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The importance of computer-aided courses in architectural education

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Abstract

Intensive technology usage in education has been increasing in every field recently. Because computer based visual technology has been developing and becoming the most popular trend in the recent years. In addition to these decreasing prices of the computer based systems make this trend more attractive. Architectural education is one of the most difficult and expensive education and based on visual material. That's why computers and complicated software usage in architectural education has increased dramatically. Using these software, an architecture student can perform his/her project design spending less energy-time but more realistic. But the disadvantage of these systems is to make students computer addicted and design their project without creativity. This paper aims to study advantages and disadvantages of this trend and to find a balance level. According to this concept, courses in architectural design are investigated. What kind of computer systems and software use in education is searched? Based on response of students, the advantages and disadvantages of this trend are studied.

Peer-review under responsibility of the Sakarya University.

Keywords:

1. Main text

Computing technology has achieved in the last two decades a tremendous advance; for example processing speed and circuit density have increased by order of magnitude. The software field has also progressed considerably, with new software development tools, programming languages and methodologies. This new powerful computing environment is packaged and made available to individual users in the form of 'Personal Computers', and to engineers or designers in the form of the new generation of 'Graphical Workstations'. During the same period, continuous research and development in the computer aided design field, has enabled to harness this computer power, and provide designers with new tools. Computer based design tools offer significant advantages over traditional design practice. In fact, they allow performing design operations in ways that have never been possible

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before. The process of architectural design since its first inception has aimed at the production of 'good' buildings. The process itself, the teaching of design, and the evaluation methods and criteria, are subject to change and depend on the state-of-the-art in research and technology. The concept of abstraction (or modelling) in architectural design is historically linked to the level of complexity of the design product. It involves the representation of existing structures and can be described as an attempt to recreate reality. Developments in the field of computer modelling, computer graphics and more recently in cognitive psychology and artificial intelligence provide the theoretical basis to build fundamentally new tools to support the architectural design process, in particular for design abstraction and evaluation. The first generation design tools that have emerged from the early computer technology development have mainly concentrated on model building for drawing production, with the exception of few design evaluation systems. These were underpinning the graphic characteristics of traditional architectural representation, where generally the abstraction hides most of the meaning of the drawing -not to the designer, but to the computer. It is the ability of a computer aided design system to 'understand' the implicit information contained in a drawing, that gives it the 'competence' to support 'intelligent' modelling and evaluation (Belhadj, 1989).

The future of architectural education has been at the forefront of architectural debate, particularly since the recent increasing computer base education. The technological and scientific development, particularly during the last century, had a decisive role in the evolution of the construction industry. The result of this progress has been the dependence of building constructions from any climate conditions and at the same time the use of heating systems, cooling, air and lighting systems (Jencks, C., Kropf K. (eds.),2006, Klotz, H., Cook, J.W.,1981, Lampugnami, V.M., Hanisch, R., Schumann, U.M., Sonne W. (eds.), 2004).

Information technology and computer aided education have been playing more important part of the life for the recent years. The computers and information technology are widely used to develop teaching possibilities. Although education is a complex process in which human and technical resources should be used and planned very carefully, teaching and learning concepts have changed radically. Computer aided virtual education and distance learning methods might replace the classical education methods in close future. Regarding this new concepts the education on all disciplines needs evaluation and development. Computer aided techniques and courses are one of the important factors of these developments

In discussing architecture education it is important to make clear first of all how one understands architecture. Because architectural education completely different than engineering education (Guney, 2011). The making of architecture involves political, social, technical, economic, aesthetic, ethical and ecological questions: to what extent are all of these relevant to education? The problem remains even if one defines architecture as an art, for the art of building and planning certainly requires a broad understanding that at least does not exclude any of the dimensions just mentioned. Yet the best way to make people sensitive to the aesthetic qualities of architecture may not be to start with economy. From this point of view, during architectural education, student should has to have enough background for technique, mathematic, engineering, art, technology, economy, law, sociology and psychology.

Architectural education has been heavily criticized. “Architectural pedagogy has become stale” (Colomina, 2012). Education, its underlying rituals and processes, has not really changed over the past 20 years and this is one of its biggest weaknesses. Schools of architecture are struggling to keep up with the current issues that are transforming architecture practice, and students are not educated to meet the industry and wider market needs (RIBA, 2005).

Advances in technology are continuing to place new demands on the construction industry. These include advances in computer software, construction and assembly methods, and materials. Architecture practices must adapt to the changing context of technology, to work more efficiently and effectively. Building information technologies present new opportunities and challenges to the architectural profession (Andenas, Livingston and Nelson, 2012). The increased use of Building Information Modelling (BIM) programs is altering the way in which many architectural practices are working. As sustainable design advances, the search for computer software that can exchange information continues. BIM introduces an alternative form of design process, procurement and construction, and changes the responsibilities of different consultants within the design team. Stakeholders, including the client, architect, engineer, contractor and subcontractor, will be able to access the building information model. It will require ‘adaption, investment and greater teamwork between the core trades’. The BIM model is a jointly developed design process, enforcing a collaborative and interdisciplinary way of working that ensures that all parties involved record all modifications to the design and build.

2. Trends of architecture education

According to a research report published by The Scientific and Technological Research Council of Turkey (TUBITAK), the percentage of computer ownership among Turkish households is 12.3% in the year 2000. A similar study made in 1997 reports this percentage as 6.5%, however it is seen that the percentage of computer ownership at houses doubled in three years. When computer ownership data are researched for different income level groups, it is observed that computer ownership percentage reaches to 64.7% in the high level income group, while it is 8.2% in the lower-middle and 2% in the low income group (TUBITAK 2001). According to this data, technology using is dramatically increasing. Today almost all students in department of architecture has their own lab top computer.

Rapidly developing virtual education and distance learning methods are replacing today the classical education methods. The rapid growing visualization techniques are one of the important factors of these developments. With the help of visualization techniques we are able to create computer graphics that display data, particularly multidimensional scientific data, for human interpretation. This technology becomes today an integrated part in the education and used to develop attractive presentations especially for three-dimensional cases, which the students have difficulties to understand.

2.1. Goals of computer aided education (cae)

The use of computer networks and information technology are becoming an important part of the everyday work on almost any profession, especially in the scientific areas and changed education concepts and many universities and education organizations decided to plan new strategies concerning computer based technologies. As a result of these developments Computer Aided Education (CAE) methods came out. These methods have been utilized and developed more than for fifteen years in many universities and organizations. The goal of CAE is to develop the learning capacity of students and increase the teaching productivity and effectiveness of instructors with the help of advanced computer based technology. This technology should be an integrated part in the education. It is also desirable to use this technology to develop attractive courses for distance education. Another area of interest is to use computers, information technology and equipment to develop attractive and understandable demonstrations of basically tasks and typical projects in the field of architectural education.

2.2. Advantages of cae

Using CAE methods students can state and explain the basic concepts in the subject easily and are able to participate in discussions of advanced concepts related to the subject content. With the visualization techniques computer graphics images are created and these images display the data and the mathematical relations of the interested subject for the interpretation, particularly of multidimensional cases. CAE provides also the substructure for interactively communication possibilities with international colleagues and presentation of the subject interested worldwide.

3. Design process and computer aided education in architecture

3.1. Computer aided architectural design (caad).

When generating models of buildings on computers, the only aspects that can be modeled are those which can be quantified, it is on these quantifiable elements that the evaluation will take place. Generally, it consists of three operations;

1. Measuring the model,
2. Performing calculations on those measurements and then
3. Comparing the results with targeted performances.

The building 'prototype' would be a three-dimensional building model, either computer generated or human generated. The computer aided architectural design process would then consist of evaluating the design solutions by comparison with computer models of existing buildings as shown in Fig. 1.

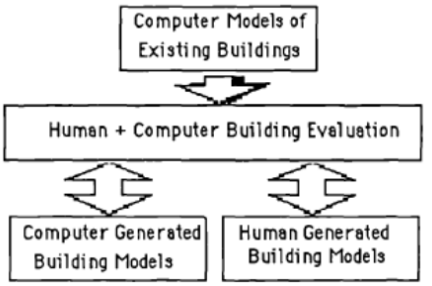


Fig. 1. Human/computer architectural design interaction.

According to Shaviv (1987), alternative design solutions should be generated automatically; according to design requirements formulated as constraints and as objective functions. Then, the generated alternative would be evaluated and appraised by means of automatic programs. Finally, the deficiencies of the proposed solution, identified by the evaluation, would be rectified through the automatic or manual generation of new and better design alternatives.

3.2. Computer aided architectural education concept

The first step of evaluatin Computer Aided Design (CAD or CAAD) education is to evaluate "why" it is critical. Researchers thinks that the increasing importance of CAD is basically due to the new opportunities and modes of design thinking that it supplied to computer based architectural design. Previous conception of the use of computers in architectural design was the vision of tools which "helps" existing difficult and complex design processes (Mitchell, 1994). During the 1980s, capability of computers have been increasingly used for generally drafting goals, a design activity which is recently almost completely computerized in architectural design offices. If the function of computer based design in architectural activities remained merely as a drafting tool, its effect on architectural undergraduation education would not be too different than that of pen and drawing papers. However, starting from the 1990s, developments in CAD caused a new vision and challenged existing situation. Due to recent visualization tools as software, forms once were hard to imagine became easy to create and the "virtual" established as a legitimate design object. The next critical change was the development of network technologies which gave rise to CSCW (Computer Supported Collaborative Work) and electronic (web based) commerce . CSCW enabled collaboration of geographically distributed design professionals and formation of "virtual teams" (Tasli, 1999). All of these developments have affected traditional architectural design practices and works, although the impact was less far-reaching compared to large industries such as aerospace and automotive. The reason for this is probably the peculiar characteristics of the construction industry. The construction industry is more fragmented, project-based and culturally diverse compared to the other industrial areas (Pektas and Pultar, 2006). These factors hindered transformation and changes of traditional applications in some extent, however, the incremental change is still going on (Pektas, 2007).

An important topic for CAAD education in architecture is the content. "What" should be taught as CAAD to students, the theories, the methods, or the technics? Is CAAD a vital side of architectural design thinking or just different skill that can be sought for competition in the job market and industy? Two different ends can be defined with respect to this critical question. Some view of point CAAD obviously as a skill (Novitski, 1999) and others advocate that CAAD teaching should be related to the theories of architectural education and/or should develop its own "digital design theory" (Oxman, 2006). Because of the diversity of the approaches to CAAD, classifying the domain of technological and complicated design is a hard task and of course, many new exciting approaches are somewhere in between. Design capability is based on imagination. However CAAD supports architect or designers to develop and visualization of their creation or design as shown in Fig. 2.

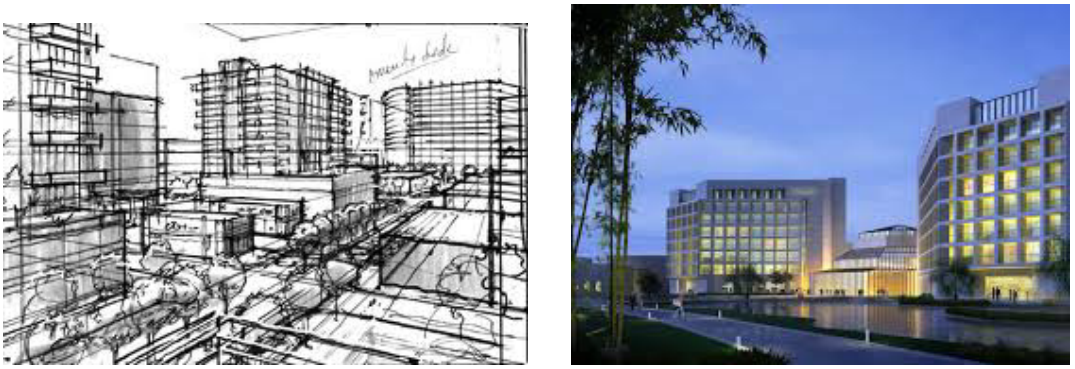


Fig. 2. Hand sketch and CAAD drawing.

The approach of CAD as a skill has been promoted basically by design professionals due to the fact that CAD has already become a leading power for job market for architects. In a recent research, professional architects in Turkey were asked to define the factors that have been most effective in architectural design practice for the last ten years. Following the lastest developments in building materials, computer based technologies ranked second in a number of factors. Moreover, the factors ranked third and fourth in the survey were also directly related to computer based technology; Internet and communication technologies and CAD technology (YEM, 2006). Under the expanding and demanding market requirements, architects search for competence in the production of digital renderings, visualization and construction projects while employing new graduates of architects. Due to these recent developments and to the massive increase in architecture graduates, manual drafters without architectural education have disappeared in recent decades. They have been replaced by CAD opera probably almost half of whom are experienced architects (Stevens, 1997). Regarding these issues, universities are forced to form the content of their CAD curriculum to provide necessary skills and a competitive advantage for their graduates (Pektas, 2007).

3.3. Computer aided architectural education in turkey

CAAD learning is now a part of education program in almost every architectural university; but, it seems that the rapid implementation of computers in design education has caught universities unprepared to develop a pedagogy for a digital technological application. Researches which focus on the use of CAAD in design education are generally theoretical and descriptive in their research area. There are a few basic studies – which test their hypotheses statistically – have been reported in the literature (Hanna & Barber 2001). Attitudes of architectural students toward the use of computer softwares in design can be defined as a neglected issues in that concept. Most of the descriptive researches in this area imply students have positive attitudes toward sofware usage in their design, but, a systematic evaluation of this attitude and its correlates is missing (Pektas, Erkip, 2006).

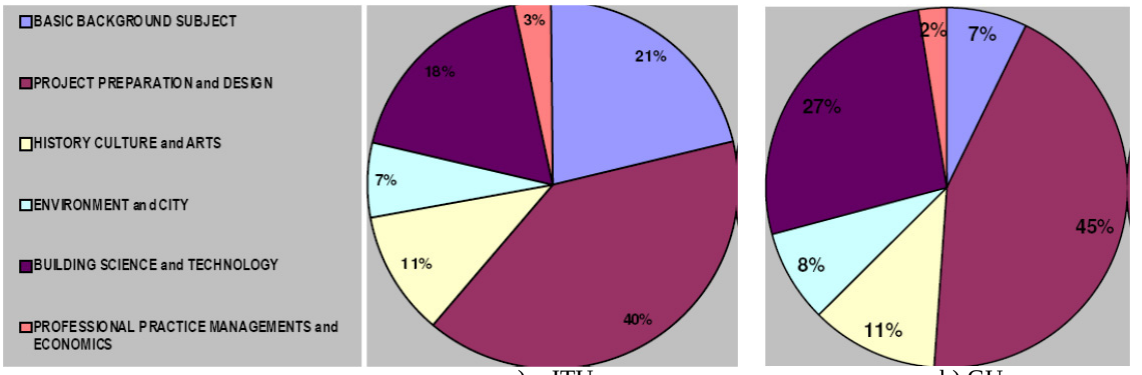
The relation between the students' and educators' attitudes toward softwares is one of the controversial issues in computer attitude study. Some acadremics have proposed a relation between the student and educator attitudes toward softwares. For example, Downes (1993) reported that an important role model, in the form of a classroom teacher who uses softwares, leads to more positive attitudes toward computers for secondary school students. On the other hand, there are generally differences between students and educators in their attitudes to information (web based) technology (Zoller & Donn 1993). Smith (1986) reported that educator technology efficacy scores are significantly and negatively related to that of students. Then, she concluded that as students' confidence went up with more exposure to computer classes, apparently educator' confidence went down. Previous research revealed that studio instructors of the Department of Interior Architecture and Environmental Design (IAED) are not very eager to use computer based technology in their professional works (Erkip et al. 1997).

Istanbul Technical University (ITU), Department of Architecture is one of the oldest (university established in 1773) in Turkey. Gazi University Department of Architecture is other well-known department (university

established in 1982) in Turkey. The distribution of the courses in ITU and GU according to groups is shown in Fig. 3a and 3b.

CAAD courses are evaluated as "Building science and technology" group. According to ITU, the focus of education in ITU Department of Architecture is % 15 vocational, % 25 arts oriented, %35 academically oriented, %25 technique oriented. Among the 1441 students, 788 (%55) student of the total number is receiving education in bachelor phase, while 457 (%32) students in master and 196 (%14) in PhD phase. Regarding the student involvement in research process, students of GU Department of Architecture in bachelor is %82, in master %12, and in PhD %6.

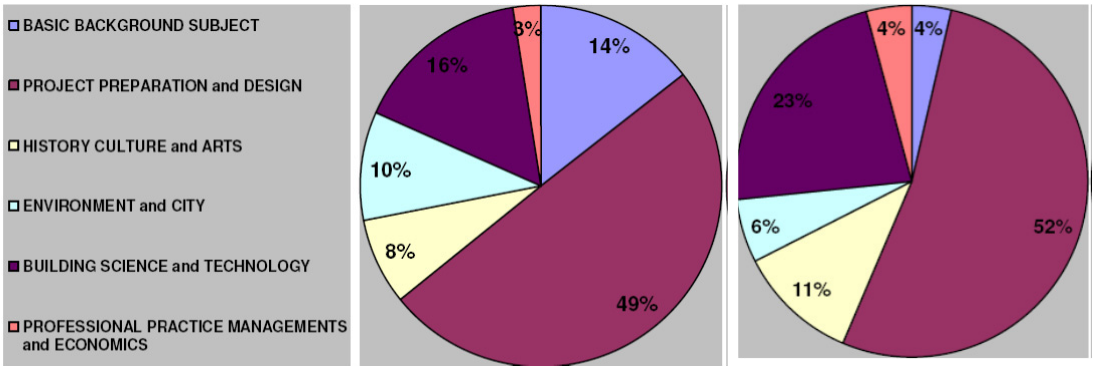
Middle East Technical University (METU), Department of Architecture is another important department (university established in 1956 with the support of Pennsylvania University (USA) and United Nations (UN)) in Turkey. . Regarding the student involvement in research process, students of METU Department of Architecture in bachelor is %57, in master %27, and in PhD %16.



a) ITU b) GU

Fig. 3. Distribution of courses in ITU and GU Department of Architecture.

Mimar Sinan Fine Arts University (MSGSU), Department of Architecture is another oldest department (university established in 1883) in Turkey. Regarding the student involvement in research process, students of METU Department of Architecture in bachelor is %88, in master %8, and in PhD %4. The distribution of the courses in METU and GU according to groups is shown in Fig. 4a and 4b (Ozelgul, 2009).



a) METU b) MSGSU

Fig. 4. Distribution of courses in METU and MSGSU Department of Architecture

Five well known architectural departments' curriculums are studied. These departments are ITU (Istanbul Tech. Univ.), METU (Middle East Tech. Univ.), Gazi University (GU), MSGSU (Mimar Sinan Güzel Sanatlar Üniversitesi), YTU (Yildiz Technical University). According to their curriculum, compulsory technology courses (CAAD based) are investigated and details are given below:

The comparison of the weight of CAAD courses credits distribution is given in Table 1. Of course there are more elective course related with CAAD subjects. This table (Table 1) just gives us an idea about existing situation based on compulsory courses.

Table 1. Weight of CAAD courses distribution according to universities in Turkey.

Name of the university	Total Credit	CAAD Credits	Percentage (%)
ITU	153	8.5	5.6
METU	154	16	10.4
GU	144	13.5	9.4
MSGSU	176	9	5.1
YTU	180	14	7.8

3.4. Analysis of advantages and disadvantages of caad.

Similar to all technology intensive courses, CAAD courses have positive and negative effects to the architectural student education. Generally if technology is properly used and effectively organized the consequences are very useful. However, if technology is replaced with education in this case results are maleficent to the student education.

Advantages:

Easy storage and sharing
Faster design stages
Easy to make revisions on the design
Drawing more alternative designs
More precise and accurate design
Better understanding, evaluation and reproducing for design environment and purposes
Remote control and sharing
3D visualization
Time saving
Better and faster communication with following projects (structural, mechanical, electrical, landscape, interior etc. design)
Avoids coincidences of improper structural, mechanical and electrical equipment

Disadvantages:

Decreasing design and imagination ability of students
Negative impact of CAD on contemporary design creativity
Low quality design
Technology addiction
Less personal contact and interaction between students and advisors
Instead of better design, better visual outputs are preferred
Inadequate literature follow

As show above, CAAD has both advantages and disadvantages. The most import thing is how to balance these positive and negative effects of technology intensive education. In this stage, university, faculty and advisor vision and behavior is too important.

There is plenty of evidence that CAD is now widely used in the profession. The most worrying recent evidence regarding CAD is that of student work. There is a growing feeling that a worrying trend is developing. Many students' project and design have been controlled and examined. In each case, I found examples of students combining impressive and convincing computer presentations with poor design which is the worst negative effect of CAAD. Of course, the software cannot intend anything, and certainly the developers did not intend such results, but the effect remains. This phenomenon can also be illustrated with reference to the graphic design (Lawson, 2002).

A small but significant and growing proportion of student work all seems to exhibit similar common characteristics. Because it is possible to produce a certain kind of 3D form in a CAD package, the student does so, bypassing that critical visual editing faculty that we try to inculcate in design schools. Even worse, some of these forms are relatively easy to generate in CAD but are hard to represent in manual perspective—for example, shell forms based on ellipsoidal sections, rotations of curved parabolic forms and so on. Perhaps this encourages students to believe that because they have drawn something infrequently seen, they are being creative. Another problem is that the software is usually a generic 3D package that can only handle form in the abstract—it does not address or comprehend the construction or materiality of the objects represented. Contrast this again with the work of Santiago Calatrava. Many of his original design drawings are freehand watercolors, but are approximately to scale. His staff, after they have applied all their sophisticated engineering software to these forms, often calculates them to be very near the size his original sketch showed. Calatrava knows about materials and their strengths, weaknesses and structural characteristics. Now, it is quite possible today to take a position about architecture that relegates structure to a purely supporting role. The negative effects should be minimized; the positive effects should be maximized by applying correct assumption.

4. Conclusions

In this study, a framework for directing most of the important aspects of computer aided education in architecture is analyzed. In architectural education, developing computer technology and software for visualization are creating exciting opportunities for design practice and less energy-time consuming for architectural designer. However, it is obviously observed that, such experience is not well connected to construction projects. Parametric 3D computer based modelling and dynamic vidualization in virtual environments enable architectural students to evaluate future capability of designs and developments in this sector seem promising for connecting the gap between the fantasies of digital world and the materiality of the real-life projects. As costs of such technological systems decrease and their compatibility with modelling computer software increase, more educators at universities will be able to utilize them and we might have better understanding of how to teach architectural students to design digitally. The education of CAAD studies have already established with its own knowledge base and research methods (Pektas, 2007). It is suggested that CAAD education should focus more on better interaction between real and virtual environment to better respond to the demands of the market and students personnel progress. Otherwise students CAAD operation capability will increase however their creativity and project quality will decrease. We will have very presentable, colorful, charming projects and drawings but these projects will probably distant from execution and real life. When these unsatisfactory projects would be executed, builders on site would experience serious troubles caused by insufficient projects.

Many famous architects do not themselves use computers or CAAD directly. Thus, while Ian Ritchie creates innovative structural form with CAAD, Santiago Calatrava also creates highly original structural form, but does not use CAAD directly. He uses CAAD for finite element (FEM) structural analysis but uses physical models for form generation. This is remarkable for two basic reasons. First, Santiago Calatrava is not only an architect but also an engineer and is clearly highly numerate and used to working with computers. Second, he creates adventurous forms that are too complicated and difficult to draw by hand, but he prefers making physical models to using computers namely CAAD. Many architects who would be viewed by their peers as creative contributors to the field have expressed concern about using CAAD for design.

Finally, the importance and meaning of the use of CAAD in design and creation is subject to fast change due to developments in computer based software and information technology. Researcher reports that in the studies on computer attitude, 'computer software usage' have been defined loosely without discriminating and classifiying different usage and purposes. Researchers criticize this assumption for not responding to expanded CAAD practices (Pektas, Erkip, 2006). Based on the view of this problem, this study has attempted to focus and underline use of CAAD in architectural education. Considering the lack of proper tools and technologies for attitude evaluation in this specific area, it is expected to contribute in that respect. I hope that this study will form a basis for future studies, which will aim at a deeper analysis and evaluation of students' attitudes toward different computer based applications in design field. In addition to this, more studies and researches should be carried on this subject in order to balance positive and negative effects of CAAD (namely intensive computer use) in architectural education at universities.

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