proposals aim firstly at creating an interactive design environment where designers do not have to be specialized 'in computers', but 'with the aid of computers'; secondly, at drawing attention to potential areas of study in computer-aid in design related to aspects particular to the profession of interior architecture. Finally, the expected contributions of the proposals introduced are discussed in terms of interior architectural practice and education, discussing the new definition of the profession and future trends.

Keywords: Computer-aided design, interior architecture, design

ÖZET

İÇ MİMARİ TASARIMDA BİLGİSAYAR DESTEĞİNİ ARTTIRMAK İÇİN BİR ÖNERİ

Burcu Şenyapılı

Güzel Sanatlar Yüksek Lisans

Tez Yöneticisi: Prof. Dr. Bülent Özgüç

1993

Bu çalışmada, iç mimarlıkta bilgisayar desteğini daha etkin ve kullanımı kolay kılmak için çeşitli öneriler sunulmaktadır. Bilgisayarın, mimaride 'tasarım yardımcısı' rolünü üstlendiği göz önüne alınarak, bu pozisyonu sağlayan faktörler tartışılmıştır. Bu faktörlere ve iç mimarinin özelliklerine dayanarak öneriler sunulmuştur. Öneriler ilk olarak, tasarımcıların 'bilgisayar üzerine' değil; 'bilgisayar yardımıyla' uzmanlaşmalarına olanak tanıyan etkileşimli bir tasarım ortamı yaratmayı; ikinci olarak, iç mimarlığa yönelik özellikleri göz önüne alarak, gelecekte bilgisayar destekli tasarım alanında ele alınabilecek konulara dikkat çekmeyi amaçlamaktadır. Son olarak, öne sürülen önerilerin iç mimarlık mesleği ve eğitimine yapması beklenen katkılar tartışılmış ve mesleğin yeni tanımı ile gelecek yönelimleri tanımlanmaya çalışılmıştır.

Anahtar sözcükler: Bilgisayar destekli tasarım, iç mimarlık, tasarım.

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I dedicate this work to the loving memory of my grandmother Mesrure Çalkılıç.

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1. INTRODUCTION

Computers are rapidly penetrating almost all contemporary, modern and sophisticated professions. The emergence of computers in every field has been fast and strong, yet, while in some of these fields they have been of extreme help to the process making it easier and faster, in some others emergence of computers has led to the restructuring of the disciplines.

Since computer technology has changed rapidly in the face of an ever-growing and ever-absorbing consumer market and this process of change is still going on full force, it is rather difficult to start a relevant discussion based on definite and proven assertions. Nevertheless, perhaps one dimension of such discussions is their potential to stimulate the human mind and imagination to the opening of new phases.

Architecture, being one of the fields where computers are being used actively is undergoing a drastic change as a discipline since use of computers in this field has proved to be more than a draft assistance. The change in the architectural discipline is not only seen in the structure of the offices and the services available in the architectural market, but architectural education is also reshaping itself with respect to the new qualification demand in the architectural practice.

Interior architecture, on the other hand, is being indirectly affected by emergence of computers in architecture. The reason for this indirectness lies in the fact that computer responds to drafting and design problems in general, discriminating little between different fields of work. It is true that interior architecture, being an indispensable and related extension of

architectural practice, bears strong similarities in defining and solving a design problem, but the particularities of this field must be taken into account when it comes to the issue of integrating computers to interior architectural practice and education.

As computers' penetration in architecture has already proved that computers are more than drafting assistants and may be of use in design, this study aims to search for ways to benefit from the advantages of this new and unprecedented medium at most. On the other hand, as computers change various radical aspects from esthetic tastes to the way information is coded; from demands of the market to ways of communication; from appreciated skills to production flow, it is found essential to study on proposals to improve computer-aid in interior architecture in order to prepare the profession and its education for future trends.

It may be asserted that, both the developments achieved and level of knowledge reached are mature enough to give birth to a big pace in computer technology, big enough to mark a turn in this field. Nevertheless, instead of directing the studies towards such an aim, most of the recent improvements are dealing with producing new software and computing equipment that are derivatives of already existing ones and are oriented towards a small group of users with high market expectations.

Believing that it is time to search for new ways, the aim of this thesis is to put forth general proposals which are believed to be of use in creating a much more comfortable basis in integrating computers to architectural discipline in general and to draw attention to the particularities of interior architecture problem definition and solution so that computers may respond to the requirements of this field on a more relative ground.

Finally, this thesis aims to state the expected changes in interior architecture practice and education if the above requirements are met, and tries to underline the specific alternations in interior architecture education and ways of their fulfillment.

In order to achieve the above stated aims the framework of this thesis is organized as follows:

The Introduction offers a brief history of the use of computers in architecture and draws a picture of the present status of computers in architectural practice and education today, underlining the changes in the architectural discipline which are caused by the emergence of computers in the field.

Chapter 2 starts with a brief history of interior architecture as a discipline and deals with the characteristics of interior architecture problems and the techniques of their solution, and exemplifies some paths upon which computer programs have been based. A table to display the similarities and differences of factors manipulated when handling a design problem between architecture and interior architecture is introduced as well.

Chapter 3 begins with the introduction of computer aided design solution techniques and then concentrates on the present services available on computer for interior architecture. Finally, the chapter ends with proposals for improving computer aid to interior architecture. These proposals, though offered together, can be grouped in two; those which are oriented towards the general use of computers in design field, and those oriented towards employment of computer aid in interior architecture.

Chapter 4 states the expected contribution of integration of computers in interior architecture and tries to put forth proposals to restructure interior design education in order to meet the expected demand from interior architecture market.

Finally, Chapter 5 summarizes what has been said all through the thesis by underlining once more points that are believed to be of ultimate importance.

1.1. Evaluation of the Role of Computers in Architectural Design

With the emergence of computers in architecture, the role of technology in this field has expanded beyond material performance and construction

techniques. Computers in architecture not only demonstrated another dimension of effects of technological progress on creative methodologies of realization and their final results, but also enabled the architectural organism to develop by a constant conjugation of form and technology, form and calculation, form and management (Fonio, 1990). Thus, various phases of architectural design procedure can be carried on together with each other, i.e. being able to make necessary decisions regarding presentation, technical issues, project and construction management as design develops. This not only prevents various operators conditioning the final result, times and modes of the project process (Fonio, 1990) without consulting the architect, but creates an interactive, interdisciplinary basis for architectural design. Finally, when the design is completed, the data to be used in presentation, construction and other necessary documentation are ready as well. These are possible by the construction of a design model in the computer -as will be examined in section 3.1.- which renders analysis of relations -fundamental to architecture- possible without having to convert them into functions. Therefore, CAD (Computer Aided Design), may be defined as a technique which creates and stores the descriptions of the 2-D or 3-D geometrical objects by mathematically modeling them. Thus, a CAD system is capable of constructing, analyzing and displaying these models. While doing that the CAD system may be supported by application programs.

It can be traced from the current literature that, almost all CAD programming can be categorized into four groups; the first of which covers the graphics programs for creating, displaying, transforming geometrical models. The second group covers analytical programs which test the design via real life conditions. Manufacturing programs make up the third group, concentrating upon numerical control (NC). Finally, we are confronted with administrative programming which helps to operate with/between/within the models (Fellows, 1983). Thus, it may be asserted that computer is a medium flexible enough to respond to the flexibility of architectural language.

As there occurs a big lag between the introduction of a technological advancement and its adaption (Fallon, 1990), in evaluating role of computers in architecture it is a hard task to achieve a certain result since the adoption

of computers by architecture is still improving. Nevertheless, it may be stated that computers have reached a certain position in architecture at least through basic issues regarding automation. Based on the research report issued in 1988 by Nolan, Norton & Co., Fallon groups approaches to automation in three groups as *task automation* (where personal computer = personal productivity), *process automation* (involving integrated computer applications enabling information flow from task to task) and *business automation* (involving information access through computers for every staff member where computer becomes part of the office infrastructure) (Fallon, 1990).

Considering the context of loading the burden of a certain, predetermined, repetitive procedure to the machine in the word 'automation', the role of computers in automation of architectural tasks can clearly be set; it expands from automation of single drawings (task automation), to cost estimations, accounting, word processing, engineering analyses, building specifications (process automation) and to the use of computer networks in architectural offices (business automation). Here it may be emphasized that computers are largely being employed to make existing tasks more efficient (Stoker in Ross, 1990), giving less importance to its potential "to take us to places we've never been" (McNealey in Ross, 1990) and to introduce new services to the architect stimulating his imagination.

Finally, considering the role of computers in architecture, it must be noted that they are of use not only in development and presentation of design, but also in the "running" of the design (Vitta, 1990). Here, it is possible to split computer's use in two branches; one being the control of thermal environment, fire alarm and lighting (Vitta, 1990), other being the storage of necessary data for maintenance, management and future changes; i.e. "...making it possible to intervene continually, even at a distance of time, to introduce partial or substantial modifications" (Caputi, 1990).

1.2. History of Architectural Computing

Though short in terms of time, the history of architectural computing covers many different phases due to the rapid improvement of technology. In this section, instead of trying to note down all the developments, it is more appropriate to emphasize the distinct features and paces which may be of use in forming proposals for future, based on learnings from history. Therefore, in order to serve for the purpose of this study, developments in architectural computing are grouped in the following manner:

- i - Drafting and mechanization of the design process
- ii - Integration of color
- iii - Modeling in 3D and visualization in motion
- iv - Artificial intelligence (AI) and virtual reality (VR)
- v - Pen-based systems

Although it was immediately after the Second World War that studies on computers have begun, it was not until 1960's that they were involved in architecture. The milestone for this initial confrontation is accepted as Sutherland's 'sketchpad' which had constituted a medium to draw with / to the computer. Thus, as studies have been carried out to improve drafting methods, mechanization of the design process came into the scene. Along with the first drafting software like URBAN 5 by Negroponte and Groisser (1970), space planning software were also developed like COPLANNER by Souder and Clark (1964) (Mitchell, 1977). These software made use of experimental studies on interactive graphics. On the other hand, software oriented towards evaluation, cost estimation, analysis and engineering calculations being used in architecture established a basis for developments on design optimization, solution improvement and selection, and relational analysis; i.e. developments related to mechanization of design process. Thus, improvements both in interactive graphic systems and mechanization provided the *specially oriented computer aided architecture software* to develop. Later on, by mid 1970's, based on these specially oriented software - each dealing with another aspect of architecture- 'integrated systems' were established; like OXSYS, CEDAR, CARBS, HARNESS, BHD which turned out

to be inefficient because of the lack of proper adaptation to general, need of constant updating and lack of creative solution production capability (Sağlam, 1992).

Consequently, color was being introduced in architectural computing after a period of black-white displays. Thus, the advantages of computer-generated images over standard ones expanded from flexibility of changing the design to experimenting with color (Greenberg, 1982). The best was still to come; but first, the modeling systems had to shift from 2D to 3D. Thus, along with replacement of vector based algorithms with primitive based ones and development of design methods from 'misfit variables' to 'optimization' and finally to 'rule based' systems (Fındıkoğlu, 1990) made 3D modeling and visualization in motion possible.

Shortly afterwards naturally, the CAD market has been confronted with a large number of architectural software boasting not only of 3D modeling and visualization in motion capabilities, but with simulation possibilities of lighting, shade and shadow, environmental analyses [See Appendix A].

As visualization in motion introduced a new dimension to architectural presentation -further details of which will be examined in 3.2.5.4.- , along with modeling in 3D, expert and knowledge based systems marked the period where computer aid had shifted from mere drafting to design. However, latest developments of computer aid in architectural presentation are displayed in the field of virtual reality - further details of which will be examined in 3.2.3.-, whereas in architectural design, they are displayed with artificial intelligence based studies to integrate knowledge based design systems in present CAD systems. According to Sağlam (1990), in the future, it is expected that knowledge based design systems will push aside present CAD systems and will introduce new building modeling systems which are capable of producing original solutions with expert languages. Thus, logical and parametric programming, problem solution and knowledge engineering techniques will bring flexibility and efficiency in CAD systems.

To sum up, by the end of 1980's, with the aid of improvements in computer technology like advancement of speed, increase in memory capacity (Mitchell, 1977) and introduction of microprocessors led to further integration of computers in architecture. This integration was also supported by the emergence of software oriented towards project and office management. On the other hand, as Schmitt underlined: "Microcomputer based interactive programmable drafting programs and analysis packages are setting new standards for design support systems in architectural offices" (Schmitt,1987). Accordingly, design generating software were introduced like 'Mies van der Rohe Generator', 'Richard Meier Generator', Fig.1, (Schmitt, 1987) and Alvar Aalto and Frank Lloyd Wright Generators (Sağlam, 1990). Such software making use of AI studies still constitute a branch for future improvements in computer aid in architectural design. But, based on lessons taken from 'integrated systems', today, the challenge is to develop multi-functional CAD systems equipped with 'special problem oriented' features.

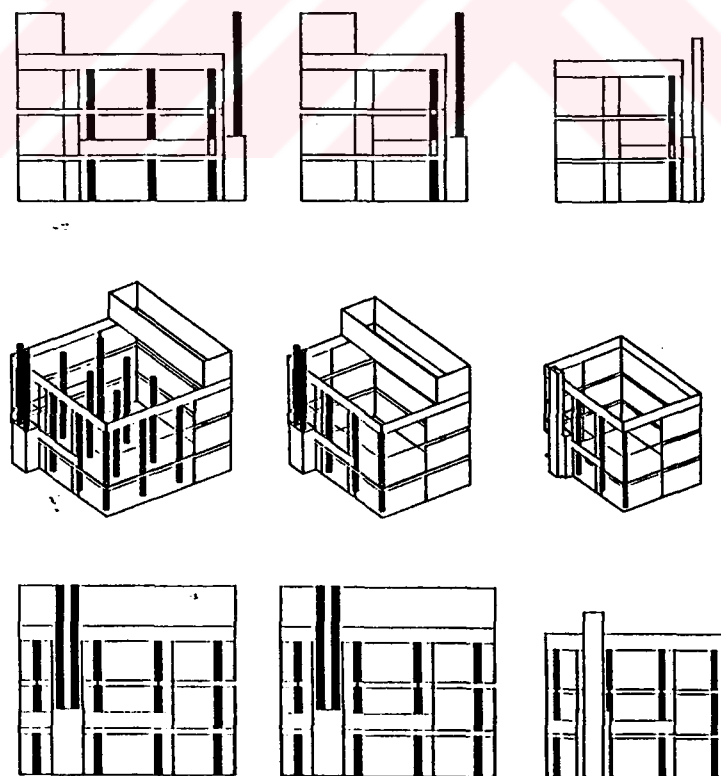


Figure 1. Elevations and axonometrics of 3 buildings by Meier Generator (Schmitt, 1987)

CAAD (Computer Aided Architectural Design) programs mentioned up till now can be compiled in two groups based on Fındıkoğlu's classification (Fındıkoğlu, 1990) in the following manner:

i - CAADrafting

Covers the production of drawings enabling further changes, coloring, scaling, zooming, shading, animating and displaying. Sub-groups being:

- a. 2-D applications are capable of producing orthographic drawings.
- b. 3-D applications are capable of producing orthographic drawings (sections being taken automatically) and producing perspectives supported by shading, coloring and animation.
- c. 3-D primary applications, unlike above groups, are provided with the stored 3D data of the primary elements used during architectural design (walls, doors, windows, plumbing equipment etc.). These overcome the overloading of the memory by the saved blocks during design (e.g.: SONATA).

ii - CAADesign

Covers not only the production of drawings and material for presentation, but is capable of making calculations, storing related data and processing it and giving critiques about the design and evaluating it. These can be considered in two groups:

- a. Data-driven Programs are capable of making engineering calculations, detail drawings and storing personal data. Allow the storing of big projects in detailed form; capable of updating the related data. Unlike drafting programs, produce several design choices based on the given data (eg: OXSYS).
- b. Concept-driven Programs, besides any of the above facilities, making use of AI (Artificial Intelligence) in general, help in evaluating and developing the design, based on the inference mechanism which is fed by the information-base and database.

Apart from these, there are architectural programs not only helping to manipulate energy control, HVAC or related factors of the design but helping to store data on the site analysis and related inferences as well. The future

aim is to combine the best parts of above programs into one big system serving for all architectural operations.

Finally, the latest milestone worth mentioning in the history of architectural computing is the pen-based graphical interfaces which offer the possibility to write, draw, doodle directly to the screen with the aid of a special kind of pen. It may be asserted that the revolutionary capacity of pen-based systems is not less than the initial and similar milestone by Sutherland: the 'sketchpad'. Han admits this expectation of revolution in the way architects use computers as: "One day soon architects on a job site will be able to sketch the fabrication process of a construction detail and have that information immediately linked to the factory, where the operator can follow along and, in return, make suggestions to the architect. ...Pen-based systems will be able to record and display the architect's freehand line and, at the same time, sketched concepts will be able to be translated in to a dimensioned drawing and immediately tested for structural integrity, energy and lighting efficiency, or budget constraints". The revolution will also effect the CAD market, asserts Han, not only with ease of portability, but with rendering available all hardline and modification services of CAD systems at the speed and intuitiveness of drawing with a pen (Han, 1992).

The importance of pen-based systems come from the fact that input devices for architects play a great role in getting familiar with the computer. This can clearly be noticed from the results of the 1991 research among a group of architects about the input devices with the brightest future; where winners turned out to be the 'mouse', 'voice command systems', 'cordless devices' and 'scanners' (Witte, 1991), devices which are easy to use and adapt to and offer flexibility and freedom in use. Considering the fact that none of the winning devices displays a capacity to revolutionize architectural computing -even 'voice command systems' do not display such capacity, due to the fact that they require knowledge of a certain language; more than required to select among command words (as today), but sufficient enough to form sentences and pronounce correctly- it may be asserted that pen-based systems will establish a new branch in architectural computing both for architects and programmers.

1.3. Computers In Architecture

It is true that architects are facing the challenge brought forth by computers not only to architecture, but to professions like law, medicine and stock breaking (Sviokla in Ross, 1990), but the density of the challenge is not the same, since computers have more to offer than to speed up and ease the conventional process. That is the reason why the emergence of computers in architectural practice is subject to different comments. As Novitski points out: "Experts may differ over how the architect's role will change in the next few years. Some emphasize knowledge management; others look forward to designing with walkthrough visualizations. Most experts foresee a day when powerful, low-cost machines will sit on every architect's desk. Some believe that, as machines get smarter, the profession will grow smaller. But one thing is indisputable. For better or worse, the practice of architecture will never be the same again" (Novitski, 1992b).

The point which separates architectural profession from many others and which renders the idea of replacement of architects by computers impossible is the existence of subjectivity and even intuition in the decision process of architectural practice. Therefore, for the sake of originality -which is indispensable in design- architects always have to be in command.

Within this framework, in order to examine the radical changes brought forth by the emergence of computers in architecture, the following sections have been prepared in two parts; one being architectural practice, other architecture education.

1.3.1. Computers In Architectural Design Practice

The emergence of computers in the architectural office has not been welcomed easily. The reason behind this is largely due to the experiences gained by early systems like OXSYS, HARNESS, CEDAR resulting in standardized solutions. On the other hand, architects have difficulty in trying to adapt themselves to a so-called 'unfamiliar' medium instead of their conventional pencil and paper. Most of them insist that each creative act is

dependent upon personal feelings and emotions, but none of these appear on the screen, whereas it is possible to demonstrate them on paper (Albrecht, 1989). In fact, this is itself an emotional approach, since the aim of design is to achieve a construction in the end; "a design is therefore an abstraction, providing a description of an artifact that can be interpreted by some other agent for purposes of manufacture or construction" (Coyne, 1990), instead of creating drawings representing a personal character. Therefore, architects and architectural firms who realize that they are in the information management business turn out to be the successful ones (Jordani in Novitski, 1992b). Similarly, it may be stated that, although computers have penetrated architectural offices largely for word processing, financial management (Stevens, 1991) and speeding up and automating some of the drafting burden, the most efficient way of making use of them is to employ them as a design assistant. But, there is a reasonable doubt behind not doing so. Based on Gero's categories of design as *parametric* (assignment of values to certain parameters of a norm in a specific architectural language in order to produce solutions), *innovative* (combining elements of various architectural languages with a morphological approach in order to achieve design) and *creative* (creation of a design inexistent before), Saglamer states that architectural software in the market are capable of aiding in the first two categories, thus not leaving ordinary architects much to do. Therefore, she continues, architects not only resist the integration of computers in architecture, but underestimate their potential intentionally and evaluate it as a mere drafting tool both in practice and education (Saglamer, 1992).

Here, it is appropriate to state that computers do not aid in rendering bad architects good, but they rather ease the job and introduce new facilities to talented ones. The point to be keen about is to equip the talented architects with adequate knowledge to benefit from the rapid progressing computer technology and not to be left behind. Since, though not totally welcome yet, computers in architectural design practice have already led to several market benefits and have gained extensive popularity among clients.

Market benefits can be summarized as assisting some firms to acquire new markets and expand old ones through increased market share (Stevens,

1991). Among the newly marketed services environmental analyses and simulation with computers (Ruffle, 1986) and visualization in motion can be mentioned, whereas expansion of old services might be considered as early cost analyses and project management features with computers (Ruffle, 1986). In addition, computers have also led to the recapturing of areas of lost practice to other professions (Ruffle, 1986) like real estate consultancy and leasing (Albrecht, 1989).

Secondly, as regards popularity among clients, though some of this popularity is due to the false belief that best possible solution is obtained by computers (Albrecht, 1989), most of it is due to the fact that clients can easily adapt to computer visualizations, especially to those in motion. In the '1992 Worldwide Computer Graphics Market Report', it is stated that the increasing demand among big clients for use of computer aid in design has lead to requirement for CAD to win particular jobs (Gantz, 1993). Therefore, though installment of CAD systems in the architectural office is possible through large investments, the demand in the market, along with other advantages render this investment beneficial. Thus, installing CAD systems in the office, it becomes possible for architectural firms to carry out the profession in an interdisciplinary manner in its true sense, through networking. Moreover, it is through networking that small offices can obtain similar chances like big offices and compete with them.

In order to examine the role of computers in architectural practice it is appropriate to classify their field of use as drafting and visualiation; design; databases; and project management.

1.3.1.1. Drafting and Visualization

One of the advantages of computer aid in the architectural office is undoubtedly the easeing and speeding of drafting. Computers' aid in making required changes easily and immediately, along with the ease of repetition and reproduction reduce the drafting burden considerably. Furthermore, the possibility of working on the same drawing by several different experts at the same time and seeing the changes made by any of them automatically

reflected to the drawing creates an efficient interactive work environment. Therefore, the speed, ease, accuracy and presentation quality brought to architectural drafting by computers cannot be denied.

On the other hand, as transforming and restoring existing structures instead of creating new ones consist a large part of present projects in the market, one of the attractive points in using computers turns out to be the ease and accuracy in making design changes and checking the structural feasibility and displaying the result both to convince contractors, consultants and client(s) (Mahoney, 1991).

In displaying the projects to contractors and clients, the aid of computers in architectural offices is more impressive than of any other medium. Computer generated presentations in 3D and in motion not only aid in marketing the project, but in stimulating the architects as well. Visualizations in motion offer the possibility to view a building in its setting within the site or city, during the cycle of the day and night, during different seasons or even during construction stages. Moreover, by 'walkthrough's and 'fly-in's the interior of the proposed buildings can be experienced more effectively than by looking at a drawing or model. These are of extensive use not only in selling a design to clients, decision-makers involved in the process, city planning officials, regulatory agencies and investors, but also in creating the process of construction, previewing of landscape, teaching architects the failing parts of design as well (Emmett, 1992). As such simulations do not require special training to understand, the client can become an active participant in the design process.

Visually interactive exchanges possible through computer graphics are bound to improve designs of buildings if architects are willing to change their work styles (Novitski, 1991c). It may further be asserted that, as computer aid in drafting enables studies with geometric transformations and difficult geometric surfaces and shapes, originality in designs can be improved as well.

1.3.1.2. Design

Computers are incapable of designing. They can only generate design alternatives if design constraints have been input or, check and improve the constraints of an input design according to preset rules. Therefore, computer should be considered not as alternative to the designer. But, on the other hand, computer cannot be said to be alternative to a design tool or medium because there exists no such tool or media except for the designer's brain. Computer constitutes an unprecedent medium that stands in between draft tools and designer's brain. Within this framework, computer's role as 'design assistant' can be examined in three groups; design (of inexistent), analyses of design and knowledge-based systems.

In designing from scratch, computers can be employed to generate alternatives within given constraints. Early CAD systems made use of this facility in generating plan and space use alternatives especially for hospitals and housing schemes. On the other hand, modeling and visualization in 3D give the architect the chance to explore many alternatives himself rapidly and easily, being able to manipulate difficult geometric forms and to manipulate them with extensive accuracy and mathematical format which gives the possibility of construction. To illustrate this point more clearly, the construction for the Reorganized Church of Jesus Christ of Latter Day Saints, Fig.2, constitutes a good example.

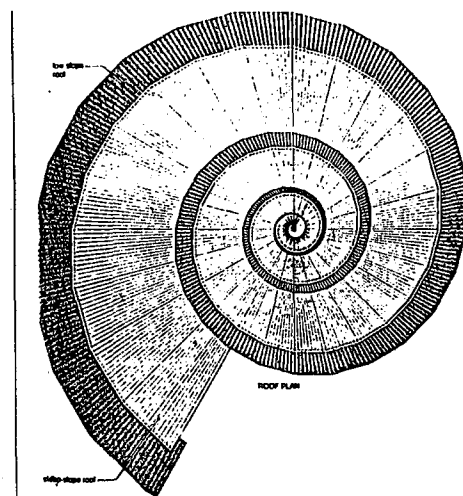


Figure 2. Computer-generated roof plan (Russell, 1992)

The spiral spire of the church has been designed and then formulated for construction by computer aid. According to Russell, it was not only the generation of form, but its support and configuration and location of elements that challenged the architects; but, the structure only made possible by 3D analysis, changed the ways designers and builders work together (Russell, 1992).

Design analyses with computers aid the architects in controlling various aspects of their design proposal with accuracy and speed. Structural analysis gives architects the chance to configure their design, before engineers impose further solutions. Environmental analyses including thermal, acoustical analyses, lighting simulations and fire protection tests help to improve safety, functionality and quality of designs and also lead to accurate cost estimations as well.

Nevertheless, one very important role of computers in design is the ability to check the proposed design according to rules and facts as in the case of expert systems. Furthermore, knowledge-based design systems aid the designer achieve highly qualified designs. In fact, it may be asserted that knowledge-based systems is the field where computers assist the 'design process' most, beyond numerical computation. As, it is a fact that, numerical computation is not enough to handle design, and reasoning with knowledge is indispensable in the design process (Coyne, 1990), knowledge-based design systems achieve in executing the fundamental part of the process; other part being already executable by computers.

1.3.1.3. Databases

Architecture, being a profession carried out by a team, has an interdisciplinary character by nature. On the other hand, as have been emphasized several times before, architecture, being an information based discipline, requires access and reference to various sources and examples during design process. Computer use in architecture offers the possibility to combine and interrelate these two aspects of architecture through networking and databases. Therefore, the data necessary for design can be

accessed by all participants with ease and speed. The computer, acting as a central point in information collection and distribution, therefore improves the team spirit and renders everyone “a tap in the communication flow” (Albrecht, 1989) and also computers, acting as information banks, support the architects’ creative decisions. As Fallon points out, one of the reasons behind employing computer aid is: “...believing that design is an information-intensive activity and that design decisions are only as good as the information that supports them” (Fallon, 1992). In addition, new or processed data can be added to the databases for further use. Storing data obtained by each new design gives architectural firms the possibility to form their own data libraries as well.

However, unlike a new design, where modeling is a creative process, a heritage project is more documentary; modeling what exists in order to add to it or finding out what had existed originally in order to recreate it (Sinclair in Mahoney 1991). In this case, the creation of the project database turns out to be a major part of the design process itself. Moreover, such a database cannot only be of use for further renovations in future (Corrigan in Mahoney, 1991), but act as a historical document as well.

1.3.1.4. Project Management

Apart from computers’ aid in running office tasks (like word processing and accounting), computers help in the preparation of realization and actual construction process of the designs. This can be achieved through construction and detail drawings, early cost estimates and preparation of final contract, along with scheduling and purchasing lists based on the requirements of the design. The advantage of employing computer aid at this stage, is not only the ease of storing these information and making modifications, but activating the feed-back process, i.e. based upon cost or scheduling analyses ability to modify or develop the design accordingly.

1.3.2. Computers In Architectural Design Education

As a natural outcome of ramifications of computers in architectural design practice, architecture education is subject to integration -though in some cases merely addition- of computers. Although, many faculties are decorating their curriculum on architecture with CAD courses [See Appendix B], approaches towards this integration vary. As those who vote for computer aid in architecture assert that computers enable architecture to be considered as a knowledge-based discipline for the first time; those who are negative on the subject suggest that architecture will always be architecture whether computers are involved or not. However, a third approach states that computers are tools which are extremely helpful and highly influential, but not really the point in architecture education (Witte, 1989). It is true that architecture will always be architecture, but the question arises in discussing whether it will be the same. Based on the emerging use and popularity of computers in architectural practice, it may be argued that architecture is entering a new phase where its definition and perception as a profession are bound to change. Therefore, change in architectural education can be asserted to be indispensable in order to graduate architects ready to serve for this new definition, changing trends and needs within the profession.

On the other hand, computers in architecture schools bring advantages regarding the success of the education as well. To put it more clearly, computers in architecture education not only prepare students for the computer-aided architectural practice and market, but “help produce better architects” as well (Ross, 1990).

One of the most advantageous aspects of computers in architecture education is the possibility of studying in 3D and visualization in motion, which help students with the difficult task of imagining the space; i.e. as “...written descriptions and diagrams, [leave] final understanding to the student’s ability to comprehend an abstract representation. The more complex the architecture [is], the more complex the analysis, requiring much study and interpretation that depended on an understanding of the manipulation of space” (Cordes, 1990). Visualization in 3D helps students develop their

comprehension of space. In addition, they may not only test and present their design in 3D, but also generate many alternatives easily and rapidly. Therefore, "...computers for previsualization significantly change the way students conceptualize, develop and experience architectural proposals on paper" (Goldman and Zdepski, 1991) and introduce the possibility to explore design in ways which are impossible in any other traditional media (Novitski, 1991a).

In fact, the presentation quality and precision which is brought by computers is another advantageous point that is very effective in architecture students' education. As Witte points out: "If an architect is to design with thorough understanding and explain the building to client and public, a realistic representation is important. Indeed, if students are to understand the effects of light, color, texture, reflectivity, form, and the like on their designs before they have constructed enough mistakes to learn them, they must have the opportunity to examine lifelike simulations" (Witte, 1989). Also, with simulations on technical issues, students "develop a sophisticated intuition" (Milne in Novitski 1991d) by making technical analyses like that of daylight factor, energy consumption and structural loads.

One other advantage of computers in architecture education can be traced not in the design studio, but in history of art and architecture courses. Computer models of famous buildings give the students the chance to 'walk in' these buildings, examining every detail. Moreover, edifices which have been destroyed in time or those which have been planned by famous architects but have never been built can also be modeled to serve the students for further information. It is reported that in some schools students are even required to build models of historic buildings in order both to provide them with an introductory exercise in learning to use computers without having to design at the same time and make them understand buildings thoroughly more than they would by passively looking at a photo (Novitski, 1993). Moreover, by constructing such a model, students may understand proportions and order of the structure (Zdepski in Novitski, 1993) and learn architectural truths which do not change through time (Goldman in Novitski, 1993).

Integration of computers in architecture education has also led to a new approach of "...intersection of architectural theory with the computational view of the world" (Mitchell in Witte, 1989). Considering repetition, variation and logical structures common to programming and design; students are expected to learn about the similarities of structures of both (Liggett in Novitski, 1991a).

However, the use of expert systems, though not very common yet, promise to be of the greatest use in architecture education, especially when it comes to dealing with norms and standards. Students can check their designs according to set architectural rules -i.e. as if they would refer to Neufert (1962), DIN and other standards- with the aid of computers. Thus, the burden of instructors and critics get lighter and get oriented more towards general concept rather than checking of details. Anyhow, it may finally be asserted that, computers' integration in architecture education is possible through the existence of a common strategy to integrate computers in the education and existence of academic staff who have the adequate knowledge of the technology.

2. INTERIOR ARCHITECTURE PRACTICE

2.1. History Of Interior Architecture

Though both the desire and the practice are old, the interior architecture discipline is relatively new. It is without doubt that people have always desired and strived to create pleasant, personal, functional and even prestigious interior environments. Therefore, the intent is as old as perhaps the first human settlements, even as caves with their decorous walls.

The desire and personal practices turned into a serious discipline in the 19th century as impact of the industrial revolution not only increased wealth but created several social classes who advertised their identities through their personal surroundings (Faulkner et al., 1986). Then, the rapid developments in technology were employed to produce different artifacts to decorate, which resulted in different styles. The introduction of Fordism, based on mass production of articles, brought yet another dimension in interior architecture. As the main target for Fordism is the family as the essential consumption unit; the 'home' turned out to be a space to express the ideals, ideas, ethics, beliefs, social standing and aesthetic culture of its inhabitants.

The worldwide commercial and industrial growth of post 1950s resulted in population explosion, unprecedented migration towards cities and building boom. This development extended services of interior architecture to fulfill the needs of growing middle classes and besides the esthetics of decoration, functional adaptation to differentiated inner spaces came to the scene.

Such developments invited the interior architect, now not simply a person with good taste but a professional, to the scene. The new professional, interior architect, is now educated in technical knowledge of construction, in relevant laws, codes, and regulations in product technology and market research. Throughout his formal education and career experience he has been trained

- a - to analyze, identify, and determine the structure, functional, technical and decorative aspects and problems of the interior space he is asked to build up (problem definition and analysis).

- b - to prepare a program and a design analysis combining his professional knowledge with existing techniques, market supplies, legal framework and user interactions (space planning), and

- c - to prepare good quality visual material to express his design.

As 20th century technology and economic development advanced so did specialization in space. Therefore, today professional interior designers may choose to specialize in residential or in many different non-residential interiors.

2.2. Characteristics of An Interior Architecture Problem And Techniques of Solution

Interior architecture deals with planning, designing and creating a lifespace and in this process the interior architect acts as a filter in between needs and the final result (Faulkner et al., 1986). Based on Faulkner's definitions of these needs and formation of lifespace, the process can be illustrated as in Fig.3.

The lifespace not only provides a place of privacy and security, but enables various activities to be held as well. The aim is to enable the activities to be carried out comfortably in a pleasing atmosphere.

Growing concern with the environment, along with the recent values related to preservation not only of our natural environment but also of our built environments for the coming generations (Faulkner et al., 1986), affect contemporary trends in interior architecture.

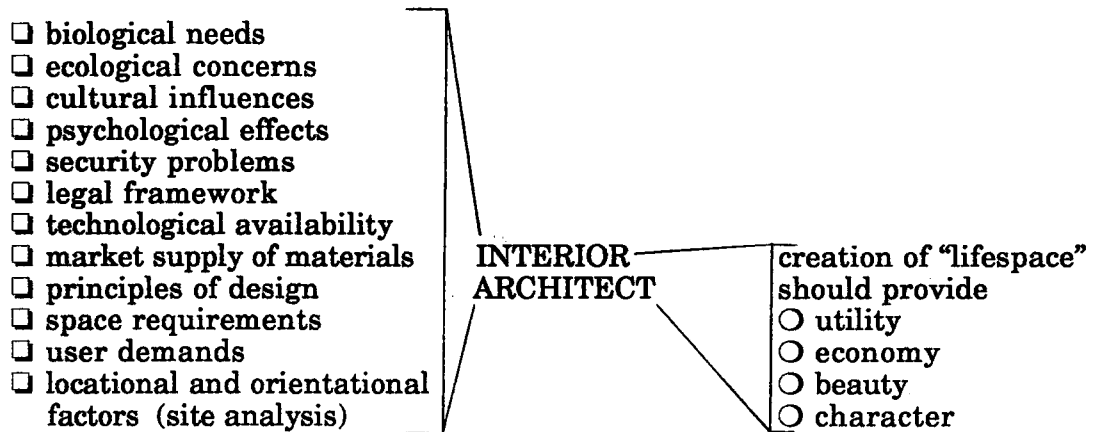


Figure 3. Formation of lifespace

However, as introduction of personal computers, fax machines, even visual telecommunication to homes are about to open an era where more people will be conducting most of their work or maybe even research and education from their homes; despite the increasing appreciation of nature, the recent turn in technology is leading people spend the major part of their lives indoors. Consequently, most enclosed spaces, whether allocated as residences or work places or even as transport media, will have to be redesigned to fulfill new needs and to integrate new technology in achieving comfortable and pleasant lifespaces. Interior architects are expected to consider spatial and functional implications of cabling and communication systems as they started to become integral parts of the spaces, rather than later additions (Harriman, 1991).

Thus, higher level of complexity and technicality of modern life, rising competitive standards and desire for accreditation and growing public interest in design are all stimulating a professional approach to interior architecture. On the other hand, interiors are natural part of building structures. This fact interlinks the architect and interior architect in the same design problem because these two different level projects have to be integrated so that the space created should provide an effective setting for whichever activity it has been designed.

It may be asserted that, like landscape architecture or structural engineering, interior architecture is a specialized branch of architecture. While the architect is responsible for the design of the overall structure, interior architect designs aesthetic, functional and psychological aspects of the interior, gives individual character to interior. Thus, the process is an integrated whole.

Both the architect and the interior architect are professional designers to begin with, trained to visualize 3-dimensional complete space, to build it up in mind, to feel and to sense it, to enter it mentally and to evaluate it. Both professionals work with the same principles, elements and constraints of design, as in Fig.4, and use the same visual language of expression.

Ideally the interior design planning should begin with the architectural planning. A good plan is essential for a well designed interior. Yet most of the time he comes in after the structure is constructed. In the first alternative when interior architect participates in planning from the beginning as a decision maker, he may present a constraint for the architect. Whereas, in the second alternative his degrees of freedom of decision is limited by the architect's already finished design.

It may also be asserted that, the interior architect acts more like the mediator between the architect and the user. For it is more difficult for the average user to grasp and perceive the totality of a structure, while he is more likely to judge the building through its interior architecture. It is a fact that users have a close and immediate contact with interior architecture, while objective judgement of a total structure requires experience and even training.

Thus, the interior architect can be considered to be the `window dresser` or `public relations man` for the building. People who experience the interior architecture at 1/1 scale are lenient to judge the building from the rooms they experience.

The elasticity of architecture is expressed through its interior. Interior architecture changes as function of space, the user's identity and building

function change. Therefore, although interlocked around the same problem, the architect and the interior architect deal with different ends of it. These ends merge somewhere along the design process and are superimposed at different points for different elements. While architecture creates the enclosed space, the interior architecture gives the first impressions, the first experiences, directs people into certain activities in certain locations, organizes activities and allocates them in space.

This brief analysis underlines the vital necessity of close cooperation of the architect and the interior architect in creation of a building which is expected to fulfill user satisfaction, while preserving universal and contemporary values of their profession. It has already been mentioned that, interior architecture consists of a group of related projects and that the ideal sequence should begin with the interior architect participating in the architectural design process from the beginning. Although his professional title seems to confine his area of responsibility to 'the interior', the interior architect can be very helpful while a location is being searched for the project. At this stage he is likely to draw attention to orientation in relation to light, to views, to possible noise and privacy problems, to possible changes which might improve space with small cost.

The following stages can be summarized based on the ordering of Pile (1988). The second stage involves 'analysis and evaluation of space' and categorization of its problems. At this stage, it is easier to consider measures which would minimize or eliminate the problems. Accordingly, a 'space requirement list' is prepared, with respect to which 'area assignments' are done. The program is expected to be based on a clear project statement expressing requirements and objectives including metric estimation of each space. In order to assign functions to different spaces 'block diagraming' and 'adjacency studies' are the most employed technics.

The final form of the program should be approved and initial budget considerations should be made in order to be able to proceed with the preliminary design. The interior plan form includes space allocations, placement of walls and openings, location of major furniture elements, fixed

and movable. Elevations and sections are drawn to add a third dimension to space on paper. This preliminary design leads to development of alternative ideas leading to specific proposals. The final stage is refined and presented in professional drawings, models and even in audio-visual techniques. Samples of actual materials may accompany this stage as well. Up to this point, the interior architect is required to develop his design not only with decision upon materials, but on dominating colors inside the space and on type, material and details of the furniture if he is responsible of constructing them as well.

When approval is obtained, working drawings (scale plans, elevations, sections plus large scale details of materials and methods of workmanship which cannot be expressed through drawings) are developed also to obtain final cost evaluation. Most often architectural and interior drawings are combined and at this point coordination between the designer, architect and engineer is necessary not only to avoid duplication but especially to avoid conflict. If there is need, other specialists on lighting, acoustics, plumbing and other matters should also be consulted at this stage.

This point brings into the work scene the technical aspect of interior architecture. Although small scale design problems do not encompass very demanding technical issues, larger and more complex projects will bring along important technological problems. While he may not be the responsible professional to solve these problems, the interior architect should have a good general knowledge of technical fields as a basis for solving the impact of these issues on interiors. The HVAC packet includes heating systems, ventilation and air conditioning and the interior architect generally deals with the visible elements that deliver these services. These elements must either be concealed or treated so as to manipulate their effect on interior design.

The wiring of electrical systems is usually under the responsibility of the engineer and the contractor. However, the interior architect, familiar with electrical symbols to be able to read wiring diagrams, determines how power will be carried to furniture locations and the placement and forms of outlets. He is also responsible for taking measures (eg. insulations) on economic energy consumption.

Architects and engineers design the plumbing system and the role of the interior architect is limited to selecting and locating fixtures but he must have basic knowledge of how plumbing systems are set up so that he can plan location and relocation of fixtures and related furniture.

Acoustics and noise transmission should also be solved through interior planning and material selection. Finally, wired systems and safety systems must be planned as part of the project rather than added as an afterthought.

Once construction plans are completed and bids are taken from contractors, scheduling starts. This is a necessary step to ensure smooth continuation of construction work without delays or conflicts. Scheduling involves the architect and the contractor as well. Purchasing of items can be made by the interior architect or by the user based on the information prepared by the architect. With supervision and evaluation the project ends.

Obviously, the sequencing and technics employed by every interior architect differs from one another like in other design-based professions. To put it more clearly, each interior architect has his own way of producing a design, as well as the techniques he employs to develop and present that design. What remains the same is the construction of a mental model of the proposed design in the interior architect's mind, with respect to which the product is achieved. Both the paths employed to develop the design and selections of materials and color not only depend upon the mental model created, but transforms and regenerates it conversely.

Various paths generally employed by designers can be said to be valid for interior architects as well, such as; *generate-and-test* (generating alternatives and testing them with respect to a constraint and requirements list), *hill-climbing* (comparing each design decision with the older and selecting the better), *heuristic* (testing each design decision with respect to final state) and *induction* (generating alternatives according to a hypothesis) (Akin, 1988).

Based on these paths, computers have been tried to execute similar tasks in order to aid interior architects. The floor layout program ALDEP (1967) followed generate and test path, whereas plan layout oriented CRAFT (1963) and IMAGE (1975) operated according to hill-climbing technique. Another plan layout program DOMINO, along with the problem solver and furniture layout program DPS (1975) followed the heuristic approach. Finally, the languages MARGIE (1975) and programs like HUNCH (1975) and STRAIN (1974) were based on induction. But, as designers could employ more than one technique in solving one design problem, these programs turned out to be inefficient. Therefore, in order to respond to the needs of the interior architect and aid him with the computer the flexibility of the design procedure has to be taken into consideration along with particular issues involved in the discipline.



3. PROPOSALS FOR IMPROVING COMPUTER AID TO INTERIOR ARCHITECTURE

3.1. Computer Aided Techniques in Modeling and Design Solution Improvement

Creation and communication depends upon knowledge carried in the forms of models in the human brain. Human beings understand and implement the world around them by building models, through modeling.

According to Cox (1989), a model provides a mental representation and allows planning for the future. Based on her statements, the following representation in Fig.5 can be drawn for the concept of a model:

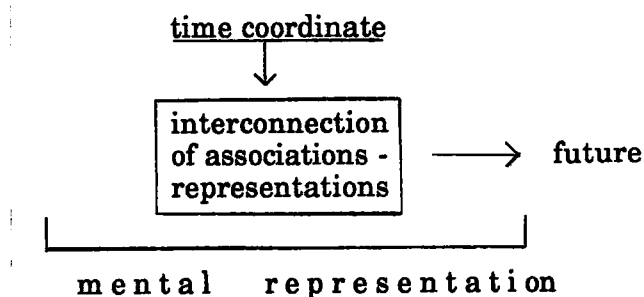


Figure 5. Concept of a model

In the creation process, the human brain re-associates concepts or representations into models which then undergo re-organization or change.

Thus, we create or recreate models by free association. Then, it can clearly be seen that, modeling is the very base of the design process.

With the emergence of computers into the area of design, one of the most important changes was observed in the concept of modeling in design. Since, the whole design process (from initial diagrammatic sketches to final drawings, simulations and representations) can be carried on with the computer, the model becomes the design method itself. Designers using computer aid, no longer build models of what they design but they build the whole procedure through which they reach the final design. Building of the whole procedure is not only necessary to reach the final design, but since with computer aid in design, the design process itself has become representable, the designer must design the stages of the process accordingly. This leads us to assert that, as the flexibility offered to the designer using computer increases, computer aid in design will improve as well. To put it more clearly, the degree of freedom of the designer in determining his own method and procedure of design when using computer-aid, determines the actual degree of computer aid.

A model in a CAD system, then, cannot only be defined as creation of an equivalent of an object which an analytical program operates upon (Medland and Burnett, 1986), but an entity that represents the thoughts, the transformation of the thoughts, their implementation and results altogether. The model can be simulated and this can result in a feed-back process. A computer model then, turns out to be 'dynamic' which is subject to continuous change -since it is easier than throwing away paper drawings or hand-made models- as a result of the feed-back process. As Beheshti and Monroy (1987) describe: "Models are simulations of the real world. They can be static models, simulating the real world at a given point in time. An architectural plan is an example of this. Models can also be dynamic, simulating the real world seen over a period of time and allowing a study of the consequences of actions. In other words, the dynamic models give us the capability to describe changes, and unlike static models, are not rigid and can offer a great deal of flexibility. Therefore, they offer a possibility to oversee the consequences of different directions or courses of actions".

Then, a model in a computer becomes similar to a model in human brain, i.e, knowledge being a certain model of reality is at a high level in the hierarchy of associations in our brains which help us to foresee the results of our actions (Turchin in Cox, 1989). This similarity is the crucial point in arguing that since mental models which help us create can be transferred to the computer, CAD is more than a draft assistance; but a design assistance.

Modeling with computer proves to be a design assistant also when it comes to relation analysis. A computer model, which is dynamic and flexible, makes it possible for designers to design and analyze on a relational basis without having to convert them into functions. This is of utmost importance since, unlike engineers who work with functional analysis, designers deal with analysis between relations. And generally, relations do not have one-to-one correspondences like functions. Based on the study by Zelissen (1987) a model can be presented as shown in Fig. 6:

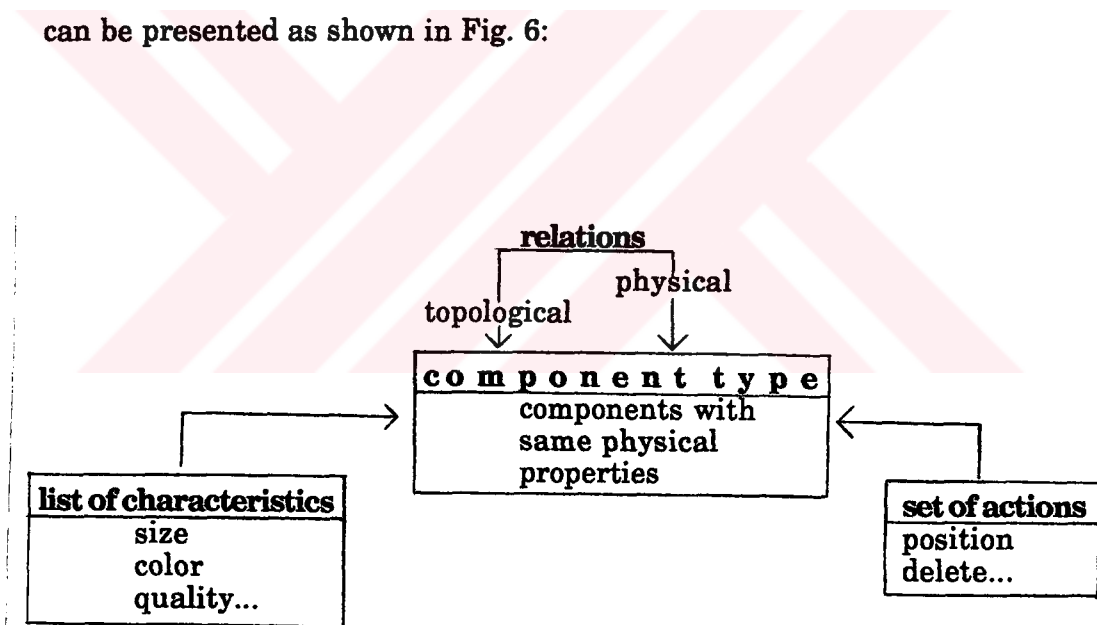


Figure 6. Presentation of a design model

Here, the points to be underlined are the following:

- i - A collection of objects, a set of which can form a new object, and a collection of relations among these objects, which refer to both physical properties and

topological relations, define reality. (As an example; "a door is a part of a wall" is a topological relation, whereas "lengthening of a beam is proportional to the magnitude of the axial force" is a physical relation.)

ii - Models describe the behavior and structure of objects and the relations in such a way that it becomes the representation of reality.

iii - Relations belonging to different models display similarity.

iv - When building a mental model, the designer defines representatives of components and operates several geometrical actions like rotate, translate etc. on them without ignoring correctness of the topology.

It was mentioned before that models help human beings not only to create but communicate as well. Communication is also indispensable for the continuation of creative process. Communication on highest level is possible by models since models become continuation of each individual brain so that people may have brain contact (Turchin in Cox, 1989), and natural extensions of the models shared create social systems and subsystems of the culture (Cox, 1989). Communication for designers is also one of the primary factors in the continuation of the design process. As information about problems is obtained through communication; traditionally in a system of cooperating individuals (Emde, 1989), then, for the creation of a 'high-level' contact among design partners, the models created in computer must be 'exchangeable' (sharable) and become 'extensions of each individual computer'. The following sections of this chapter concentrates upon proposals to establish such an environment.

3.2. Proposals

This section aims to put forth proposals to improve computer aid in interior architecture. The proposals can roughly be grouped in two; those which are of a general character, aiming to create a comfortable and easy-to-use environment when employing computer-aid in design; and those which are oriented towards improving computer-aid particularly in interior architecture. Nevertheless, as computer-aid creates an interactive and integrated environment in design, strict borders and work discrimination between professions seem to vanish. Therefore, this section refers to design

and the design field most of the time for the sake of extending the proposals on a larger frame which will fit to the establishment of a communicative, interactive and integrated design environment.

3.2.1. Development of Standards

In the rapidly developing vast world of CAD systems, one of the most important issues turns out to be development of standards in order not to get lost or get far away from the needs of the designers. In developing standards, three main titles must be taken into account: user orientation, sensitivity and control and comparison criteria.

User-orientation: It is a difficult task to introduce to designers with a new medium which needs different handling methods both in drafting and design. Many of the designers will long for the traditional old techniques if they have difficulty in understanding and manipulating computers. Some of the key-words that are believed to be of utmost importance in evaluating a CAD system can be set down as given below. These are assumed to act as initial steps in standardization:

- i - Familiarity: ease of learning (accessibility) and use (intuitiveness)
 - ii - Efficiency: quick, correct and clear operation capability
 - iii - Flexibility: ease of adaptation and enlargement
 - iv - Interactivity: ability to communicate and share data with any other system
 - v - Economy: relatively cheap to install, enlarge and maintain
 - vi - Reality: ability to produce images similar to that in reality
- (Barron, 1991)

The familiarity of a CAD system brings along the notion of user-friendliness. User interfaces should be so easy and feel so natural that architects can concentrate on design and forget the details of operating the machines (Novitski, 1991d). Since creativity requires a conscious state of mind, it is argued that designer should not waste his attention on operating the computer (Albrecht, 1989). Thus, user-friendly systems which introduce the

designer an easy and comfortable environment are of utmost importance.

One of the strong opportunities for automation is seen in interaction with the designer (Barron, 1991). A very important point to be taken into account here is highlighted by Beheshti and Monroy: "While it is true that introducing automation into the practice of architecture will change the working conditions of architects, on the other hand the automation process should also be based on the way in which architectural design is carried out in the real world. The changes of the environment will result from a combination of the two. This may require certain changes but it does not imply introducing a completely new system or method of work and/or design" (Beheshti and Monroy, 1987).

In the following sections, we will seek the chances to load the computer with the burden of conversion process between the computer-aided design system and user for the sake of being able to introduce the designer a familiar environment. Before such a radical approach, few proposals can also be put forth. It is argued that there exists an intricate and complex relation between process of design and the media in which it is carried on (Albrecht, 1989). One of the reasons why designers feel themselves foreign to computer-aid in design is the difference of the monitor and mouse from sketch paper and pen. Thanks to studies carried on regarding sketch recognition, computer can idealize a freehand sketch and accept it as an input (Durgun and Özgüç, 1990). Moreover, with the advent of pen-based systems (Han, 1992), a comfortable drawing environment can be created by being able to directly draw on the screen, but it could be of further help if the screen can be in lateral position.

The operating language of the computer, in addition, turns out to be another important factor in the relation of the designer and the computer. Although commands, which are generally in English, can be translated into the user's own language, they may still remain foreign and require initial training. Studies carried out by 'Apple' in developing "world-ready" systems which are capable of adoption and customization regardless of language (Gromala, 1992) constitute an appropriate step in rendering computers more easy and

familiar to use. However, as visually coded information is always easier to comprehend and harder to forget, the basis to operate computers must be visually coded at its best. This promises to be a more successful interface than 'voice-based system's, since they also require special training.

Nevertheless, it may still be argued that computer-aided design is in fact the most familiar design environment. It was stated before that creation process is carried on by building mental models of what is thought to be turned to reality (Cf. Section 3.1). That is to say, drawing is not the medium of creation but a medium for representing what has already been created in the designer's mind. If designers had had computer-aid before the professions started drawing with pen and paper, today issue of 'familiarity' would have had a different dimension. Though now, in integrating computers into design, making them familiar to what the designers have been used to is important; for the new generation which will be educated with computers 'familiarity' may cease to be an important factor.

On the other hand, the flexibility of design packages and the enlargement of both their capability and vision seem to be some of the most important areas of study. Since, it is reported that: "CAAD programs are, in most cases, drafting programs, not offering, the flexibility required for carrying out a complete design process" (Beheshti and Monroy, 1987), achieving flexibility allowing designers benefit from various services available by computers is a desired pace. In the following sections it is tried to construct a route in order to achieve a flexible model description. Issues regarding interactivity and reality will be focused on in the following sections as well.

Sensitivity: Computers offer a capacity which is more than what is needed sometimes. A good CAD system must be designed to use this capacity efficiently so that no operation will demand excessive share from computer's power and memory. As Canter underlines: "It's inappropriate to be a slave to the computer's absolute precision. You don't need it to the same degree at every stage in a project, and you may lose your flexibility to make changes" (Canter in Novitski, 1991e). For example, the study carried out by Kennedy (1986) has pointed out that a CAD system was to support 62,500 levels, which

were "far more than necessary". His solution was to assign CSI (Construction Specifications Institute) sections to ten layers which had ten subsections each and then differentiate each by a color. Of course, layers formerly assigned to cover data about one section is of great use when issue of interactivity; i.e. exchange of information between users, is of mention. As each participant has his own way of using the information in a design, the execution of a model is sensitive to context, requiring the concept of an active context guiding the interpretation of the incoming information and the interaction with the user (Lapre and Hudson, 1987). Based on this concept, in standardization of layers it may be a useful approach to split layers into sub-layers, each containing information and enabling operations about the same object for different purposes. For example, a layer belonging to windows might have sub-layers like that of dimensions, material, type, style, energy control, daylight factor etc. Such standardization is one of the key points in creating an interactive and global design environment by computers.

The issue of color, which is very important especially in interior architecture, can also be mentioned here. Computers can display a large number of colors depending upon their capacity. Moreover, some software lets the user change hue, saturation and value of the color (Kennedy, 1986). In using colors for rendering purposes it may be joyful to select among a vast collection. The question then, turns out to be whether or not so many colors are useful if they do not correspond with real ones. Standardization regarding color then, is likely to diminish the number of colors kept in computer's memory.

Control and comparison criteria: In the research on the developments in office automation, databases and computer-aided architectural design, carried out by Beheshti and Monroy, it is stated that: "...the lack of adequate methods to check the completeness and the consistency of the information is experienced as a negative point" (Beheshti and Monroy, 1987). Since generation and accumulation of information has become easier and faster with computer aid in design, it is clear that there is need to establish a control and comparison basis in order to be able to manipulate such vast number of data which increase and change quickly. Therefore, one of the initial tasks is to establish control and comparison criteria for databases which keep and

order accumulating information. The criteria should render databases able to provide design coherence and checking of legal issues concerning codes and specifications. As Ross asserts, databases should become smarter by including quality-assurance routes and turn out to be of utmost help by this ability of checking and control, which is especially important to clients (Ross, 1992).

On the other hand, computers offer presentation of a different quality and quantity compared to traditional methods. Since computer presentations are closer to reality, i.e. in 3D, with appropriate shade and shadow, in motion, etc., the information given is expected to be as real as possible. Returning to the issue of color mentioned above, the CRT color displayed in a rendered presentation is expected to be similar to the real color to be applied. If not, the many colors offered by the computer not only become useless but a reason to be mistaken as well. The same is true when one mentions texture used in rendering and time in motion displays which is the determining factor of distance. Thus, it may be stated that standardization of these issues is of vital importance. The task can be solved by constructing a data base in which every material has at least two correspondences in computer, one being color, the other texture. This data base is best when it is possible to connect to a mega database (Cf. Section 3.2.2.1) which is updated by every firm responsible for the production of the materials. It must also be remembered that, such a data base can be thought to contain other information besides color and texture such as; price, availability, places of use etc., again to be updated by the production firms.

3.2.2. Problem of Compatibility

Both architecture and interior architecture, and any other discipline where design is involved, are usually carried out by a team of specialists. As Emde points out during the problem solving process, the designer needs images, descriptions etc. related to the problem. This information is reached through communication, "...traditionally in a system of cooperating individuals. Herein each participant contributes according to his specific professional and human abilities" (Emde, 1989). Most of the time, the communication and

relation among such a team becomes one of the determining factors of the success of the design. Emde sees the achievement of a successful communication among participants in their sharing of equivalent means in a well-defined environment: "The ability to communicate is the fundamental prerequisite for an active discussion of problems: the participants must have equivalent means to express themselves, their terms and meanings must be clarified" (Emde, 1989).

In a computer-aided design environment then, one of the most important factors turns out to be the compatibility of systems, terms, files, anything shared by the nodes of the design team. It was stated before that computer-aid in design renders possible the analysis of relations without having to convert them into functions (Cf. Section 3.1) and thus it was possible to establish a polygonal definition of relations with computer. The same can also be valid in constructing a polygon where vertices consist of participants and the intricate relations among them are handled by computer networks. Here, Fig. 7 can be constructed based on studies by Beheshti and Monroy (1987) for interior architecture:

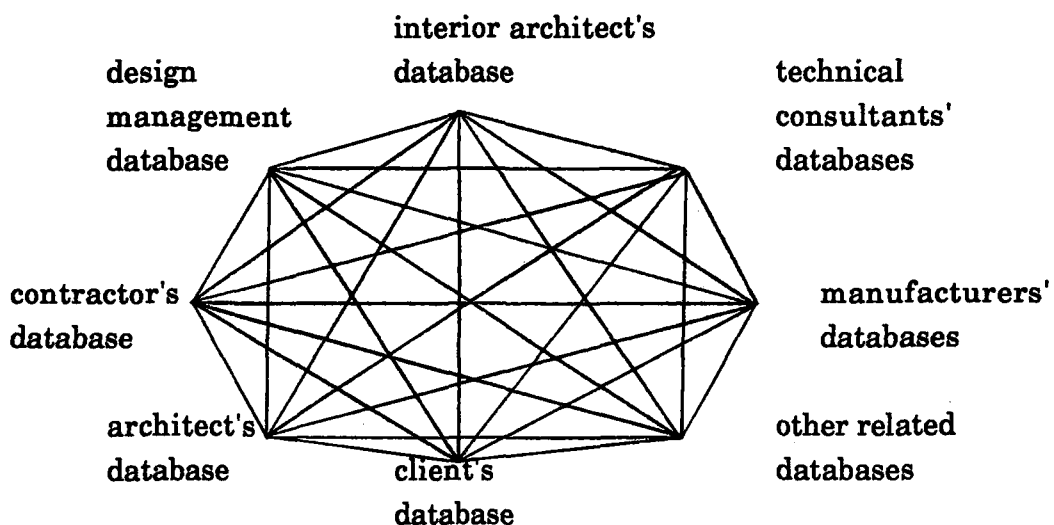


Figure 7. Interior architectural design participants' polygon

In order to establish this, problems of compatibility between systems and files are being worked on in recent years. As Ross points out file incompatibility will disappear with the standardization of common operating systems such as: UNIX, OS/2, System 7, etc. (Ross, 1992). This will not only ease communication between partners but, also within a firm where it is a very common trend to employ more than one system. As Novitski was pointing out in 1991, a large number of architects having more than one kind of computer, urged the industry to improve communication between systems and "...translate software to new platforms" (Novitski, 1991b).

With this push, systems are becoming more compatible everyday. Hughes reports that the Vancouver firm Aitken Wreglesworth Associates, employed both Macintosh and DOS systems in their design work. And now, there remains little difference between those two systems and as vice president of the firm, Ute Philips admits: "...we figured it would become irrelevant what our hardware was, because at some time this platforms would have to converge. And ironically enough, they have" (Philips in Hughes, 1991) System compatibility, being a very important step in creating a communicative environment for partners and even for clients; design practice in near future can be pictured as: "Your computer will speak directly to their computer" (Ross, 1992), having designer's, contractor's, constructor's and client's computers on line. But, in order to achieve such communication system compatibility alone is not enough. The following sections examine issues of data and know-how compatibility which are indispensable in a polygonal meshwork of communication.

3.2.2.1. Data Compatibility

One of the advantages of a computer-aided design environment is to be able to reach and handle a vast number of data easily and quickly. This provides not only ease and speed in design, but also makes data communication possible which was not achieved on full terms before -as results of the research made by Beheshti and Monroy showed that data communication between participants was "practically and virtually non-existent"- (Beheshti and

Monroy, 1987). During design, the model created by the computer (Cf. Section 3.1) has to be unifying since it is going to be used in many areas, by different disciplines, for different purposes. Thus, the related data must be organized in a manner so that it can be withdrawn, used and returned easily. Design communication between the members of the design team, depends upon data exchange and implementations of the model created. As Beheshti and Monroy underline: "This is found to be of vital importance in the architectural design process, because it can enable the architect to fit in changes, brought about in the project by different parties. Furthermore, they will be able, to oversee promptly the consequences of changes or decisions in a comprehensive manner" (Beheshti and Monroy, 1987). This is done by the establishment of databases which are naturally of utmost importance when communication, sharing of a model and transfer of information are of mention.

Before starting with design, the designer has to reach data, norms, standards, costs, descriptions related to the problem from various sources. It is a hard task to reach several sources in a limited time and order them for use. It should also be noted that data related to one specific problem may not be of use ever after or may become obsolete. Thus, purchasing of sources turns out to be inefficient. To overcome this problem, data sharing is found out to be the best solution (Beheshti and Monroy, 1987). Then, it can be asserted that, an interactive environment of data sharing in computer-aided practicing of architecture and interior architecture can be achieved through the creation of a mega database which will act as a "huge on-line electronic library" (Beheshti and Monroy, 1987), to which all designers and participants will have access through networks. So, the network for interior architecture becomes as illustrated in Fig.8.

Beheshti and Monroy describe such a library as "...containing up-to-date architectural design information, literature, documents, etc. At the same time, the system offers necessary design aids such as computer programs for design process, drawing programs, evaluation programs, cost calculation programs, etc." (Beheshti and Monroy, 1987).

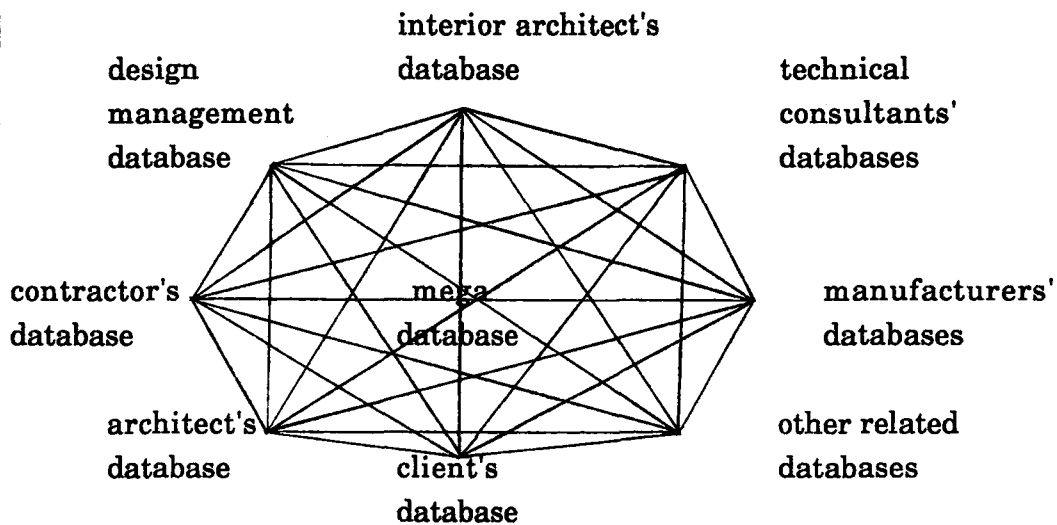


Figure 8. Network among interior architectural design participants

The description of Beheshti and Monroy of an on-line electronic library considers an Architectural Design Information System (ADIS) benefiting from artificial intelligence as well. In deriving the concept of mega database based on this description, it is thought that the database will consist of separate databases of different fields -which should constantly be updated by their own organization (Beheshti and Monroy, 1987)-, all put together. In order to maintain the integrity of these databases, they have to be compatible among each other as well as with other databases of individual users. Thus, the designer will not only be able to retrieve information from the mega database, but will be able to update his database with respect to the mega database. If this is achieved, as Beheshti and Monroy put it, the financial burden of updating hard and software which change rapidly will be eased (Beheshti and Monroy, 1987).

Ross draws a future picture where designers will be able to choose their software on a free basis since: "The underlying 'databases' will all be

compatible" (Ross, 1992). Such compatibility is important from the point of view of constructing a polygon among design participants for design communication (Cf. Section 3.2.2). As Beheshti and Monroy state: "Data communication is not only limited to data inquires" (Beheshti and Monroy, 1987). Introducing the "project-related data-base" (Beheshti and Monroy, 1987) to a selected group of experts and making use of theirs will be achieved through compatibility of databases.

Be it for the construction of a mega database or for individual ones able to communicate and exchange information among each other, data compatibility proves to be indispensable. This compatibility is possible through the standardization of data according to a set of criteria. The operations to which data dynamism is converted during design and implementation procedure must be determined in order to eliminate unnecessary stability of data, like in a sequential data file where no data can easily be added, or unnecessary dynamism.

According to Wright: "The challenge is to set standards for the correct translation of one computer's vision to another. The integration vehicle will be a 3D electronic data base describing the building design, passed from the designer to manufacturer to facility operator. It will be used to operate, renovate, and eventually dismantle the structure" (Wright, 1989). When architecture and especially interior architecture is of mention, it is really of great use to employ a 3D database since these disciplines involve manipulation of 3D. In creating a 3D database one of the most important tasks to be fulfilled is to render the database able to manipulate the model created and self-improve with it by covering the information about the model, i.e. both the model and database can update and change with respect to each other.

In future compatible databases to be used in design, one issue that is of utmost importance is the ability of databases to keep, handle and track new information created with a new design, apart from keeping information which already exists (like codes, specifications or material, detail knowledge). Design not only creates a new building, but also generates new

knowledge about the building, including data that cannot be represented geometrically (Novitski, 1992b). Be it graphical, numeric or verbal, the new information created by a new design is important to be integrated in databases from two points. The first one is the advantage of transferring the information to future projects to be used. Thus, the productivity of the designer is improved since the knowledge used in one design can be carried to the next (Novitski, 1992b). This accumulation of information in database also helps to clarify the methodology and approach of either the designer himself or the firm. As they pile up their own data project after project, designers convert general purpose design packages to their advantage and fit them to their way of designing. As Stoker explains, the really useful programs are oriented for one project, i.e. one can define problems of one project at a time, but: "...if you use a system long enough, project after project, you build up an 'information asset'. As you accumulate details, symbols, and macros, you capture your design firm's methodology" (Stoker in Novitski, 1991d). For a computer-aided environment in which the designer will be able to define his own procedure of design with available tools, accumulation of new and individual information in databases is indispensable. Thus, the specialization and individualization of general mega database will be maintained.

Secondly, with databases containing data about a new design it becomes possible to track information about maintenance, use and problems of the design and implement desired changes. This is especially of use in interior architecture, which has a dynamic character, not only since it is being continued after architectural activity has been finished but also since it is subject to change anytime with respect to change of occupants, change of function or the like. Novitski explains that, with electronic drawings and data tenants, inventories, personnel and interior design can be tracked (Novitski, 1992). The database, then, becomes 4 dimensional and new participants like building managers or even the owners of a simple apartment flat come into scene as nodes in database sharers.

In an environment of 'underlying, compatible databases', finally, one last issue turns out to be the 'know-how' compatibility of the database sharers. All

sharers have to have equivalent means to access database and use it. In such a crowded use tempo one other important question is as Wright puts forth: "...how to put the architect's seal on the database" (Wright, 1989). A very similar doubt is introduced, this time by Fallon, as how to keep information 'confidential' (Fallon, 1992). Finally, the problem regarding the demand for the same data at the same time, namely concurrency, comes into the agenda (Beheshti and Monroy, 1987). Next section tries to analyze problem of 'know-how' compatibility, which is crucial not only for compatibility problem in general, but for achieving database compatibility as well.

3.2.2.2. Know-how Compatibility

It may be asserted that, in order to establish future computer-aided interactive design environment, all the nodes of the interaction polygon (i.e. design participants, reference databases, client, etc.) must speak the same language and be compatible. Unlike scientific or engineering professions, which make use of functions that can be manipulated on binary grounds provided that a threshold has been defined, professions like architecture and interior architecture operate on grounds where discussions are being made with respect to relationships represented by polygons, each vertex being a property of measure (Güvenç, 1991). Thus, definitions made for the fields like architecture, interior architecture might not coincide if they do not hold the same vertices as measures. A complete definition of design practice is possible with the formation of a polygon in which vertices are well defined in order to construct a common ground for discussion, i.e. a common frame work on which the items and the relations between the items are defined well enough to lead to a complete understanding of the design practice.

As it was mentioned before, computer-aid in design brings along the possibility to build, analyze and finish design on a model which is transferred and transformed among design participants (Cf. Section 3.1). As Lapre and Hudson indicate; for communication between participants and their computer systems a common ground, a frame of reference is indispensable and "this frame of reference or model must support participants accessing the same information with different objectives and for

different purposes" (Lapre and Hudson, 1987). As shown in Fig.9, they analyze design communication as conversion of domain specific knowledge - which is individual and not shared- into a common language base -which is gained through education-.

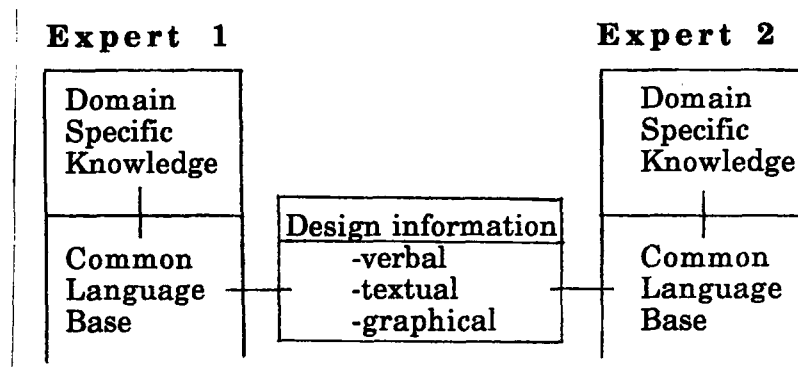


Figure 9. Design communication (Lapre and Hudson, 1987)

According to this analysis: "When a participant wants to work with a design he has to convert the information from the common base to his domainspecific higher level abstractions, perform operations on them, and convert them back into base language elements for the next participant to use" (Lapre and Hudson, 1987). Based on this analysis, computer integration into design can be inferred as shown in Fig.10 :

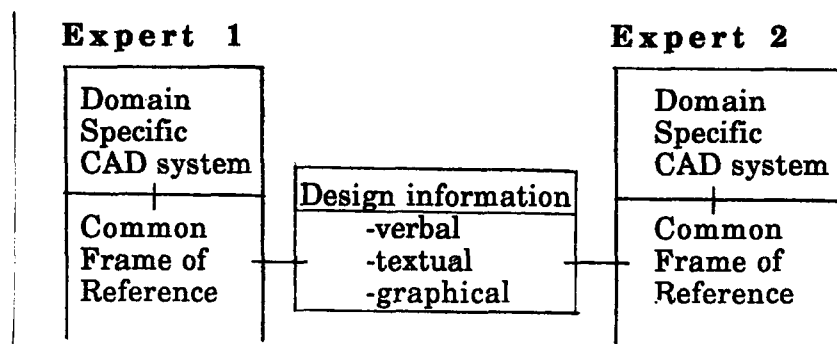


Figure 10. Computer integration into design

The important task is to render the common language base of Lapre and Hudson's model and common frame of reference 'compatible'. It is through the achievement of this compatibility that Lapre and Hudson's assertion for future: "...the burden of converting design information to and from domain knowledge could be placed on the computer" can be made possible (Lapre and Hudson, 1987).

In order to establish this compatibility, it is suggested to employ a virtual design file, which is created within a virtual design model format. This is thought to be a standard which should be known and used by all design participants. In private use, the virtual CAD file is to be taken, used, then returned back to the center of design participants polygon in virtual file format. Thus, every method, data, elements and model used during design become 'conceptual entities'. It was stated before (Cf. Section 3.1.) that, the design model created in designer's mind could not be transferred to the participants in the same manner by traditional methods, unless computer-aid was employed. Traditional methods -like drawings, models, text, etc.- can only present the design model partially, while computer-aid can build the equivalent of the mental design model. With the use of virtual design format this model becomes a conceptual entity, a virtual design model, and acts as an interface between domain specific computer-aided design system and common frame of reference.

From a broader view, the virtual CAD file concept being a standard or format to be known by every design participant can be considered as a common basis for operating systems of all computer-aided design packages; kind of a user interface which enables the user access various databases and programs and construct his own way of design procedure within the computer-aided environment.

It is a long known fact that since major computer-aided design packages which developed mostly by engineers and people other than designers themselves, designers have difficulty in adapting themselves to the procedure of the package and manipulating them. Mazzotta also draws attention to this and states that: "...scientists with backgrounds in engineering, physics,

mathematics and computer science -they contribute the tools used by architects" (Mazzotta, 1989). Most designers express their difficulty in trying to get used to the sequence of operations introduced by the design package since it is different from traditional methods they have been used to. Based on the fact that, ties to traditional methods lead architects to customize software, Jay Pace, computer manager for the Taliesin Architects, asserts that if the famous architect Frank Lloyd Wright were alive today, he would take an active part in customization and insist that there should be grid options like hexagons, rhomboids etc., other than squares and vertical grids should also be available for use as well (Novitski, 1991e).

It is now a very common practice, not only for designers but for firms as well, to develop their own software. Moreover, although there is more software available now, than there was when these architecture firms developed their own programs, some firms continue to use and develop their own software because they enjoy the special fit between it and their practices (Novitski, 1991e). As designers try to modify software, there rises the question whether it is designers' duty to develop software or not. It would be unnecessary if every architect had to write a computer program before designing a building electronically, as similarly architects should be forced to customize, since their duty is to design buildings, not to develop software (Novitski, 1991e).

It is true that designers should not have to write software before starting with design. Instead, what they should do is to arrange computer operations in sequence and organize computer tools available according to their design procedure. If this can be carried out as easy and as natural as designers make their design program and schedule before designing, the problem can be solved.

It is one of the major problems in computer-designer dialogue that every designer has his own, individual approach to design, while computer-aided design software provide a general, predetermined ground for designing. Barron gives examples to architects' different ways of approaching a design problem as; one may start by building a model, while another produce bubble and block diagrams, while another concentrates upon site. He further states

that: "When 3D CAD programs were introduced, many CAD developers seemed to ignore the architect's intuitive approach to design" (Barron, 1991). Though software producers have tried to analyze and examine the design process, the level of subjectivity and the role of intuition prevent the process from being formulated or even being fit to certain procedures. As designers try to bring this subjectivity into CAD packages, studies are being carried on for making the design process computable. As Novitski draws attention: "The common thread in the drive to customize -whether it's in university research labs, CADD software companies, or architectural firms- is that architects are working to incorporate their knowledge and creativity into a mechanistic environment that is better suited to computations and simple graphics. It's a frustrating struggle, but progress is being made, thanks to advances in hardware and to continual expansion of ideas about how to translate design into computable formats" (Novitski, 1991e).

Design, by its very nature, can never be computable as a whole. But, with the virtual file concept, designers can be free to sequence the operations in a computer-aided environment -as they normally do before starting to design without computers- so, the long feared aspect of computer-aid in design that would mechanize the design process by diminishing it to a list of predetermined sequence of steps will turn out to be void. Because as Albrecht warns: "There is the danger that the design process could be determined by only one method only: the sequential ordering of design steps prescribed through a set of operational rules.", and he further reports doubts that such a determination will lead to "proceduralization" and "technocratization" of the profession (Albrecht, 1989). This can be prevented if ordering of design steps is left to the designer himself. Then, the best approach turns out to be to introduce computer-aided facilities to the designer and make him capable of sequencing them as he wishes.

This is of utmost importance since sequencing of operations is, indeed, solving of the problem. As Beheshti notes: "The task of problem solving corresponds to finding the right sequence of operations (or action path) that transforms the problem description state into the solution state" (Beheshti, 1986, in Beheshti and Monroy, 1987). Based on this statement, Beheshti and

Monroy, in the system they offer, explain this concept as: "In this model, the design starts with a choice for the architect with regard to defining the phase according to his/her requirements, or, alternatively, he/she can follow the standard phase requirements for the phase as already implemented in the system. The system will assist the architects if he/she chooses to follow a different action path. Input of every phase will be the solution of the previous phase" (Beheshti and Monroy, 1987).

The virtual CAD file concept is introduced to give designers the chance to construct their own procedure of computer-aided design not only by using one system but by being able to access other databanks or databases of experts during design as well. In an extended frame, it may be asserted that the virtual CAD file concept requires that every operating system and CAD package should be written and operated according to virtual format. Thus, every designer will be able to access the systems and use the package he wishes as long as he knows virtual format.

To put it more clearly, the virtual file concept is thought to be the unique system which will give designers the opportunity of using different software easily. Because as Beheshti and Monroy state: "...no available CAAD program offers all the required aspects and an unlimited capacity for complicated projects and various design tasks during all phases of the architectural design process" (Beheshti and Monroy, 1987). In addition to this, in order to integrate problem oriented specific software for having an integrated computer-aided environment, the virtual file concept proves to be indispensable. As Zelissen points out: "Integrated problem oriented software (IPOS) fits the designers' behavior and the mental world much better. For this reason it is to be expected that integrated software will be of great importance in the future" (Zelissen, 1987). To operate such a number of software, a unique system is needed. If all could be written in virtual format, designers may have the chance to call the software, operate it according to his wishes and put it back in virtual format again.

As for access possibilities to databanks and databases of experts the virtual file concept creates a common ground to exchange files. The exchangeable

files, written in virtual format will be subject to selection and then each can be processed according to the designers' need and put back in virtual format for further use. virtual CAD files will always be available without being subject to any change, whereas changes can be applied after their adoption to the designer's system. (Thus, on Fig.8 every connection between databases can be considered as a conversion to virtual format.) A similar approach is employed by Beheshti and Monroy where they concentrate upon issue of product specifications: "...direct access to manufacturer's files will enable architects to make enquiries with regards to possible changes of specifications by directly bringing his/her required changes on product specifications. Such changes will not affect the original files of the system. They will be part of data communication between the architect and the manufacturer concerned. Decision on implementation of changes will depend on the manufacturer entirely who may adopt it for the project or make it, alternatively, part of the current product specifications" (Beheshti and Monroy, 1987).

Original files will be stored in the owner's system so that problems regarding the keeping of data confidential and subjective (Cf. section 3.2.2.1) can be solved. In fact, it was suggested by Beheshti and Monroy that; a communication system for the design coalition team and users' project-related databases will be: "...data files of individual users, i.e. they will be retrieved information from the architects practice, inaccessible to other users. Nevertheless, if information about a particular project or method is interesting for general use, an architect may make part of his/her files available to the system for others" (Beheshti and Monroy, 1987). This can be achieved by 'virtual format'. Furthermore, demand for the same data at the same time (Cf. Section 3.2.2.1) can be solved by copying the required file and then returning it so that, it will be available in an instant.

Finally, based on above suggestions, designing a distributed virtual design database with different authorities of data access is believed to be an efficient solution in establishing the mega database.

When talking about designer-expert participant communication, another dimension is that, among designers, who try to customize CAD packages according to their needs, it is a common practice to employ consultants "to write simple macros or develop elaborate programs" (Martinez, 1992). As Martinez further warns: "Before hiring someone to write software for you, find out if there is a third-party package that already exists for that particular application. Using an existing program will likely be more cost-effective than hiring a programmer to do the job" (Martinez, 1992). Be it use of a ready support program or employment of a consultant to prepare a support route, the virtual file environment is expected to create an adequate basis for both, i.e. the designer can access a support program written in virtual format, take it and run in his system or make a consultant write a procedure in virtual format without having to wait for the consultant get familiar with his system and write the program accordingly.

In order to establish use of the virtual CAD file, one of the initial requirements is the existence of a flexible design model. Based on the idea that: "From the programmer's point of view, it must be possible to abstract the several models and the actions on the components of a model, and therefore to build one program with a model description as parameter" (Zelissen, 1987), it is suggested that this "model description" should be virtual file, thus "one program" can be achieved.

Beheshti and Monroy underline the requirement of a flexible model as follows: " [it] allows the architect to formulate his/her own definition of phases according to specific requirements of the project or the architect's method of work and design. The model will adapt to this new definition. Therefore, we need a model capable of encompassing this flexibility without bringing about fundamental changes in the system or new training for the architect in using the model. With regard to this characteristic of the architectural design activity, the structure of ADIS will also require a dynamic model to encompass the changing status of procedures in conjunction with the data environment which will change accordingly" (Beheshti and Monroy, 1987). At this point, it can be noticed that, as was stated in former section (Cf. Section 3.2.2.1), data compatibility requires a

flexible model as much as a flexible model is possible through data compatibility. Therefore, it may be asserted that; if a data dynamism standardization is achieved, a flexible model can be achieved as well. But, on the other hand, data compatibility and standardization is possible by virtual format, since for storing data, for updating and using it the same format must be employed.

When a unique flexible model description is of mention, the route to be followed is offered as follows:

i - Defining of common objects, i.e. component types and related list of characteristics (Section 3.1., Fig. 6), related information in groups of 'default' and 'specific', -"...default information can be overwritten with specific information. It enables participants to fill in specific information in a later phase of the design." (Lapre and Hudson, 1987)-, common operations and set of actions -various combinations of the latter two can be grouped under 'methods'-.

ii - Assigning each method, which is context sensitive (Section 3.2.1), to a unique layer.

iii - Defining constraints of each layer, i.e., which operations and actions can be applied (since some operations will be restricted in some cases as: "...at the design of an interior layout: the designer will not position two tables (they are representatives of the component type "table") at the same time" (Zelissen, 1987), and some actions must be prevented: "Each component can be positioned or deleted, provided that it does not conflict with the relations. Some components are not to be rotated or scaled: a support in a frame model is not to be scaled" (Zelissen, 1987). This, will relieve: "...the operator of searching through menus full of commands which are never used for the chosen object in the selected context" (Lapre and Hudson, 1987)) and which data can be processed -i.e. with respect to 'context' (Section 3.2.1)- .
Determining layer interaction -i.e. which layer is a prerequisite to another; layer hierarchy or which layer should directly modify itself with respect to the changes made on another-.

iv - Developing a user interface which will: "...model part of the common language base and build a prototype CAAD system which can interact with the user" (Lapre and Hudson, 1987), to enable the user access the flexible

design model. The most important task here is to make input procedure unique and assign virtual file to organize input data in such a manner that the same data can be processed for various different purposes without demanding user's input again. It is true that: "...most architectural design activities -modeling, evaluation, presentation- are currently available as discrete computer operations that are isolated from one another and require their own unique input procedures" (Novitski, 1991d). On the other hand, in order to make computer recognize an entity for different purposes, it must be defined again. To put it more clearly: "A line that represents a wall length, for example, may need to be redrawn if the computer is to understand it as a boundary. Every time a designer has to redraw an element to redefine it for the computer, the advantages of automation diminish. Software systems that build 3D models that can be converted to their equivalent 2D drawings (plans, elevations, sections, perspectives) provide a step in the right direction" (Novitski, 1991d). It can be stated that, the most important task of virtual file is to act as a conversion port as illustrated in Fig.11. :

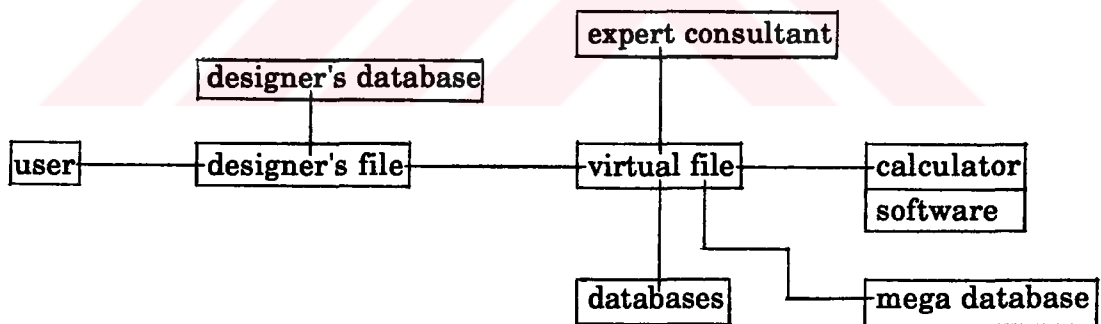


Figure 11. Virtual file as a conversion port

v - Related to what has been stated above, determining "levels of abstraction" as Lapre and Hudson name them (Lapre and Hudson, 1987), is indispensable not only for sketch recognition purposes but for determination of layers and their hierarchy as was mentioned above in steps 2 and 3. A computer generated model is an abstract entity like a mental model. In manipulating models, designers make use of a hierarchic sequence of abstractions. Such

similar sequence must be defined for each layer so that designers will not have to input data each time they change layer, but same input will be used for different purposes by being abstracted. To put it more clearly, as Novitski points out: "Depending on the context, two parallel lines can represent a volume, a surface, a material, a social function, a structural system and so on. With training, the human brain can interpret a collection of these symbols as a complex building" (Novitski, 1991d). The level of abstraction, then has to be defined for each layer, related to the context the layer has been assigned to. In order to set the designer free, he may have the chance of defining his own context and layer, defining his level of abstraction (i.e. which symbol will represent what) himself.

3.2.3. Issue of Virtual Reality

As the final issue to be taken into account within proposals of furthering computer-aid in interior architecture, virtual reality comes into the scene. This new technology is not only promising as an interactive space simulator in interior architectural design, but also as a high potential interface. Considering that, most GUIs (Graphic User Interface) are extensions of low-power, bitmap based graphic workstations (Deaton, 1993), the capabilities of virtual reality promise a lot. Therefore, this section handles the issue with respect to potential contributions to interior architecture.

As a term, virtual reality (VR) has been used from 1980's onwards. The term was put forth by Jaron Lanier, feeling the need to differentiate existing types of computer simulations and the digital world Lanier was working on (Lanier, 1992).

The world created through virtual reality in computers displays a space; called "cyberspace", which man can 'enter' and 'interact'. With the aid of special monitors and scanning devices which give a 3D view, the user gets into the computer-generated world and, using movement/gesture tracking devices can move the elements within that world, an example of which can be seen in Fig. 12. It was in 1989 that the first demonstration of cyberspace was introduced by Autodesk at the A/E/C Systems Show under the heading of

“virtual-reality system” (Fallon, 1990).



Figure 12. Head-mount display device with sensory gloves (Brill, 1992)

Gromala refers to the virtual reality system as: “A highly developed multimedia environment” adding that, the environment in which the user enters is a sensory computer-generated space, with high degree of simulation capability (Gromala, 1992). As the user is isolated from all outside stimuli, he gets the feeling of having entered completely inside a computer-generated environment (Pittman and Zobel 1991 in Gromala 1992), where the displayed view constantly updates and changes itself with respect to the viewer’s position and the modifications he has made.

Although there exist several problems, VR is considered as “the ultimate example of ideal human-computer interface” (Brill, 1992). It is through VR that the indirect and 2D information exchange between man and computer has been transformed into a direct and 3D one (Cyberspace, 1991). Man and computer face each other in the cyberspace, which stands in between ‘real’ and ‘regenerated’. On the other hand, lack of any specific language

requirement in order to adapt to or understand VR (Gromala, 1992), renders it an ideal form of interface. Thus, when considered as a presentation tool for architects and interior architects, VR turns out to be the easiest and yet, closest to reality compared to drawings, models and texts.

The use of VR in architecture and interior architecture, though has not been wide-spread, promises a powerful future, not only because of the ease of adaptation as a presentation media, but because of its advantages regarding the ease of change and intervention to the design before actual construction. As there occurs no actual threat of physical danger in VR (Gromala, 1992), it may be used as an efficient medium in construction tests both for educational and practical purposes. Seeing the results of any changes applied to the structure is especially of importance not only to interior architecture students in learning to deal with structures, but to interior architects who attempt to make structural changes (like pulling down a wall, omitting several columns or adding some) within the space which was designed beforehand by an architect.

Moreover, with a closer look, it may be noticed that present applications of VR are more oriented towards interior architecture than architecture, since it simulates the interior and demonstrates a space, as shown in Fig. 13.

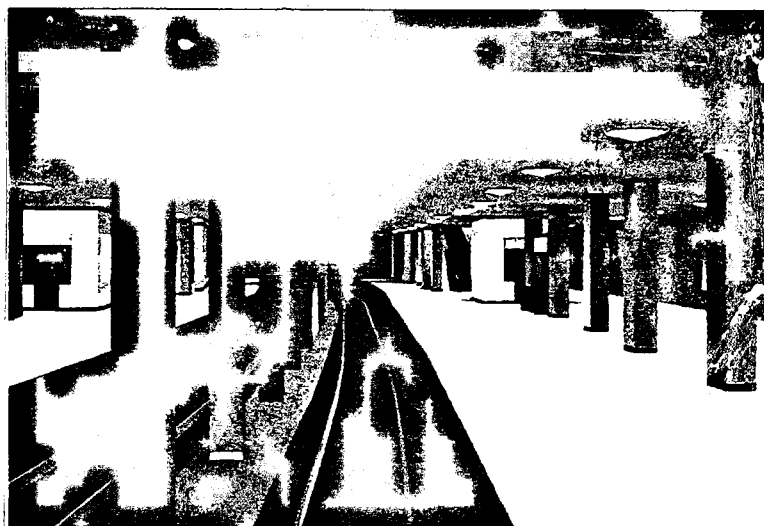


Figure 13. Virtual model of a subway station (Brill, 1992)

VR can be considered as a form of 'walkthrough' (Cf. Section 3.2.5.4) where one does not only watch but actually 'walks' himself, even making modifications if necessary. Also, the elements, which are displayed and tested in a VR simulation, are those of interior architecture. Based on Novitski's classification of elements of an interior environment as "static" (color, lighting and texture) and "dynamic" (access, acoustics and traffic patterns) (Novitski, 1992a) it may be asserted that, by VR both static and dynamic elements of interior architecture can be viewed and modified.

In order to render VR more useful and adequate to interior architecture, there awaits two groups of problems to be solved; first one being general, latter particular to interior architecture. In the former group, technical issues regarding VR equipment come to the scene: the poor ergonomics of head-mount display devices (Delaney 1992 in Brill 1992), lack of high resolution and realistic capability of the displays (Delaney in Brill 1992; MacLeod 1992; Novitski 1992a), limited range of tracking devices (Delaney in Brill 1992; Novitski 1992a), intensive power demand (MacLeod, 1992), restricted mobility (Novitski, 1992a) and time lag (Brill 1992; MacLeod 1992). Stating that participants do not spend a long time in VR architectural walkthroughs (Lasko-Harvill in Brill 1992), it may now be relevant not to bother about poor ergonomics of the devices or resolution quality or time lag for interior architecture applications, but it must be taken into account that, they will gain importance in future through improved use of VR, especially if design process is carried on within a VR environment.

The interesting point is that, as the solution of problems in the former group is improved, they become problems for the latter group, i.e. as resolution quality is improved and simulated interior space looks more 'real', determining the degree of closeness to reality turns out to be a problem. If the texture, color and lighting which is displayed in VR environment rendered in high quality and looking 'real' cannot be obtained in actual construction, then what is the point in making 'almost-real' quality simulation?

Lack of set of formulas and rules of thumb in VR leads to uncertainty in trusting the accuracy of simulations (Lanier, 1992). At this point, as it was

offered beforehand that texture and color used in computer presentations should have 'real' correspondences (Cf. Section 3.2.1); the same is valid for VR. As MacLeod clearly states: " Virtual Reality in its most common form is really just graphics. That red polygon you see in three dimensions is just that - a red polygon. While it may represent a painted wall, it does not carry any of its properties or behaviors such as fire-rating or its R-value. Even its color is just a combination of red, green, and blue dots rather than a paint manufacturer's specification" (MacLeod, 1992).

In order to render VR useful and prevent formation of incorrect impressions, VR in interior architecture has to develop standards and control and comparison criteria. As an initial step, materials represented in VR setting should have real correspondences of texture, color and other relevant specifications. This will successfully be achieved when designers will be provided by a palette of actual materials and be able to create the VR environment choosing among them. In addition, a list of actual lighting fixtures to be used in order to obtain the same illumination level and quality displayed in VR environment must be available, so that the simulated environment can have the possibility to be actually constructed on one-to-one basis.

Another issue to be handled is the time lag problem. Though it is stated that real-time simulation is not of vital importance for architectural walkthroughs in VR since there is little interaction between the participant and the environment (Lasko-Harvill in Brill 1992), it must not be forgotten that, time is an important factor in determining the distance between two nodes. Thus, with real-time simulation, the distances and circulation efficiency within a space can be tested directly. Such a test will especially be of use in design of hospitals, airports, train stations etc., checking the efficiency of circulation with respect to distance and time. Furthermore, if real-time simulations can be achieved in VR, they can offer the possibility of fire-alarm tests (determining the time needed to evacuate a space and distribute help) and rushhour tests (checking the efficiency of public circulation) and in the extreme case, strength tests (determining how long a building will stand in case of any natural disaster).

When closeness to reality is of mention, among problems particular to VR applications in interior architecture, one other important field of study in VR is the improvement of audio facilities. Such an improvement will especially be of use for acoustic analysis purposes. On the other hand, thermal analysis, though yet not possible on sensory terms, can still be handled with colored patches representing heat levels in the VR environment. Another suggestion can be developed, based on DegliAntoni's idea that when the heating plants and the outside temperature are chosen, the computer will be able to determine the temperature of the rooms and display them on a thermometer (DegliAntoni, 1990). Thus, instead of heat patches displayed in color, a thermometer can be hanging at a wall in the VR environment, displaying the temperature of the space the user is in. Yet, another interesting task is to accurately simulate daylight and shades and shadows created by position of the sun.

Achievement of all the above stated factors requires accurate input of data needed to perform analysis and display of the results. Then, at the end, it is again 'compatibility', which turns out to be the most important issue in VR. Since, in order to 'create' an environment with all of its elements and with high level of reality, a great deal of data is required, it is an initial task for VR to gather data from different nodes. As Lanier underlines: "Actually, the toughest challenges of VR are related to connectivity -that is, reading data from disparate systems and processing them in a virtual reality setting" (Lanier in Gantz 1992). At this point, in order to read data from different systems, it is required that VR environment and all involved systems should be compatible. Thus, virtual file format (Cf. Section 3.2.2.2) can be put forth once more to achieve this compatibility, i.e. data input during various design steps either by the designer himself or by consultants in virtual format can be gathered to create VR environment.

Here, it must be underlined that by gathering discrete data to create the VR environment, in fact VR succeeds in becoming a database for the whole design procedure. Furthermore, by constructing the design virtually in a VR environment, not only the correctness of material, color selections and other design decisions can be tested, but cost estimations and construction

scheduling may be determined as well. To put it more clearly, a VR setting can be considered as a rehearsal of the actual construction of the design, though in forwarded format. Nevertheless, DegliAntoni extends the span of the facilities of such a 'preconstruction' in VR from decision on deadlines, procedures, on-site layout plans, evaluation of costs, analysis of difficulties to be confronted, risks in excavation to relations with material suppliers. He also suggests that, the display in VR to be in two colors during construction stage; one color indicating the parts already built, other color representing the remaining parts to be built (DegliAntoni, 1990).

It is a common belief that, VR systems can be used in establishing an adequate ground for communication and sharing of ideas, experiences and emotions (Lanier, 1992). Based on this, studies are carried on to allow designers from different locations come together and design in a VR environment (Durward in MacLeod 1992). It may not only be considered as "a radical new approach to architecture" (MacLeod, 1992), but for interior architecture and design communication as well. If designers can design with the presence of both consultants and the client in a 3D space, testing the results of design decisions by seeing them in full scale as if in the actual setting, that is bound to change the procedure of the whole design practice.

Lanier refers to a new form of communication presented with the emergence of VR as a "post-symbolic" one: "In the physical world, you can't make physical changes to your world very quickly. The only thing you can do is use your tongue to form words that refer to all the possible changes you might make if you could. ...But in a good shared virtual reality system, you can just directly make up the objective world instead of using symbols to refer to it. Then what you have is this possibility for a new adventure that's as big as language. It would be a kind of a alternate form of communication, which would not in any way replace language, but exist side by side with it" (Lanier, 1992). Then, it may be asserted that, design in VR environment is also "a kind of alternate form" of design communication, not replacing the design language but existing as an alternative. It should then be underlined that, design communication in VR environment turns out to be a very 'familiar' one (Cf. Section 3.2.1) since VR renders our mental images 'visual'. It is

through VR that, the design model in the designer's brain can directly be transferred to the computer on full terms.

On the other hand, one very strong prediction concerning architectural practice is the emergence of a new field of work with VR which is the building of the VR environment itself. As VR introduces a new estate to be developed (Gelband in MacLeod 1992), in future architects may be employed to design VR environments, buildings and interiors of such environments (MacLeod, 1992). This not only promises a brand new market for architects and interior architects, but seems to lead to a new branch of 'specialization' as well, within both practices. However, client participation in both practices can be predicted to increase in VR environment, since the client can comprehend and implement such an almost-real environment easier than any other form of representation. For DegliAntoni, this participation is extended to the limit where: "He'll take away a copy of the house to look at it on his own computer" (DegliAntoni, 1990). Lanier goes further and draws a future picture where people will be able to change their environment decorated by new virtual furniture as soon as they return home and put on a pair of glasses and gloves (Lanier, 1992).

As entrance into VR environment is achieved through some devices which do not cover the whole body, it is not inappropriate to assert that, virtual furniture will be different from those used in real life, unless full body suits are developed. D'amato refers to "full-body resistor suits" which press against the body when you touch or bump into something as the "next big technological step" and asserts that senses of texture and temperature can be felt through "local nerve stimulation" (D'Amato, 1992). Though, latest developments in VR equipment, offer projection of an image directly onto the retina of the eye by laser beam (Greenfield, 1992), yet, the ultimate point in VR development is considered to be perceiving VR environment using natural senses without special devices (Krueger in Brill, 1992) and "direct nervous system interface" (D'amato, 1992).

Finally, it must be emphasized that, VR is a 'model' after all. Therefore, proposals stated above are all related to the issue of modeling. Consequently,

the latest operating system for VR, VEOS (Virtual Environment Operating System), capable of offering a highly interactive operating environment and reflecting in real-time changes of color, objects, elements made by the user, provides rapid prototyping, ease in defining objects and a modular environment for creating virtual entities (Emmett, 1993).



4. EXPECTED CONTRIBUTIONS OF THE INTEGRATION OF COMPUTERS IN INTERIOR ARCHITECTURE

Though computers have been involved in interior architecture, their effect on the discipline has been less compared to architecture. The most powerful reason for this is that use of drafting or design packages are written to serve design problems in general, not for interior architecture in particular. Therefore, interior architecture can at most make use of the drafting capacity of computer and generally, in schools where interior architecture is being taught, students learn to use architectural aid packages instead of packages that are oriented towards interior architecture. In fact, interior architectural aid packages would lead to an easier comprehension not only of using computers, but to the design procedure of interior architecture as well. As Clemons states: "Software programs directed at the interiors profession,...are taking the tedium out of the learning curve associated with CAD. This allows time for the computer to be used as a tool during all stages of the design process..." (Clemons, 1990).

It is true that, there are few software marketed that serve directly for interior architecture at present. Based on the proposals introduced in Chapter 3, it may be asserted that, full integration of computers in interior architecture must be handled in two groups which should in fact feed each other. One of the groups is individual software designed to be of use in specific problem solutions (i.e. design of bathroom modules or design of furniture pieces). The other comprise an interactive environment where all data and media can be available for all designers and an environment where the former group (individual software for interior architecture) can be applied. Such an environment is very likely to be created since one of the most important issues

brought forth by virtual file format is the possibility of information access at any time, by anyone. That is to say, in the very near future, designers of all fields will have access to all data needed in any kind of design problem and thus, as Neeley clearly admits: "One individual will have the knowledge and power to understand and control the entire architectural process" (Neeley in Hoyt,1991).

This assumption leads us to a future picture where most probably the strict distinction between professions -the definition and set of services provided by each profession- will fade away. Specialization within professions will surely survive if designers of any field are armed with adequate knowledge to access the abundance of information and the adequate skill to use the reached information intelligently.

The question, then, is where and how will interior architecture stand in this picture. In order to define the future place of interior architecture the viewpoint must be set in two directions; one being interior architecture practice and market and other being interior architecture education.

4.1. Future Trends In Interior Architecture Practice

Although being used extensively for their drafting capability, CAD systems are being used in interior architecture offices with increasing percentage. In a survey carried out by Interior Design, it was reported that in 1988 among 100 leading interior design firms in United States 84 were using in-house CAD systems and the increase in use of CAD among second leading 100 firms was reported to be 43 percent in 3 years i.e. 1986-89 (Clemons, 1990). Within the framework of proposals introduced (Cf. Section 3.3), with the establishment of virtual file format, enabling designers access information easily and form an interactive design environment, along with the possibility of directing their design procedure in a flexible manner will not only lead to improvement of computer-aid in interior architecture services, but also, will further computer-aid in interior architecture profession. Such involvement of computers in the profession can be said to have three important effects regarding the firm, the market and the client.

4.1.1. Change In Firm Structure

With the introduction of computers in design office, the first and undebatable change occurred in the burden of drafting and editing. The computer was a sure help in easing and quickening the drawing process, along with being useful in storing and restoring the drawn documents.

It can further be argued that, since with the use of computers the drawings came to contain more detail easily, now it is possible to replace several stages of drawing procedure with one. This will lead us to believe that soon the firms will be dealing with less drafting since it will be possible "...to follow design through to a much more advanced level of detail than previously possible" (Ross, 1992). As a natural result of this the definition and role of the drafters in a firm will change. Draftsmen will have to be more qualified, almost as a designer himself, to be able to manipulate the emerging level of detail requirements. Finally, the designer may become his own draftsman.

Therefore, the change in the structure of the interior architecture firms may lead to two extreme cases, one being a large firm consisting of several departments, the other being a one-man firm.

In the future, if the environment which was proposed in the former chapters is created i.e. if architect, interior architect or designer can have the opportunity to choose or create his own procedure when using computer aid in design process rather than having to obey the procedure of a definite design package, this, along with the possibility to access information of any sort, will free him from the strict work share within a firm. Thus, designers can work on their own sufficiently whether to combine their work later with others in a firm or release it directly on an individual basis.

According to Ross, in near future, architects will not have to learn a specific drawing tool, but they will be able to work with what suits them and this will also be compatible with the efforts of the others in the firm. So, Ross states, the organization of the firms will be affected profoundly i.e. in a highly structured firm consisting of departments all the designers will have the

chance to initiate and work out their designs the way they like, in the order they feel the best and then be able to cooperate with the staff. "All can coexist in the same office" writes Ross (Ross, 1992). This draws a clear picture of an office which is complex and crowded in structure, containing designers of diverse background and field of application who can work individually and then combine their efforts. The interesting point here is the potential of freedom of geographical participation; i.e. the members of one firm do not have to be of the same city, region, even country as long as they are 'on-line', exchanging information in virtual file format. Then, it would not be wrong to think of the firm as "a nerve center for coordinating the efforts of groups of architectural and construction firms" (Basta, 1990). This is not only true for an interior architecture firm, but for an architecture firm where interior architecture will exist as a department. Such a 'mega-firm', able to offer different services is one of the firm models of the future introduced by the emergence of the computers.

On the other hand, as even a home computer offers many chances to the designer, it is also possible that the concept of one-man firm will be possible with a designer equipped with adequate tools. As Pile correctly observes: "The more complex tasks still demand large and powerful computer equipment, but the ever-expanding capacities of even the smaller computers, plus the ability of small-computer terminals to tap into larger computers over telephone wires, are making it possible to use highly sophisticated computer techniques with comparatively small and simple equipment" (Pile, 1989). Thus, computers becoming more and more accessible give even to the individual the opportunity to compete with large firms. According to Wooldridge: "Sole practitioners will be able to do astonishing amount of work without a support staff" (Wooldridge in Novitski, 1992a).

Whichever the case, be it a mega-firm or a one-man one, one point can clearly be underlined in the structure of the firms: "the change from a labor-intensive to a capital-intensive structure" (Mitchell, 1977). This clearly summarizes the future trend in both interior architecture and architecture firms concentrating on skills in using technology along with the skill of creating and designing and emphasizes the fact that whomever will be able to

be equipped with the latest and better technology will have the biggest potential in the market share.

4.1.2. Market Change

Departing from the above framework regarding the future structure models of the firms, at first glance, it may be said that individual participation into the market is one of the issues concerning market change. Whether big or small, individuals or relatively small firms will be able to compete with large firms. This opening up of the market to the individual, will definitely have some measures and effects on interior architecture education which will be discussed in the next section.

As for large firms, it is clear that they will be able to cover an abundance of services which were not among the list of services of a firm before. This widening of services may be new like presentation in visualization in motion or giving the possibility to the client to experience the proposed design by walking in it and being able to make changes as in the case of virtual reality, or combining of various services, executed by different design participants. For example, space management and space design, stated to be two separated activities previously can now be combined in interior architecture since computer allows documentation of constantly changing space needs and search of new alternatives (Albrecht, 1989).

As the services turn out to be new in the list and large in number, it may finally be stated that one of the most important area for the firms will be 'marketing'. Ross draws attention to the argument that architects' effort in selling their services may result in less effort in design (Ross, 1992), but it may be seen as another new service in the list, yet a useful one to introduce the new face of the firms. It is believed that this marketing competition will give a boost to computer applications since they surely constitute a very attractive factor in the client's choice of the firm. According to a study by Fallon (1992) clients are demanding that computers should be used in prescribed ways: "Both government and private clients are demanding the use of specific CAD systems and even application software and databases".

4.1.3. Client Participation

The visualization possibilities of design in 3D and especially in motion, offered by computers have not only opened a new phase for designers but gave way to clients' integration in the design process. For the client it is easier to interpret a 3D model or a 'walkthrough' and presentations which are virtually real, give them the chance to experience the offered space and make desired changes. Therefore, instead of trying to work out construction drawings which mean less to anyone not in the profession, the client may now act as a decision maker in an environment which he is used to. Because as O'Malley states: "Not everyone can read a floor plan, but everybody knows how to watch TV" (Roundtable,1991). This is clearer in Vance's words where he underlines that: "...we find that many clients are much more capable of getting a sense of scale looking at a TV screen or a computer screen than they are looking at a model" (Roundtable,1991).

The precision and realistic quality of computer-generated presentations of the interior spaces, on the other hand, give the clients the possibility to comprehend the proposed interior space easily. Based on the proposals introduced in Chapter 3 about improving computer-generated interior space images, it may be asserted that, presentations prepared with material, color and light simulations which have correspondences in the market will lead to the active participation of the client in decision making process of material selection as well.

Thus, clients are participating in the design process more and more by the aid of computers. Vance tells that: "...the client actually came in and sat with us at the computer and went through a study of the escalator. They wanted a much more interactive - "what if I stand here and look through, what type of a view do I get?" presentation - as opposed to a canned presentation where we were selling them something" (Roundtable,1991). Client participation may even gain larger dimensions with electronic databases and more powerful computers which will ease the creation of alternative solutions both for the designers and the clients (Ross, 1992).

It was already mentioned in section 4.1.1. that the role of draftsmen is changing. With the urge due to client participation in design, draftsmen are very likely to change from being inside-people to professionals with client relation skills (Ross,1992). Finally, client participation in interior architecture will lead to a new formation of designer-client relationship, giving the client the role of a design critic besides any other role he may have.

4.2. Computers In Interior Architecture Education

The change in the interior architecture practice introduces new demands from interior architecture graduates. Therefore, interior architecture education is bound to restructure itself according to the changing market and practice conditions. Besides, it should be underlined that full integration of computers to interior architecture is only possible through their integration to the interior architecture education.

As Clemons notes: "Practicing designers are searching for graduates with design and CAD education rather than computer experts to operate their CAD systems. Therefore, training in CAD is becoming an integral part of interior design education at community colleges and universities" (Clemons, 1990). When talking about integrating computers to interior architecture education it would be a mistake not to change the general education program and add computers as an independent course. Such an action will be similar to that of the firms which use computers only for drafting what has been drawn by professional architects by hand. So then, the question is; how to integrate computers in interior design education?

As adding courses teaching how to use computers is simply inefficient, computers must become integral parts of design courses, aiding the students improve the quality of their design proposals. In the short term, the most outstanding course where computers can be integrated at ease is design studio; through visualization in 3D and in motion, interactive visual simulations, expert systems and environmental analyses. In the framework of the proposals introduced in Chapter 3, one of the most important and attractive services offered by the computers to be improved is the instant 3D

visualization for the interior architecture student. Since, the primary concern of interior architecture is to create 'space' with a certain atmosphere with the help of structure, furniture, properties of the materials used (i.e. color, texture, form, amount), color, light and environmental factors (i.e. thermal, acoustic, safety, etc.), visualization in 3D is of extensive help to the students which displays the result of all the design decisions. However, in order to draw the student to working with computer, 3D facilities must be easy to handle, quick and powerful, sophisticated procedure should be minimized as much as possible (Clemons, 1990) and display capability must offer a realistic presentation so as not to lead to a wrong impression.

Also, from another point of view, computers can be taken as helpful resources in teaching basic principles of design activity. Baker asserts that: "In experimental imaging the computer is used to demonstrate many of the basic principles of composition, proportion, harmony and rhythm. Traditionally these aspects of visual education are introduced to students on foundation courses using paper, pencil and paint, but these are all concepts that could benefit by using the interactive visual techniques of a computer" (Baker, 1990).

As for developing a general comprehension and sensitivity of interior architecture measures, codes, norms and scale, aid of expert systems enabling students test their alternatives with respect to human dimensions, feasibility constraints and material properties are of extensive use. It is therefore recommended that, expert systems oriented towards interior architecture should be prepared and integrated as an indispensable part of the design studio; not only helping the instructors, but improving the quality of the projects as well. One other requirement for the design studio must be simulation of environmental factors of the proposed design, evaluating the project with respect to thermal, acoustic factors, along with simulation of lighting system and safety constraints.

Expanding the framework to a more distant future and to a more integrated state of computers in interior architecture education, the requirements get more difficult. As computer field is subject to rapid development and change, the techniques, software and methods learned in school are very likely to be

out of use within a short period of time (Pile, 1989). Therefore, instead of teaching certain software packages in schools, the education must concentrate upon teaching a general approach to computers and CAD as was proposed in Chapter 3. As is being done in the Harvard University Graduate School of Design, the obligation of the education must aim at graduating professionals with adequate theory on CAD which will help them to "learn and assess emerging techniques" and instead of teaching software, the advantages of various approaches should be focused upon, helping the students understand the knowledge inherent in tools (Novitski, 1991a).

The point then, in integrating computers in interior architecture education turns out to be showing and teaching how to use the capacities of computers in general and letting the student integrate it as he wishes, rather than teaching certain packages as another lecture course. Witte underlining this aspect has stated that: "Perhaps as a result, most students see the computer as a normal part of their work, not as a specialization" (Witte, 1989). One of the important points in future design education -as it was previously stated that future education is expected to differentiate little between professions- is to give the students the chance to get specialized not 'in computers' but 'with the aid of computers'. Within the framework of the proposals introduced in Chapter 3, it is believed that, virtual file format, which enables users access and exchange information from various sources without having to use different approaches for conversion, will aid the students in using computers in design, without having to get specialized in computers.

It can be stated that that with the disappearance of strict boundaries among disciplines with the introduction of computers, as was mentioned before, the interior architecture education of the future must prepare itself to teach the students how to access information and how to use that abundance of information intelligently. In such a case, 4 or 5 years of education as it is being carried on today might only be adequate to introduce students with 'interactive use of information'.

In addition, information exchange between the student and the computer may reach a level where student gets data from the computer, processes it

according to his concern and 'teaches' it to the computer for further use. However, the present trend in computer integration in design education is divided in two camps, one being to consider students as "tool-users", who are capable of applying technology to traditional problems of the profession, other being to educate the students as "tool-builders", trained to develop design oriented software (Novitski, 1991a). It may be asserted that, the best approach is to establish the undergraduate education so as to graduate students with a general design knowledge, covering basic principles and rules, who are able to use technology and capable of adjusting themselves to the changes in technology, who can access and pick up necessary data they need.

Finally, as interior architecture practice becomes capital-intensive, the education is bound to become capital-intensive, too. That is to say, integration of computers to education has an economic dimension which is important in determining the level of use of computers offered by the schools. It should also be noted that as Witte points out, the way computers are introduced to the education has an impact on its perceived role (Witte, 1989). To put it more clearly, the amount and distribution of computers within a faculty act as determinators of expected role of computers in the education. Therefore, in determining the procedure of introduction of computers in interior architecture education, the cost confronted with must be compared with the cost of 'time', more than anything else and must be rendered available to all students within their reach as an integral part of their design studio.

In order to achieve a suitable environment for the use of computers in education, the restrictions regarding system, language and software compatibility must be solved. Moreover, although, many schools have started to include courses on computer-aid in interior architecture [See Appendix C], as computers offer an interactive environment, teaching computers alone is not enough. Other disciplines, like information sciences and communication through interactive media must also be taught to make computer literacy better. Moreover, as computer-generated simulations in motion introduce new concepts to be manipulated, like dimensions of time, motion, sound, drama, narrative and editing, organizing, filtering of complex information (Gromala, 1992), related subjects on these concepts must be integrated in the

education. As the critical point in such simulations is to design a path showing presentable views, neither boring the viewer, nor detracting the architectural message (Novitski, 1991c), interior architects must be trained in film-making and even in liberal arts, along with computer sciences in order to grasp collaboration with other disciplines better (Gromala, 1992).

An academic environment is the place where the future fate of disciplines in relation to the computers will be determined. Therefore, all the educational units throughout the world should have compatible means of design and design data communication as was proposed in Chapter 3 for the sake of full integration of computers in education and practice. The reflection of this to design education is the creation of a method which will enable the students to create their own procedure in designing with computers, independent of different design aid packages. In such an environment, students will be equipped with necessary information about elements and logic of CAD along with design principles and rules and be capable of accessing relevant data. Then, they will be free to construct their own algorithm and apply it accordingly with respect to the design problem they have in hand. This may be resembled to instructing the notes and musical system and then letting the students make their own compositions and tunes. Giving each student, who are future professionals, the chance to be a composer is also the true spirit of design as well. The virtual CAD file concept proposed in Chapter 3 is then, from this point of view, has an academic implementation and can be employed to create an environment where all design students have the possibility to communicate and interact through their design models.

5. CONCLUSION

After having discussed in Chapter 4, the expected contributions to interior architecture of the proposals introduced throughout this work, as a final word, it is appropriate to note down that, the *raison d'être* of this thesis is the wish to search for ways to integrate computers in interior architecture as efficient and as easy-to-use as possible.

It is observed that, computers lead to restructuring of most of the disciplines where they have been employed, and lead to changing of many aspects which shape these disciplines such as esthetic values, market needs and education. Especially in architecture, where computers have proved to be more than mere draft tools, but design assistants, the urge has been initiated as to render interior architecture capable of employing computer aid efficiently and restructuring itself so as to meet expectations and needs of the changing market and social conditions.

Looking closely at the profession of interior architecture, though it handles issues similar to architecture, it must be underlined that, it is through interior space that people appreciate architecture, i.e. the degree of comfort and functionality of the interior environment lead people enjoy living within that enclosure. Therefore, creation of interior spaces, with all details, dynamic and static elements consist the job of interior architect, which is to be carried out with the association of the architect at its best, resulting in need of an interactive medium to participate.

Within this framework, in order to put forth the proposals, the question asked is: do computers render us more intelligent? No. It is only the fact that, we

have to analyze how we think before trying to teach computers to think like us. To put it more clearly, in order to get a task done by the computer, we have to sequence the process, model it in our brains, then 'convert' it to the language of the computer in the form of commands and menu choices. It is this 'conversion process' that requires additional knowledge and care; which renders the use of computers kind of a 'specialization'. In searching for new ways of computing, the first issue to be handled is to load the burden of 'conversion' to the computer and free the user of bothering about operation of different systems and software packages.

Based on this idea, the proposals are introduced in order to make use of computers not only in design, but in establishment of an interactive design process. In doing this, two points are stressed and tried to be proved; that computers are design assistants since they offer the possibility to display the design model in the designer's mind on full terms, unlike any other traditional medium; and that as modeling is the basis of design process and conventional methods are not media for creation but presentation, the long argued term "computer-aided design" is an unprecedented and familiar medium.

Believing that computer technology is mature enough to accommodate and achieve a big step in computer-aid in design, the study wishes to be considered as an initial basis for discussion on improving computer-aid in design.

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APPENDICES



APPENDIX A

Following is a selected list of architectural software released until the end of 1989. The selection is made in order to display software with different features in order to cover various aspects of software in the market by the end of 1980's.

AutoCAD: developed by Autodesk Inc., it is the most commonly used system. It runs on IBM PC and compatibles. The latest version 11.0, is capable of controlling the database, supports a network, AutoCAD Development System, solid modeling facilities and the like. The system may interactively work with AutoArchitect, AutoShade+AutoFlix, Animator which are the additional software that expand its capabilities. AutoCAD may be styled according to the wishes of the user provided that the user may use AutoLISP language. Autodesk has also introduced feature-laden ASG Architectural to run with AutoCAD.

GDS (Graphic Design System): produced by ARC Ltd., GDS is a CAD package with stress on 2D drafting. Automatic hatching and dimensioning and capability to interface programs of any computer language and to database management systems are among the features of the program which is claimed to be a very 'comprehensive' one. Thus, learning to use GDS is not easy.

IGDS (Interactive Graphics Design Software): is vendored by Intergraph Corporation and can produce both 2D and 3D drawings which it can process at ease. Automatic hatching and dimensioning and dynamic rotations of view are among the covered facilities. To obtain high performance, advanced hardware must be employed resulting in expensive solutions.

MiniCad: developed by Diehl Graph Soft Inc., is a CAD system running on Mac models of Apple. It is basically a 2D and 3D drawing and display tool.

MacArchitriion: being a product of Gimeor, it is a 3D architectural package with the unique feature of calculating sun and shadow effects for a given view. The same properties are also valid for the French firm Abvent's SpaceEdit.

CADDS-4x: released by Prime/Computervision, it is basically a modeling software.

Fastcad 3D: developed by Evolution Computing, the system is a 3D CAD

system for IBM and compatibles running DOS 2.0 or higher. It boasts with providing four different views of the same drawing at the same time on the screen. Icons of panning, zooming or those serving for change of layers are available.

VersaCAD: is a CAD software prepared by the VersaCAD, capable of 2D drafting and 3D shading and providing HyperCard stacks. The transfer of 2D drawings to 3D is possible with the choices of wireframe, isometric, hidden-line and perspective. The program has Macintosh editions.

ModelShop: developed by Paracomp Inc., the program is a 3D surface modeler, helping the architect display the possible 3D models of the design with 235 layers and flexible view options.

SilverScreen: is a 2D and 3D drafting and modeling package released by the Schroff Dev. Corp. It claims to use polygons and solids and Boolean solid-modeling functions and features camera-walk function which may offer snapshots for a slide-show.

HICAD: released by Hitachi America Ltd., introduces an interface for the C-language and boasts of the capability of manipulation of advanced geometry with fine options.

DRAWBASE: developed by SKOK Systems, Inc., the program features 3D SHADE enabling the user to show the light effect on the model created. An integrated text editor and integral programming language are also provided.

3D CAD: released by IBM and Skidmore, Owings and Merrill, the package is capable of storing graphic data in 3D and introduce a relational database as well.

Generic CADD: prepared by the Generic Software Inc., the program is available both for the PCs and Macintosh. It offers possibilities of manipulation of shapes and coloring them up to 256 different colors and using PICT format may refer to other programs.

SONATA: released by the Silicon Grapics, the program is a 3D building modeling program which is expensive due to its content since it provides possibilities of basic graphical tasks, modeling to 1/1 scale and allows work of different disciplines with only one database.

VELLUM: prepared by Ashlar, it is a PC design and draft software which is capable of thinking. Thus, it can pinpoint and align geometry as user draws and sets precise dimensions at any time while drawing free-hand.

Apart from those listed above, more software can be mentioned which are capable of achieving the same tasks like those of above. Among these; ANVIL-5000pc, MICROCADAM, AutoSolid, MicroStation may be highlighted.

A broader list may be achieved with mentioning the following groups of; 2D drawing packages: DOGS (PAFEC Ltd.), SWIFTII (TANGRAM CAE Ltd.), MLD (Mountford & Laxon Ltd.), GENIE (Norrie Hill Ltd.), MICRO_DESIGNER (Hytech Consultants Ltd.) and 3D modeling packages: ROMULUS (Shape Data Ltd.), BOXER (PAFEC Ltd.), MEDUSA (CIS Ltd.), EUCLID (Matra-Datavision).

Finally, 2D non-interactive system MEDALS (CAD Centre of Cambridge), 2.5D non-interactive system CARBS (ICI Ltd.), 2D interactive systems DAISY and ARK/2 (Decision Graphics Inc.) and 2.5D interactive systems BDS/OXSYS (Cambridge) and RUCAPS (GMW Comp. Ltd.) should be underlined which do make up the academic research part of the CAD and constitute its history.

(New Releases, 1989; General Data, 1988)

APPENDIX B

Following are chosen curriculum examples and course definitions from architecture departments of various universities, which include computer, computer-aided design and related courses.

Term 2 (Spring)

A4002	Core studio, II	9 pts
A4123	Structures, II	3 pts
A4220	Architecture and technology, I	3 pts
A4349	History of architecture, II	3 pts
		18 pts

Term 3 (Autumn)

A4003	Core studio, III	9 pts
A4125	Structures, III	3 pts
A4535	<u>Computer-aided design in architecture</u>	3 pts
	History/theory distribution course	3 pts
		18 pts

Term 4 (Spring)

A4004	Advanced studio, IV	9 pts
A4221	Architecture and technology, II	3 pts
	History/theory distribution course	3 pts
A4503	Architectural drawing: advanced	3 pts
		18 pts

Term 5 (Autumn)

A4005	Advanced studio, V	9 pts
A4610	Architecture and technology, III	3 pts
	History/theory distribution course	3 pts
	Elective	3 pts
		18 pts

Term 6 (Spring)

A4006	Advanced studio, VI	9 pts
	Methods/practice distribution course	3 pts
	History/theory distribution course	3 pts
	Elective	3 pts
		18 pts

Total for M.Arch. degree: 108 pts minimum

(Columbia University, Graduate School of Architecture Planning and Preservation - from M.Arch Degree Curriculum)

2. Research Areas

Presently students choose between two areas of concentration: Computational Design or Building Performance and Diagnostics.

2.1 Computational Design

Computer-aided design is a rapidly growing field throughout the developed world. The traditional focus of research has been the representation of built environments, components or artifacts in a form capable of supporting documentation, automated analysis and simulation. More recently, attention has also been given to exploring the use of computers as a new design *medium* and to developing capabilities that surpass some limitations inherent in more traditional media. Of particular promise is work in formal grammars and knowledge-based systems, complemented by cognitive studies of the way in which designers and architects perform their tasks. The Department's research is at the forefront of these areas.

2.1.1 History

The appointment of Charles Eastman in 1968 to the faculty of both the Department of Architecture and the Department of Computer Science initiated a series of research projects that became seminal to the field of computer-aided architectural design. Initial efforts concentrated on design automation and culminated in the General Space Planner (GSP), a software system for solving space planning problems. This work was supported and enhanced by research in human problem-solving ongoing in the Departments of Psychology and Computer Science. Subsequent research activities concentrated on a general modeling scheme for buildings and led to three generations of software: the Building Description System (BDS), a three-dimensional solids modeler; the Graphical Language for Interactive Design (GLIDE, and its later version GLIDE2), a general database for engineering and architectural design.

2.1.2 Current Work

This work continues through the efforts of current faculty members. Ömer Akin concentrates on the investigation of problem-solving strategies in design. Recent work includes a design simulation program, called HeGeL, which is used to study problem structuring in architectural design tasks, and a new NSF grant to study the collective design process. Ulrich Flemming has concentrated on the use of formal grammars in the analysis and generation of designs and on the development of generative expert systems for architectural design, with particular emphasis on floor plans and other types of layouts. The LOOS system that resulted from the latter effort has become the basis for various follow-up projects in several departments. Professor Flemming also collaborates with faculty in Civil Engineering in efforts to develop an integrated software environment for building design and construction (IBDE). Ramesh Krishnamurti's interest lies in the area of computational design and theory with particular emphasis on developing algorithms for spatial designs and descriptions. He is currently working on problems relating to spatial grammars and design semantics. Irving Oppenheim holds a joint appointment in Architecture and Civil Engineering. An expert in geometric reasoning, structures and robotics, he provides a link between the two departments. Doug Stoker is exploring new approaches towards the design and development of computer-based design tools and systems. He is currently working with the Software Engineering Institute to develop a relational CAD system incorporating aspects of graphics and geometry-oriented systems with those of relational data base platforms. Cornelius (Skip) VanWyk's research focuses on design analysis and visualization techniques that rely exclusively on geometric representation and procedures common to most computer-aided design systems. His work has led to an integrated design/analysis model that can be used for visualization and photorealistic rendering, for modeling daylighting, and for modeling insolation on an arbitrary geometry. Robert Woodbury studies the representation and manipulation of geometric information. His work has led to two new systems, for solids and spatial structures respectively; interpreters for these have been developed. He collaborates on the IBDE project, where his emphasis is on architectures for distributed problem solving. Professor Woodbury has also directed the development of VEGA, a boundary representation solids modeler.

(Carnegie Mellon University, Graduate School of Architecture -Master of Science in Architecture)

Architecture/Urban Design Courses Listed by Subject

Architectural Design

- 401. Projects in Architecture
- 411. Introductory Design Studio
- 412. Building Design Studio
- 413. Building Design with Landscape Studio
- 414. Major Building Design I
- 415. Major Building Design II
- 416. Comprehensive Design Studio
- 421A-421B. Architectural Drawing
- 422. Advanced Architectural Drawing
- 461. Architectural Practice
- 490. Urban Innovations Group Workshop
- 496. Special Projects in Architecture

Urban Design

- 187. Planning and Designing Our Cities
- 258. Urban Morphology
- 271. Elements of Urban Design
- 272. Real Estate Development for Planners and Architects
- 274. Introduction to Physical Planning
- 280. City Studies
- 289. Special Topics in Architecture and Urban Design
- 402. Projects in Urban Design
- 490. Urban Innovations Group Workshop
- 497. Special Projects in Urban Design

Policy, Programming, and Evaluation

- 203. Decision Making in Planning and Design
- 204. Imaging the Future
- 278. Qualitative Research Methods for Planners and Designers
- 291A-291B. Theory of Architectural Programming
- 292. Social Meaning of Space
- 294A-294B. Environmental Psychology
- 297. Group Process in Design
- 298A. Research Practicum in Policy, Programming, and Evaluation
- 403A. Projects in Policy, Programming, and Evaluation

Technology

- 242. Climate Responsive Design
- 243. Energy Modeling
- 247A. Introduction to Energy/Resource-Conserving Solar Design
- 247B. Energy/Resource-Conserving Solar Design and Practice
- 248A. Passively Integrated Solar Systems: Heating
- 248B. Passively Integrated Solar Systems: Cooling
- 255A-255B. Climatic Issues in Urban Design
- 298B. Research Practicum in Technology
- 403B. Projects in Technology
- 431A-431B. Structures I
- 432. Structures II
- 433. Structures III
- 434. Structures IV
- 436. Building Construction
- 437. Construction Documents
- 438. Systems Building
- 441. Environmental Control Systems
- 442. Building Climatology
- 444. Light and the Visual Environment
- 445. Architectural Acoustics
- 448. Communication and Diffusion of Innovation

Design Theory and Methods

- 224A-224B. Formal Theory of Composition
- 226A. Introduction to Graphics Programming
- 226B. Computer-Aided Design and Modeling
- 227A. Computer Programming of Applications in Architecture and Urban Planning
- 227B. Geometric Modeling
- 227C. User Interaction Techniques in Design
- 227D. Data Bases in Design
- 228A-228B. Computational Foundations of Architectural Design
- 298C. Research Practicum in Design Theory and Methods
- 403C. Projects in Design Theory and Methods
- 460. Computer-Aided Design Practice

History, Analysis, and Criticism of Architecture

- 154C-154D. History of American Architecture and Urban Planning, 1600 to the Present
- 200A-200B-200C. Introduction to History of Architecture
- 201. Introduction to Architectural Theory
- 281A. Introduction to History of the Built Environment in the U.S.
- 281B. Advanced Seminar in History of the Built Environment
- 282A. Roots of Modernism
- 282B. Modern and Postmodern Architecture
- 283. History of the American Household and American Home
- 286A-286B. Ancient Architecture
- 287. Architecture in Europe and the Middle East, 400-1500
- 288A-288B. Renaissance and Baroque Architecture
- 290. History and Theory of Landscape
- 298D. Research Practicum in History, Analysis, and Criticism of Architecture
- 403D. Projects in History, Analysis, and Criticism of Architecture

Other

- 190. Human Environment: Introduction to Architecture and Urban Planning
- 199. Special Studies
- 279. Housing for Developing Countries
- 296. Proseminar in Architectural Theory
- 298A-298D. Research Practicum in Architecture
- 375. Teaching Apprentice Practicum
- 403A-403D. Project with Specific Topic
- 498. Program Development
- 596A. Directed Individual Research and Study in Architecture and Urban Design
- 597A. Preparation for Comprehensive Examination or Ph.D. Qualifying Examinations
- 598A. Preparation in Architecture/Urban Design for Master's Thesis
- 599A. Ph.D. Dissertation Research in Architecture

(UCLA, Graduate School of Architecture and Urban Planning -Curriculum)

226A. Introduction to Graphics Programming. Lecture, three hours. Design-oriented introduction to computer graphics programming using PASCAL language. Ms. Liggett

226B. Computer-Aided Design and Modeling. Function and structure of modern CAD systems; practical and theoretical aspects of their use and evaluation; two- and three-dimensional geometry; attributes and customization. Mr. Eastman

227A. Computer Programming of Applications in Architecture and Urban Planning. Lecture, three hours. Prerequisite: course 226A. Logic and problem solving using PASCAL and C. Review of algorithms, data structures, and applications. Ms. Liggett

227B. Geometric Modeling. Lecture, three hours. Prerequisite: course 227A or equivalent. Theory and implementation for computer modeling of three-dimensional shapes and volumes; various representations; transformations, surface modeling. Mr. Eastman

227C. User Interaction Techniques in Design. Lecture, three hours. Prerequisite: course 227A or equivalent. Software algorithms and techniques for implementing modern computer-user interfaces; raster operations; cognitive models; window management systems. Mr. Eastman

227D. Data Bases in Design. Lecture, three hours. Prerequisite: course 227A or equivalent. Survey of data base management systems and their application to design and engineering. Physical and logical level system design; special issues associated with engineering and design, including meta-file management and storing of geometry. Mr. Eastman

228A-228B. Computational Foundations of Architectural Design. Lecture, three hours. Prerequisite: consent of instructor. Introduction to composition and description of architectural designs in algorithmic processes; alternative representations of shapes and their corresponding algebras, shape grammars and languages of designs, description schemes. Mr. March, Mr. Stiny (F.W)

460. Computer-Aided Design Practice. Lecture/seminar, three hours. Introduction to professional practice in context of computer technology — planning for introduction of computer technology, system selection, education and training issues, operational issues, costs, benefits and financial implications, ethical issues.

(UCLA, Graduate School of Architecture and Urban Planning -from course explanations)

Computer Applications

New equipment to be located in Atkinson Hall will improve opportunities for faculty and students to investigate computer applications, and in particular, new visualization techniques for design.

Professor Nicholas Musso is completing research funded by the Graham Foundation: Re-Integrating Technology and Design Software Development.

Cheryl Ayer's Master's thesis, in which she developed a typology of nursing home plans, included consideration of an expert system that designers could use to test their design decisions.

A study by School of Architecture students and faculty will become part of a traveling exhibition sponsored by Montage Foundation. The LSU team subjected a number of Luis Barragan's designs to computer-aided analysis to discover what, if any, proportioning systems underlie Barragan's work. Graduate students Cheryl Ayers and Gordon Cameron worked with Professors Wayne Attoe and Jack Leaver.

(Louisiana State University, Graduate School of Architecture)

COMPUTER-AIDED DESIGN

Robert S. Frew, *Study Area Coordinator*

Computer-aided design (CAD) involves the study of computer methods and their application to design. The courses cover an introduction to computing, the use of CAD systems running on various computers, computational methods in computer graphics, and the study of mathematics as it applies to design. The equipment includes personal computers with digitizers and plotters, and advanced CAD workstations.

850a or 851b, **COMPUTERS FOR ARCHITECTS**. 3 credits. An introduction to computer-aided architecture. No prior experience with computers is assumed, and no programming will be required. The following topics will be addressed: personal computer hardware and operating system software, word processing, computer-aided design (2-D and 3-D), electronic spreadsheets, and other architectural applications such as solar energy analysis, structural design, and cost estimating. Throughout the course, the fluid nature of electronic information will be emphasized, with particular attention paid to the exchange of information between the various application programs. M. Horowitz.

856b, **ADVANCED COMPUTER-AIDED DESIGN**. 3 credits. A course designed to give students an understanding of how computers can be used in all phases of architectural design, from schematics through the presentation of the finished product. Using advanced CAD workstations, the class will explore wire-frame modeling, surface modeling, and solids modeling. The first half of the term will deal with the computer as a tool for drawing and analysis; the second half, as a tool for design and presentation, using plotted drawings, slides, and video. *Prerequisite:* 850a or 851b or permission of instructor. R. Frew.

861b/685b, **ARCHITECTURAL PROJECT MANAGEMENT WITH COMPUTERS**. 3 credits. (See course description for 685b under Architectural Practice and Construction.) P. Bernstein.

870a, **COMPUTER GRAPHICS**. 3 credits. An introduction to computer programming for architects, this course will explore the fundamental algorithms of computer graphics, from point to line and plane, 2-D and 3-D operations using matrix transformations—move, scale, and rotate—will be introduced; 3-D database structures and axonometric, isometric, and perspective projections will be reviewed and programmed. *Prerequisite:* 850a or 851b or permission of instructor. Faculty.

875b, **DESIGN AND COMPUTING SEMINAR**. 3 credits. The course introduces the relationships between design, mathematics, and computation. The concepts of finite mathematics will be introduced using building design examples. Problem-solving methods in design and computation will be explored. The analysis of plan types and their relationship to topology and geometry, and symmetry and combinatorial groups will be introduced. Computer projects and readings will be assigned to explore the concepts. *Prerequisite:* 870a or familiarity with programming language. Faculty.

899, **INDEPENDENT COURSE WORK**. 3 or 6 credits. Program to be determined with faculty adviser of student's choice and submitted with endorsement of study area coordinators to the Rules Committee for confirmation of the student's eligibility under the rules. (See *Rules and Regulations of the School of Architecture*.)

ARCHITECTURAL PRACTICE AND CONSTRUCTION

Donald J. Baerman, *Study Area Coordinator*

The courses listed under this area attempt to relate academic education to architectural practice. Factors which affect the design and performance of built environments are considered both as restraints and as opportunities for design freedom.

661a, MATERIALS IN ARCHITECTURE. (Required in first term; see earlier description.)

666b, ARCHITECTURAL PRACTICE. (Required in sixth term; see earlier description.)

671b, CULTURE AND CONSTRUCTION IN ARCHITECTURAL COMPOSITION. 3 credits. The assignments and seminars in this course will examine how the perceived meanings of buildings, the composition of their elevations, and the construction of their walls are all directly interconnected, with some emphasis on adjacencies between new and old buildings. Four lectures by visiting scholars will suggest a framework for considering architectural meaning in relation to the culture of today's world. Limited to 12 students. P. Millard.

681a, ARCHITECTURE AS BUILDING. 3 credits. Analysis of major buildings of this century through detailed dissection of their methods of construction. Graphic display of the major systems that make up a contemporary work of architecture will allow for a reconstruction of the design process and re-establish the thought patterns that formed the design priorities. Emphasis will be on the relation of systems of structure and enclosure with the required technical systems. T. Beeby and faculty.

685b, ARCHITECTURAL PROJECT MANAGEMENT WITH COMPUTERS. 3 credits. This course will acquaint students with basic principles of architectural project management, combined with appropriate microcomputing skills. It is designed to provide an understanding of the fundamentals of organizing and running architectural projects. Lectures will describe concepts and techniques for determining scope of services, writing owner/architect and consultant contracts, negotiating fees, assessing and minimizing risk, and planning schedules. Accompanying laboratory sessions will introduce appropriate computing instruments to support project management, including word processing, spreadsheets, and computerized scheduling. The final project will provide an opportunity to integrate these skills by producing a proposal for a small commission undertaken by a fledgling free-lance practitioner or member of a small office. No previous computer experience is required. P. Bernstein.

(Yale University, Graduate School of Architecture -from course explanations)

Architecture A4136 Computers and structures. 3 pts
Mr. McCormick.

Use of the computer to solve contemporary structural problems. Hands-on use of hardware and software employed by structural consultants and architects for analysis, representation, and design of elementary structural systems. Enrollment is limited to 24 students. Prerequisites: *Structures I.*

Architecture A4535 Computer-aided design in architecture and preservation. 3 pts

Messrs. Tountas and Muir.

A previous knowledge of computers is not required. An introduction to concepts, issues, and methods in computer-aided design. Topics include interactive and procedural approaches, parametric design, and integration of spatial modeling with other information-processing activities. Emphasis is placed on the creation of three-dimensional models using the University's computer center, as well as the program's computer-aided design facility that includes several work stations, plotters, digitizers, etc.

Architecture A4534 Advanced computer-aided design in architecture and preservation. 3 pts

Messrs. Tountas and Muir.

Prerequisite: *Architecture A4535* or equivalent.

Continuation of *A4535* in a smaller seminar format.

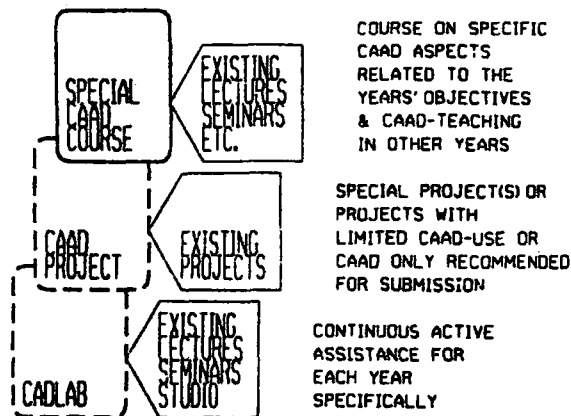
Architecture A4536 Development and finance. 3 pts

Mr. Bell.

An introduction to economic decision making with regard to income-producing properties, through case study examinations of the effects of feasibility studies, political restraints, pioneering, financing, methods of leverage, taxation, and investment return. Successful and unsuccessful suburban and urban multifamily housing, shopping center, rehabilitation and renovation, and office building projects.

(Columbia University, Graduate School of Architecture Planning and Preservation -from M.Arch Degree Curriculum Course explanations)

CADCUR BUILDING BLOCKS FOR EACH YEAR



DASHED LINES: OPTIONAL ITEMS
 SOLID LINES: COMPULSORY ITEMS

(National University of Singapore, School of Architecture)

APPENDIX C

Following are chosen curriculum examples and course definitions from interior architecture departments of various universities, which include computer, computer-aided design and related courses.

B.F.A. DEGREE	
CORE CURRICULUM	
Foundation Program	50 hours
DR100 Drawing I	
DR101 Drawing II	
DR111 Architectural Graphics I	
DR112 Architectural Graphics II	
DR204 Architectural Rendering	
DS100 Two-dimensional Design	
DS101 Color Theory	
DS102 Three-dimensional Design	
CR 101 Introduction to Applied Arts*	
SC 101 Introduction to Sculpture*	
** Studio Elective	
Liberal Arts Program 60 hours	
AH100 Survey of Western Arts I	
AH110 Survey of Western Arts II	
AH** Art History Elective	
AH** Art History Elective	
AH206 Nineteenth Century Architecture	
AH208 Twentieth Century Architecture	
AS121 History of American Culture	
EN123 Composition and Literature I	
EN** Language Arts Elective	
PS101 Introduction to Psychology	
MS101 Music Appreciation	
CM121 Computer Math	
MAJOR PROGRAM 60 hours	
ID 101 Introduction to Interior Design	
ID 200 Interior Materials	
ID 201 Space Planning	
ID 206 Decorative Arts	
ID 208 Twentieth Century Interiors	
AR225 Computer Aided Design	
AR241 Construction Technology I	
ID 309 Contract Design	
ID 402 Commercial Design	
** Building Arts Elective	
** Building Arts Elective	
ID 403 Business Practices	
ELECTIVES	10 hours
TOTAL COURSE OF STUDY	180 hours
*Select either CR 101 or SC 101.	
** Consult your faculty adviser in selecting elective courses.	

(Savannah College Of Art And Design - Bachelor Of Fine Arts In Interior Design curriculum)

SOPOHMORE YEAR	34 CREDITS
INT 201-202 <i>Design I & II</i>	8
INT 211-212 <i>Mechanical Systems I & II</i>	4
INT 215-216 <i>Building Construction I & II</i>	4
INT 223-224 <i>Architectural Drawing I & II</i>	4
HA 215-216 <i>19th & 20th Century Art History</i>	4
<i>Studio Electives</i>	4
<i>Social Sciences/Philosophy Elective</i>	3
<i>Science Elective</i>	3

JUNIOR YEAR	34 CREDITS
INT 301-302 <i>Design III & IV</i>	8
INT 315-316 <i>Building Construction III & IV</i>	4
INT 317 <i>Furniture Design</i>	2
INT 321 <i>Lighting Design</i>	2
INT 323 <i>Architectural Drawing III</i>	2
INT 332 <i>Environmental Theory</i>	2
HD 360 <i>History of Interior Design</i>	2
CH 300-400 <i>World Civilizations I & II</i>	6
<i>Liberal Arts Electives</i>	6

SENIOR YEAR	30 CREDITS
INT 401-402 <i>Design V & VI</i>	8
INT 415-416 <i>Working Drawings I & II</i>	4
INT 424 <i>Architectural Drawing IV</i>	2
INT 431 <i>Professional Practice</i>	2
INT 432 <i>Contract Administration</i>	2
INT 439 <i>Computer Graphics for Designers</i>	2
<i>Social Science/Philosophy Elective</i>	3
<i>Liberal Arts Electives</i>	7

439 Computer Graphics for Designers

2 credits
This is an introductory course in computer graphics with an emphasis on plan and spatial projections. Students learn the use of the VAX-11/780 computer with MOVIE.BYU software and produce slides of final projects directly off the computer.

(Pratt Institute - typical program of study in Interior Design)

INTERIOR ARCHITECTURE

A holistic view of the architectural space, its design, structure, materials, and finishes, characterizes the field of interior architecture. This program emphasizes the explorative and conceptual aspects of the design process, as well as the development of the technical and theoretical skills required of an interior architect.

The department promotes visual literacy, conceptual thinking and designing, theoretical discourse, and the development of a student's own design language. Students are encouraged to explore a range of media, including drawing, model making, photography, video, and computer imaging.

Interior Architecture Equipment/Facilities

Materials and samples library

Computer lab with Macintosh IIsx, color and black-and-white printers, scanner

35mm copy camera

Common graduate studio with drafting tables

Parallel rules

Slide projectors

Lighting samples lab

Video recording equipment

(The School Of The Art Institute Of Chicago - from Master Of Fine Arts In Interior Architecture information)

Master of Fine Arts in Interior Architecture and Environmental Design

COURSES OFFERED

Autumn Semester

IAED 501	Graduate Studio I	3
IAED 511	Research Methods I	3
IAED 551	Environmental Geometry and Structure	3
IAED 561	History of Theory and Criticism	3
IAED 571	Lighting and Color	3
IAED 573	<u>Computer Programming</u>	3

Spring Semester

IAED 502	Graduate Studio II	3
IAED 512	Statistical Analysis	3
IAED 514	Research Methods II	3
IAED 542	Environmental Factors	3
IAED 562	Historical Component in Contemporary Environment ..	3
IAED 572	Building Safety	3
IAED 574	Art, Science and Technology	3
IAED 576	<u>Computers in Design and Architecture</u>	3

Required Thesis or Projects

IAED 590	Research Topics	—
IAED 599	Master Thesis	—

IAED 573 Computer Programming

Introduction to computers, computer applications and programming. Starting with the Disk Operating System, some word processing applications will be used to describe programming logic and high level language constructs.

IAED 576 Computers in Design and Architecture

The use of computers in various design professions is discussed. Computer programming will be further studied together with an introduction to the principles of computer graphics.

(Bilkent University, Department of Interior Architecture and Environmental Design - from graduate course descriptions)

IAED 212 Computers and Geometry

Introduction of basic hardware and software concepts and the command language relevant to the operating system. A fully covered text processor. Basic geometric concepts related to two and three dimensional design are produced by the aid of a software system.

IAED 311 Computer Aided Design

Matrix representations of the homogeneous coordinate system and transformations are introduced. Concepts such as symmetry, pattern, shape and graph theory are covered. Two and three dimensional design concepts are demonstrated through a CADD system. Prerequisite: IAED 212.

IAED 316 Computer Applications

Introduction to better hard disk management. Creating simple screen macros. Working with various application programs.

(Bilkent University, Department Of Interior Architecture And Environmental Design - from undergraduate course descriptions)

Interior Design

The master's program in interior design offers advanced study in commercial and residential design and design research. The diverse expertise of the faculty includes historic preservation and adaptive reuse, facilities management, barrier-free design, lighting, and computer-aided design. Graduates of the program are prepared for careers in professional practice as well as being qualified for college and university teaching.

Research topics can evolve from a wide variety of subjects related to interior design. For example, recent theses have addressed design-related problems in computer usage; play equipment design for children; adaptive reuse of historic structures; and pre-design evaluation procedures.

(Virginia Tech, Department Of Housing, Interior Design, And Resource Management - from Graduate Study Areas descriptions)