Military Technical College
Kobry El-Kobbah,
Cairo, Egypt

9th International Conference on Civil and Architecture Engineering
ICCAE-9-2012

Digital Practicing of Architecture – Limits and Future Horizons

Dr. Hossam Eldin Ibrahim Sayed Ahmed
Lecturer at the institute of Architecture & Housing
Housing & Building National Research Center (HBNRC)
87, El-Tahrir St. Dokki, Giza
Mob. 01222113887
Email: hossibrahim@hotmail.com

Abstract

The effect of the digital revolution on practicing the profession of archite cture during its different phases is evident and unavoidable. Digital technology has produced a variety of new tools and techniques that resemble and enhance the various tasks involved in the practice of architecture in an accurate, rapid, and easy -to-use ways.

In all projects, from small scale housing unit to a large scale national project, there are several phases which the project must go through, starting from client briefing, preliminary project (Avant Projet), construction drawings and coordination, and finally execution and supervision. Digital technology has participated in all these phases by producing different tools and programs that enhance the quality of the profession.

Although digital technology has totally changed the traditional approach o f architectural projects in the last decade, most architects still consider digital technology as an assistive technology that just aids the pra ctice of architecture. In this sense, digital technology constitutes a continuous challenge for architects to ad apt their way of thinking, imagination, and practicing to cope with this endless digital revolution.

The paper explores practicing the profession of architecture from a *digital* point of view. It discusses the different digital tools of practicing the profe ssion in all project phases and the effects, either positive or negative, of this new way of practicing on the qualities required in each phase. It also discusses the future prospects expected from the digital revolution in the architecture domain.

1- Introduction

The technological tools used in building and architecture domains have always represented a key component of architectural thought which is always affected by the availability of new and developed building techniques. There is no doubt that throug h the history of architecture, since the old ages and until the era of the industrial revolution, there have been clear and vast effects of the available building techniques on architecture. The most obvious example of that is the great development in buil ding construction using steel sections which enables architect to design and construct tall buildings exceeding hundreds of floors, which was a kind of fiction during the nineteenth century.

The practice of architecture has changed more radically in the la st fifteen years than perhaps at any time in its entire history. Recent developments in contemporary architecture have been significantly influenced by the emergence of digital technologies as a primary production tool allowing for new ways of thinking. Th e key in the development of digital tools to enhance the practice of architecture is the facilities it introduces with which the various tasks involved in the practice of architecture have been represented, enabled, or enhanced. The digital representation and manipulation of architectural entities have provided a lternate means to the production process of buildings. Drawing, modeling, performance simulation, design collaboration, construction management, and building fabrication are now routinely performed using computer based technology. Many of the new techniques pioneered by digital architects more than a decade ago are now finding their way into mainstream architecture, creating a greater public appreciation of what was once perceived as "radical" architecture. The most famous project expressing this turn movement of architecture is Guggenheim museum in Bilbao, Spain designed by the architect Frank Gehry in 1997 (figure 1).

In the early stages of their engagement of computer technology, architects approac hed the technology as an assistive technology that would enhance the practice of architecture. The scope of the engagement was captured in the phrase ‘computer -aided architectural design.’ During the following four decades, the role of computer technology in architecture has gained a remarkable significance to the degree that the scope of

computer engagement in the profession can be expressed as "totally computer-mediated architectural design". Digital revolution has not enhanced the profession by providing only computer techniques, but has also added to it the internet facilities and its wide-spread capabilities. These two technologies have totally reformed the tools and ways of practicing architecture.

The paper discusses the usage of the advanced tools provided by digital technology in architectural practicing from a user point of view. The user here means an architect practicing the profession using the stat-of-the-art digital solutions.

2- Phases of The Architectural Project

The steps of working in an architectural project, from a small scale dwelling unit to a large scale national project that the architect has to encounter are as follows:

2-1 Initiation:

The client is usually the party who call for the architect to solve the problem. Based on a request for proposal (RFP) submitted by the client to the architect, the later has to identify and comprehend the design problem specifically.

2-2 Preparation:

It is the process in which a thorough analysis of the design problem should be undertaken by the architect, with the assistance of the client, to identify and investigate the functions of the building, the required spaces, and the furniture and equipments needed. The limits of the allocated budget should also be studied. Special requirements should be discussed with the client covering issues such as building style, preferred materials, and any special requirements proposed from the client side. A kind of a theme board presented by the architect can help in this matter. This step is crucial for the architect in order to explore what is exactly in the client mind regarding his project in order to assure his approval at the end. This process called Briefing in USA and programming in Europe.

2-3 Design Production Phases:

2-3-1 Preliminary Design (Concept Design):

The objective of this phase is to establish the concept adopted for the project and produce the schematic design (Avant Projet) that meets client requirements according to the brief generated from the previous phase. The produced design has to be complied with, and be certified to, codes & regulations for local authorities as well as functional, economical, and environmental considerations for all required disciplines and trades associated with the type of the project. As this phase is mainly addressed to the client in order to get his satisfaction and approval, the architect has to communicate with the client by the best media that clarifies his ideas and thoughts, and which in the same time can be comprehended easily by the client. Any major alteration or modifications should be done during this phase. At its end, the architect has to produce the following:

- Colored General Layout and Master plan.
- Colored Plans, sections, & elevations.
- 3D views & artists impression.
- Finishing materials proposed.

2-3-2 Design Development Phase:

This phase is addressed to the engineers who will be responsible for the design and construction of the project. In this phase, the architect has to prepare the design development package to ensure that the work is in accordance with all requirements from owner and is coordinated with all various disciplines. This package forms a valid basis for proceeding with the Final Construction Drawings & Documents phase. The architect tasks in this stage are as follows:

- Prepare & provide Design Development drawings, draft specifications, documentation for design and engineering drawings (plans, sections, & elevations).
- Establishing equipment layouts.

- Preliminary design and layout of any built-in furniture, equipment, and fittings.
- Co-ordination with consultants & sub consultants of other related trades including the interior designer.
- Prepare and provide external hard and soft landscaping drawings and specifications and documentation including lighting, graphics, and signage (if it is included in the tasks).
- Prepare and provide finishing schedules materials and equipment schedule, bill of quantities, and the preliminary bid specifications.
- Provide a Design Development phase budget estimate for costs of construction for each line item, sub-totals by section, overhead and indirect costs.
- Provide a working sheet layout for review and approval.
- Prepare and coordinate drawings and specifications tender documents and schedules for obtaining tenders.

2-3-3 Construction Document Phase:

This phase includes preparing and providing the final construction working drawings, specifications, Bill of Quantities, materials and equipment schedules, and other documents setting for the physical, technical and performance requirements for the facilities. At the end of this phase, the final design and construction documents should be reviewed, approved, and produced as the Final Contract package. A Final cost estimate report, based on up-to-date prices should also be available to the owner.

2-4 Site Supervision:

To provide permanent, or periodical, construction site supervision services undertaken by a team of specialized site engineers. This team works under the coordination and direction of a general project manager (PM) assigned for the job. Construction supervision services should be provided through the whole construction period. This phase is normally associated with technical verification,

performance compliance, and quality control. The supervision phase includes these duties:

- Review and approve shop drawings samples and technical submittals prepared by the contractor, ensuring that each is in accordance with the contract documents.
- Prepare and respond, in a timely manner, to requests made by the contractor and/or owner during the construction phase for clarification of design and contract documents, and issue revised drawings or details to provide missing information and corrected design details whenever required.
- Progressively and finally inspect the works to ensure compliance with the contract documents, and issue certificate of partial, substantial and final completion when required.
- Attend construction progress co-ordination meetings as scheduled by PM.
- Progressively and finally, prior to the provisional turnover of each phase to the owner, verify the accuracy of the contractor as-built drawings reflecting in details the as-built conditions.

3- The Effects of Digital Technology on The Phases of The Architectural Project

3-1 Preparation:

This phase requires a thorough and comprehensive understanding of the concerned project by the architect. Digital technology can assist in this respect by collecting different data about the type of the project through the internet. By just browsing between different sites concerned with the type of project, the architect can collect a huge amount of data in a short period of time ranging from theories of design, architectural codes & standards, previous similar works, critiques of projects, recommendations from experts in the associated fields, preferable types of structure used in such buildings, different products and materials used in the projects as well as information about their producers, and any innovations related to the type of the building concerned. This data can be collected in the form of texts, images, and video,

depending on their availability on the internet. The data collected helps the architect to start from what others have ended up with, and also opens m ore horizons in his imagination. Also by using Google Earth program, the architect can get free satellite images of the project site clarifying site surroundings, site accessibility and traffic routes, any neighboring land marks, and also preferable views. For special projects, paid satellite images with high digital accuracy might be required and obtained from specialized agents.

3-2 Design Production Phases: Preliminary Design, Design Development, & Construction Document Phases

The application of digital technology in these phases requires distinction between the design process itself through which the design produced, and the sort of media by which the design represented. The effect of the digital technology on the architectural realm had first taken place through providing digital drawing tools utilizing computer techniques which affects the process of producing design documents (drawings), but eventually, and by continuous progress, digital technology has interfered in the design process itself by producing the digital techniques of Virtual Reality.

By introducing the personal computer (PC) combined wi th the CAAD (computer aided architectural design) programs, digital technology has facilitated the communication between the architect and the computer. Software packages were released to enable the architect to draw on the computer screen without having t o know any programming languages. Since then, designers are using computers as a digital board to be an alternative to the conventional drawing board. CAAD systems have been used to produce technical drawings and primitive 3D computer models and movies. Typical CAAD software has been used by architects to draw the geometrical shapes of a building design. Following traditional workflows, these drawings are then interpreted by craft people, delivered to the contractor and building the design on site.

Computer aided Architectural Design (CAAD) has been defined and redefined several times over the years as the role of the computer in architecture has been subject to many changes. The Revolutionary pace which has taken place by digital technology in

the nineties of the past century is the Virtual Reality which affects the design process itself not just the production of design documents as before. It has proved that computer technique is not just a tool for drafting, but is also a medium for inspiring thinking in the realm of form conceptualization.

Design is a process of problem solving in a creative way. In this respect, creativity plays an important role in design thinking, as working in the three dimensional forms demands the architect to be more than just a problem solver. In a paper-based culture of design, architects drew what they could build and built what they could draw. Manual media used through design process restrict design to what architects could reasonably conceive, draw or model by hand. In criticizing architecture's past, Kolarevic suggests that there is a direct relationship between the tools the architect used (T-square, paper and pencil) and the rectilinear buildings he built.

The commercial availability of complex software and its dependent hardware technologies have resulted in a fast, accurate, and globally transferable design culture. The main characteristics of digital media introduced in simulating tasks of visual design thinking are the higher levels of geometrical definition and abstraction, the elaboration and coordination of complexity and details, and the transformation and manipulation of both images and models in an easy way comparing to the manual-media used before.

What an architect can conceive and comprehend depends on what this architect can visually perceive through the media used. There is a difference in the process of visual design thinking used along with manual media, and of the one used along with digital media. The perception of paper based drawings differs from the perception of computer-based models. The acceptance of architects to certain new-comer software depends on the degree of that software proofs that digital thinking is indeed architectural thinking. All updates to the programs are aimed to achieve this rule. In this respect, a new source of inspiration has been found in Virtual Reality that makes visible what does not really exist.

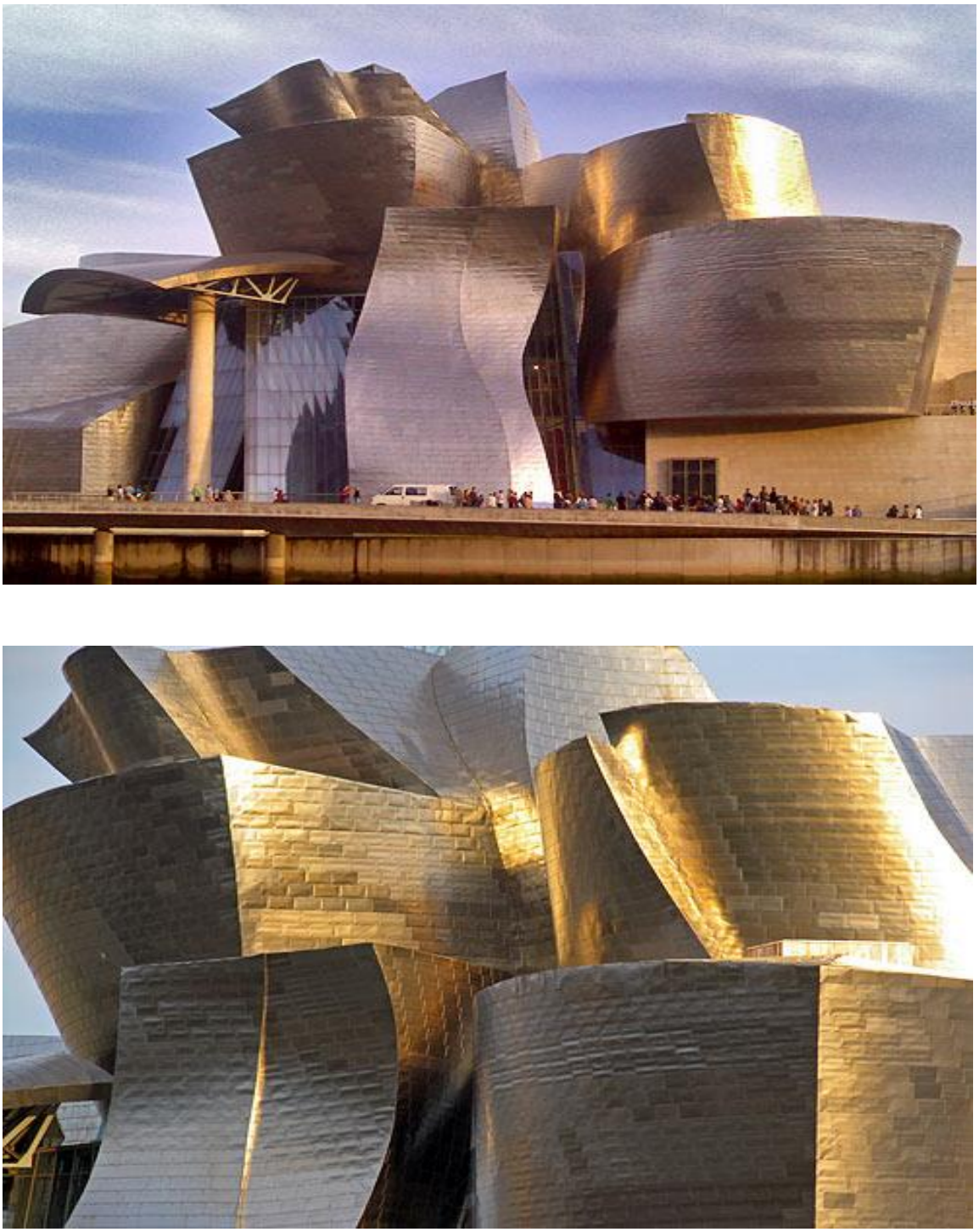


Figure (1) Designing in space. Guggenheim Museum at Bilbao, Spain by Frank Gehry, 1997. The building consists of radically sculptured, organic contoured titanium panels. Computer aided Design programs have been used heavily in the project in both architecture and structure design.

To best achieve the virtual reality in architecture, digital technolo gy has produces the technique of Building Information Modeling (BIM) which transforms the computer from being just a tool for representation of geometrical descriptions to a tool for representation of real building objects. Thus Building Information Modeli ng is a Computer Aided Design (CAD) paradigm that employs intelligent 3D objects to represent real physical building components. BIM technique attempts to create a virtual model of a building by adding additional information to the geometry. This model does not only contain geometrical information but also properties and relations of building objects and components: geometrical properties (area, volume, and amount), physical properties (U-value, weight), cost information and planning relations (neighbors, room functions).

This process integrates all building components and the 3D model is used and worked on by the whole design team either architects, engineers or spe cialist consultants. The model might also be handed over to the client and users of the building, serving as a database for facility management and maintenance. BIM has dramatically changed the traditional design workflow and improved the communication bet ween all members of the design team.

Designing in a three-dimensional digital environment might be described as designing in space. Design mistakes could be found early in the process, changes incorporated easier and faster, calculations of areas and costs become more accurate. The creation of form in space, through BIM, has become available without any intermediation. Addition or subtraction can be utilized, allowing the modeling of virtual space similar to the creation of a sculpture according to the reac tion and judgment provoked by the perception impact. The most wide-spread programs based on BIM are Archicad, and Revit which work the way architects and d esigner think.

Each program allows the architect to create a "virtual building" in any kind of forms he can imagine. This virtual building includes structural elements, walls, slabs, roofs, doors, windows, and furniture accompanied by a large variety of pr e-designed and customizable objects which come with the program. Using BIM programs allows the architect to work with either a 2D or 3D representation on the screen. Two-dimensional

drawings can be exported at any time, even though the model in the program's database always stores data in three dimensions.

Drawings such as plans, elevations, and sections are generated from the three dimensional virtual building model and are automatically and constantly updated if the architect makes any changes in the design. The program is a single database file represented in the various ways which are useful for design work. Such representations can be plans, sections, elevations, legends, and schedules. Because changes to each representation of the database model are made to one central model, changes made in one representation of the model (for example a plan) are propagated to other representations of the model (for example elevations). Thus, drawings and schedules are always fully coordinated and more reliable in terms of the building objects shown in drawings.

These programs have the feature of teamwork which allows several architects to work on the same building model simultaneously. The building can be divided into parts and each part is assigned to a certain architect to develop. The PM or the senior architect has to coordinate and monitor between the architects. The program automatically and simultaneously synthesizes building portions developed by each individual architect in one building. This feature is best adopted in large projects and in limited timeframe. It also enables remote access to the same project over the internet thus allowing worldwide project collaboration and coordination.

The advantage of programs such as Archicad and Revit is that the architect using these programs has to build the model and all its component and details in the way *exactly* as the building will be in the real. All components such as columns, beams, slabs, walls, layers, fixtures .., etc should be in the real shape and dimension and assembled at the exact places. The architect should deal with the model as it is the building itself, and what he does on the screen is not making a model for the project but building the project. By this way, the architect does not start with producing drawings entitled plans, elevations, section, as the old process, but he starts instead with building the model itself including all components, layers, and details. Has the model been completed, it is very easy to generate all drawings by just identifying the plane of elevations required or

the location of the section plane and the direction of views . In this method, and to guarantee its success, the architect should not neglect any component of the building while assembling them to generate the model. This feature also facilitate the process of understanding the building and its components for any ot her architect working in the project, as well as the engineers in any other trade, especially structural engineers, whereas it will be easy to disassemble the model to show any hidden component and reassemble them again. The feature of disassembling and re assembling the model assures that the building can be understood by any engineer.

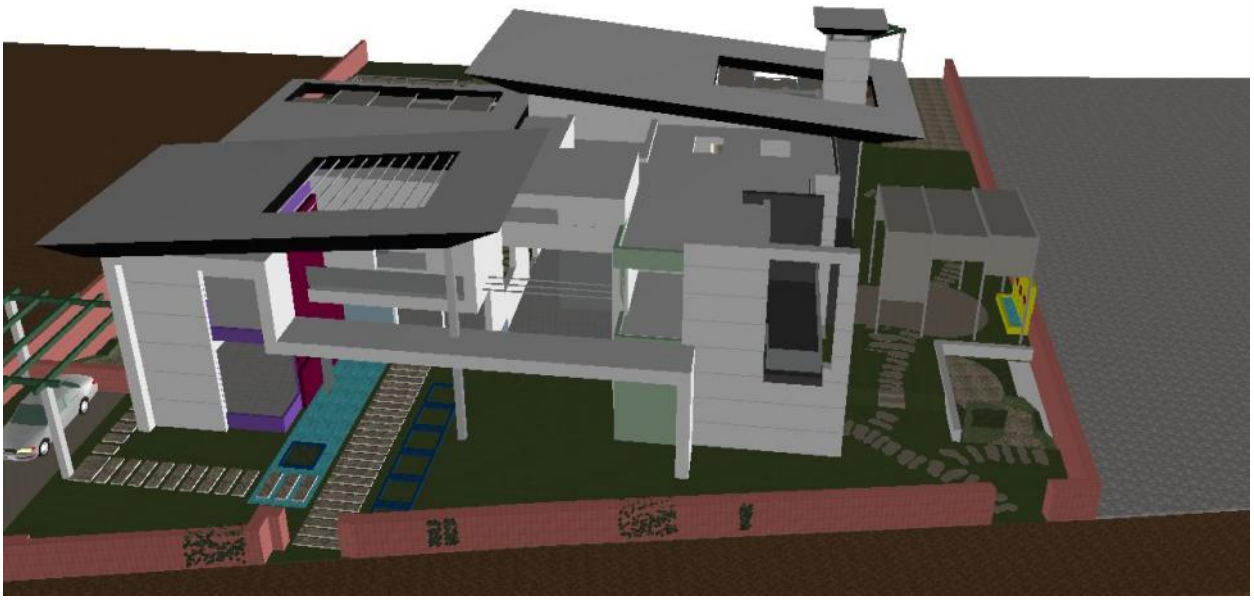
In addition, program's database for a project can contain information about a project at various stages in the building's lifecycle, from concept to construction to decommissioning. This is sometimes called 4D CAD where time is the fourth dimension .

The program can also produce the Bill of Quantity for any building component once it is assembled in the model, and it is updated automatically if any changes have happened. Once the model has been completed, the architect can get an instant, yet very accurate, BOQ for all building components and works. The accuracy of the BOQ depends on the accuracy of building the model.

Also, using this program can help study the effect of sun m ovement on the building itself and on the surroundings. It is a useful tool for the architect to know previously what parts and spaces of the building will be in shades or in shadows and to enhance the design to meet the environmental codes.

The program equipped with a high performance rendering tool which enable the architect to produce photorealistic pictures and videos. Making movies and fly -through has become very easy and it can be done any time as requested by the client or any engineer and through any path inside or outside the building. Making movies depends on the capability of the computer, not the program, as it requires a very high speed processor.

Shot (1)



Shot (2)

Shot (3)

Figure (2) A project built by Archicad 13. Notice the complicated relations between the masses, the planes, and the structural elements which cannot be clarified using traditional methods. These shots are mainly targeted to architects and structure engineer. Planes and masses are colored this way for more clarification and not for final.

Shot (1)

Shot (2)

Shot (3)

Figure (3) A project built by Archicad 13. Finishes materials and colors are final. The shots have been taken from a movie generated by the program and targeted the client.

3-3 Supervision

Although digital technology has not intended to interfere in the phase of work supervision on sites until now, and non tools have been invented to this objective, some digital tools can be useful in this respect. The usual image of site supervision comprises of a site engineer with blueprints and different tools in hands and checking what has been executed with what has been drawn in sheets. The process of supervision by this way is complicated to the engineer due to the volume and numbers of sheets he has to carry especially in critical sections of building full of details and from several trades. Using Tablet Computer in hand instead of a number of blueprints makes the process much easier and trouble free. As the whole construction drawings, even the Avant Projet, can be stored in the Tablet, the engineer can go through several sheets with just finger touches and makes zoom to any part of the sheet for more clarification.

Some technologies has enabled the immediate communication between site staff (site engineer, supervisor, project manager,..) and the other parties involved such as the designer, the client, or the operator (in specific projects such as hotels & hospitals). The communication can take place regardless of the place of the parties are at. This kind of communication provides all parties with full audio -video information about the problem (through program Skype for example) which provide an online video cam and images of the drawings in addition to the voice description and the discussion. This advantage has achieved giving comprehensive and full understanding of the problem to all parties involved and enhancing taking immediate approved decision (if it is possible) through this process of *online problem solving* which reflects on the execution periods of projects. This technique has its shortage which exists in that video communication can take place between two parties only while audio communication can be carried out with any number of parties. There is a need to advance this technique to achieve this goal.

4- Conclusion

A deeper insight on the effects of digital technology on architecture practicing indicates that they have clearly modify the ways that architects have used to do in all phases of the project, except the essence of the design process itself which still relies basically on architect's imagination. Digital Revolution introduces just *tools* to help architects doing their works. The computer has replaced the board, the digital file has replaced the drawings, and the Tablet will replace blueprints. These tools become more and more sophisticated as the technology advanced. However, the relationship between architecture and the digital technology is bidirectional; whenever technology moves forward, architecture practice changes.

As the role of digital technology in practicing architecture is emphasized, schools of architecture have to integrate digital design in architectural education curriculums in a way that help the graduate to practice the profession in any phase of architecture project and with confidence in using all kinds of digital tools. Also, architectural entities such as professional syndicates and societies should address the issue of digital applications on practicing the profession between architects by adopting seminars, workshops, and training courses.

Practicing architects should transform themselves from the passive position as just users of the technology to an active role participating in its development. Architects should cooperate with producers of architectural programmers by feeding them back with the results of using their products in real practice for more enhancements and progress. Any suggestions and requirements should be addressed in this way.

References

Julio Bermudez & Kevin Klinger (ed.), *Digital Technology & Architecture* - White Paper, ACADIA, 2003.

Branko Kolarevic,ed, *Architecture in the Digital Age: Design and Manufacturing ,* Spon Press – Taylor & Francis Group, 2003.

Wael Abdelhameed, *Visual Design Thinking in the Design Process as Impacted by Digital Media,* eCAADe 22nd conference, the Royal Academy of Fine Arts, Copenhagen, September 15-18 2004.

Rabee M. Reffat, *Computing in Architectural Design: A Reflective Perspective ,* Sixth International Architectural Conference in Assiut, Assiut University, 15 – 17 march 2005.

Shaimaa Mohammad Kamal, *The Impact of digital technology on the liberation of Architectural formal language*, Al-Azhar Engineering 9th International Conference, April 12 – 14, 2007.

Amaal Abdu, Ashraf Al-Moqaddem, Magdi Al-Bastaweesy, *A Future Vision For Architectural Form In The Digital Revolution Era*, Sixth International Architectural Conference in Assiut, Assiut University, 15 – 17 March 2005.

Kristian Agger, *Complex Geometry in Architecture based on Building Information Modelling* - First half year report / research plan, Aarhus School of Architecture, February 2010

عبير سامى يوسف محمد ، العمارة ما بعد الثورة الرقمية ، المؤتمر **الدولي الثالث** للجمعية **ال**عربية للتصميم **المعماري بمساعدة الحاسب (أسكاد)** تجسيد **العمارة** التخيُّلية ,الإسكندرية ,**مصر**

المعلوماتية وأثرها**في** التصميم **المعماري** ، ميسون محيي هلال **و احمد** حسين **احمد** ، مجلة الهندسة والتكنولوجيا المجلد **٢٨ العدد ١٩، ٢٠١٠**