A Computer Aided Model for Supporting Design Education

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***Abstract*—**Educating effective architect designers is an important goal of architectural education. But what contributes to students' performance, and to critical and creative thinking in architectural design education? Besides teaching architecture students how to understand logical arguments, eliminate the inadequate solutions and focus on the correct ones, it is also crucial to teach students how to focus on exploring ideas and the alternative solutions and seeking for other right answers rather than one. This paper focuses on the enhancing architectural design education and may provide implications for enhancing teaching design.

***Keywords*—**Architectural education, design studio, teaching method, GUI-Graphical User Interface.

I. Introduction

ARCHITECTURAL design is a mental process. It incorporates the collection, analysis, and interpretation of data. The design process yields different results for different architects Due to the very nature of architecture; this process consists of complex phases. The goal of architectural education and training is to help the student find architectural solutions and to produce socially conscious students able to develop their own architectural styles. For this reason, a virtual, student-centred and computer-aided environment has been developed to teach beginner-level architecture students the early stages of architectural design. The teaching model in this new project is constructed by means of a virtual environment, interface design (computer technology), and Piaget's constructive learning theory (education). In terms of its subject matter, the model is based on science, art, philosophy, (living) society, and technology in architecture The cognitive style in this approach is based on processing and constructing architectural knowledge. According to Oxman [1], the structuring and manipulation of knowledge in design may be a significant objective in design education.

We are interested in enhancing architectural design education. In particular, we developed an approach that starts with understanding of how architects design thinking in order to inform architectural design education. The major goal of this study is to equip students with an architectural frame of reference (that is, to enable them to think like architects). The following aspects will be developed throughout the study: data collection related to the design problem and the ability to collect data derived from the site the design is related with, from the site data belongs to, the culture data belongs to, the user and the building data belongs to. Among these data, the prioritized data related to the design problem will be discussed first. For example, the northern light is directly related to eye sight and needs to be emphasized in projects such as library halls, dedicating special "importance" to maximizing the use of the light. A second example is related to the Mediterranean climate where the goal is to consider equipping external spaces with properly situated shadow spaces, taking into consideration the fact that natural ventilation within buildings or/and using natural regional materials is as important as the view itself, and optimizing the use of wind direction in the yards; utilizing these possibilities to "gain/develop architectural awareness", in other words, interpreting and enhancing the data in the design without compromising its positive aspects – eventually enabling the students to think like designers. To achieve this, it is necessary to use different environments such as computer aid, self-expression through sketches, and multimedia. The next step of this study is to equip the system with highly interactive "artificial intelligence" features. At this time, web sphere is prepared to support the design process of students via interaction through context specific interface model in architectural virtual environment.

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II. Computer Aided Design and Design Computing in the History

By 1963, Ivan Sutherland's sketch pad system and then by the early 1970s, computer aided architectural design systems were beginning to penetrate architectural design and practice. But these were limited to support design process. Digital information processing capability was characterized after 1980s. Digital storage devices and associated database technology allowed to store, edit and process large, detailed, complex, three-dimensional digital models of buildings. Computational methods and tools associated with artificial intelligence. It is a branch of computer science dedicated to solving problems in ways that would be considered "intelligent" if done by humans [2]. At about the same time, computer graphics provide designers visualization techniques as a rich tool kit from drafting to rendering, presenting systems. Powerful personal computers turned into wireless laptops in the late of twentieth century. As the Internet and network systems developed very fast, transferring design information among design team grew more practical in design process. Today, designers all over the world, as well as engineers, have the ability to work independent of time and space; on the other hand, we also have the means to use intelligent systems during specific phases of the design. Nowadays, computer aid in architectural design is routine. This opportunity has opened up new horizons for the architectural imagination through education.

III. Hypothesis

It is important to equip students with design awareness, enabling them to socialize and develop more flexible, dynamic, natural approaches and put human scale to better use. To this end, a study has been conducted to outline the major aspects of the computer-aided support; considering the difference between the frame of reference of the architect and architecture students; and taking into consideration the greatest challenges these students face. The aim of computer-aided support is to enable students to:

(1) spending enough time to define the design problem.
(2) gathering information to solve the problem and to share with the other students
(3) conscious design process steps
(4) develop an ability to chose the best alternative solution & have a higher quality final design
(5) develop social, collaborative and participating design approach

The goal of this study is to develop a *computer aided* constructive teaching method that will identify the differences between the designer and the student's design process thus facilitating the architectural design process. To this end, the works of Meniru [3] and Adams [4] have been used as designer's design process references. However, since the student design process has not been completed yet, the basic method applied in this study is based on surveys and protocol analysis.

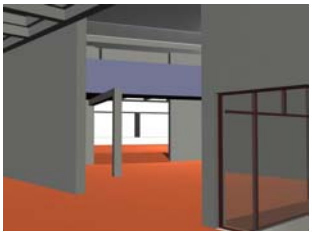
IV. Methodology

The learning method known as the 'computer aided model to support design teaching' has been constructed through Piaget's experience gaining, sharing, and interaction key approaches and conveying them into the computer domain. According to Piaget's constructivist theory (1956-1990), learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. The experiences and contexts that make the student willing and able to learn easily grasped by the student designed to facilitate extrapolation and or fill in the gaps. These are the overview and principles of the Piaget's learning theory in simply [5]. One of the implications of Piaget's constructivist theory is: "knowledge is experience that is acquired through interaction with the world, people and things" [6]. Piaget [5] observes that "logical truths dressed up in psychological guise, suggest that learning must proceed from the simple to the complex, or that concrete operations with objects must precede abstract thought with them". This remark is reminiscent of the objection commonly raised to Lewin's system, namely that it employs advanced mathematics to explain why individual can not go straight from A to C when B is in the way [7]. Regarding the cognition area as a learning method, Piaget encourages the students to go to the original works and discover more for themselves in an area in which concepts are already well-established.

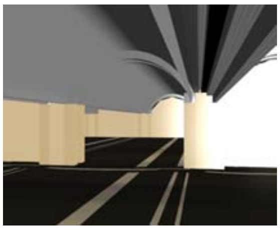
Design are description of things that do not yet exist [8: foreword]. Design is an information processing. According to Rowe [9], the information processing theory is the dominant school of thought about creative problem solving. Rittel characterized the design as "an activity aimed at achieving certain desired goals without undesired side- and after-effects" [10]. In the 1980s the search for computational methods and tools that could assist architects in their quest for "good" solutions was strongly influenced by the general eupria associated with artificial intelligence [8:p15]. At this point, the interaction between a human being and a computer is paramount. Therefore, it is necessary first to get to know the architectural approach of the user(architectural student). Thus it will be possible to develop supporting computerized data, and constructing a library database interaction.

Until recently, the structure of the designer's design process has been determined and observed through protocol analyses [11], [12], [13], [3]. Protocol analysis has been used to investigate the design process of students. In this way, we have identified the architectural thinking process, data retrieval, and time utilization. At the same time we have used surveys focused on design thinking skills in the context of "design process awareness" to identify the challenges students face. These graphics show the brackets between professional engineering designers and architect's design processes and time utilization based on the studies of Adams [4] and Meniru [3]. In this context, there is a difference between "the student's design process" and the "designer's design process". This observation has significant implications for the education method, and constitutes the launching pad for this study. First, the student design process has been observed in depth with updated protocol analyses and questionnaires. Then, the designer process has been compared with the student design process, and the "discrepancies" have been pinpointed. In the next stage, the computer-aided virtual environment has been used in order to consolidate these discrepancies, and transform them into sub-processes and pieces of knowledge within the main process. As Salama [14] argues, these sub-processes and pieces of knowledge have been scrutinized with regard to the seven phases ((perception, definition, analysis, planning & prediction, alternative generation, evaluation, synthesis)) in design process. At the same time, the five complementary thinking techniques (brainstorming, synectics, role playing, buzz session, group discussion) in the literature are recommended by the model to enhance creative thinking. To sum up, this study explores the idea of what support methods will be necessary in design teaching. Analyzing the approach of students to architecture design process, finding the sources of their problems and troubleshooting will determine the structure of the teaching support program. As a frame of reference, this paper will adopt a *computer aided* constructive teaching method that focuses on the initial phases of architectural design education; the model is taught to second and third-semester beginning architecture design students at the Anadolu University. Methodology in brief: First, examining design behaviour; Second, application of the method; Third and final, the properties of the model developed and still developing.

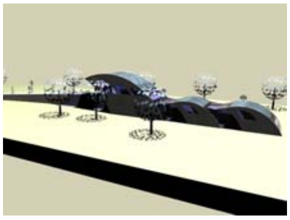
The computer aid developed for these purposes not only helps solve the architectural problems, but also develops the imagination and cognitive algorithm of the user. We recommend simple and entertaining tasks/games such as Origami and links in order to develop algorithmic skills, and the CAD-Tangram puzzle (creating new shapes by bringing together seven basic pieces) to motivate the user by enhancing a research-oriented, patient attitude and reach the ultimate goal. The table below shows the findings of the protocol analyses and survey questions derived from the study of Adams [4] and Meniru [3] (Table I).

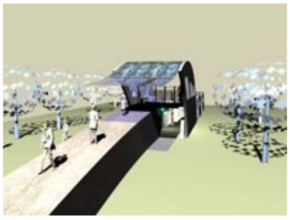


Student 1- Designing an exhibition hall by students: Z. O.Ozalp and O.A.Yildiz, 1999-2000 Autumn term



Student 2- Designing an exhibition hall by students: K. O. Keskin and G. Baran, 1999-2000 Autumn term





Student 3- Designing a small library by S. Eren 2004-2005 Spring

Fig. 1 CAD models of students (Computer Aided Design 1999-2005)

A similar yet less comprehensive study focused on using surfaces, lights, texture, function and form, materials and learning activities (Fig. 1); the study observed the design thoughts of students [15]. Generally, the problem between students and the design process stems from taking wrong steps or inaction that results from overlooking the data that is lost or unused; or presenting a weak design defence.

TABLE I
THE DESIGN PROCESS OF ARCHITECTURAL STUDENTS, AND AVERAGE USAGE OF TIME (THE QUALITATIVE NATURE OF HOW THEY SPEND THEIR TIME)

Design process steps… **avarege time/total time (minute)**	**Description**
Information gathering… 20/60	Starting by reading and discussing the program carefully, and showing examples.
Analyses... 15/60	Identifying a clear and understandable goal, isolating the data in line with the goal.
Synthesis… 10/60	Researching the application of abstract thoughts on concrete spatial aesthetics /attraction
Alternative suggestions… 10/60	Suggesting at least two or three spatial organizations
Selecting the best alternative and decision making… 5/60	Returning to the analysis phase and comparing demand/product
Activity… **avarege time/total time (minute)**	**A detailed explanation of what is expected of the activities**
Designer reads the requirements carefully (design brief)… 10/60	Try to understand requirements (the client's needs and resources)
Site preparation… 10/60	• Try to understand the topography, adjacent construction, sun path and climate • Information about natural environment • Information about built environment • Legal liability • What is gained from the environment, interpreting the experience • What can be contributed to the environment, interpreting efforts
Building space… 20/60	Functional scheme: the relationships between spaces and elements resolving by bubble diagrams etc.
Building elements… 10/60	Consider more tangible items: walls, floors, furniture, colors etc.
Safety… 5/60	• Harmony between body and dimension • Material specification: function–appropriateness of selected materials and technical details • Handicapped accessibility
Cost analysis… 5/60	• Harmony of program- space-material: a realistic consideration of building costs • Maintenance concerns: a realistic consideration of using costs

V. Specifications for Computer Aided Design Environment Support for Architectural Design Teaching and Learning

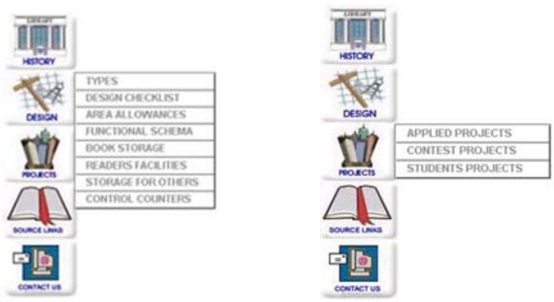
Table II compares the design events of students and architects. If the design events of students are ordered from the most frequent event to the least frequent, "establishing communication: consulting and/or desire for sharing" ranks highest. Interpretation through lines "volumetric study, group spacing, sketch etc" is subsequently ordered within itself. However, for architects, "new sheet" is one of the most typical encounters: that is "placing the drawing on top and redrawing" is the most frequent event. Diagnosing and training individual problem solving behaviour is significant, and designers approached the design process differently [16] because of perception and experience [3:p65]. Rather than drawing, the students have a greater need for consulting and communicating because the biggest challenge is comprehending the design problem and lack of experience. In this case, it is clear that the students need support in the form of knowledge and orientation. Therefore, for computer–aided environments, e-libraries consisting of visual, audio, drawn and written knowledge (multimedia) and testing the design thoughts, it is necessary to resort to "artificial intelligence" that will help the student take rational steps by putting new knowledge on top of the old one, and developing an architectural thinking formation.

TABLE II
Design Events of Students and Architects

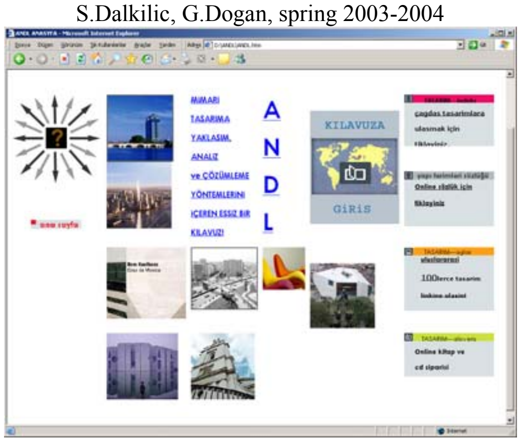
Design events	**Student ((from most frequent to least frequent)**	**Architect [1: p 65]**
Desire to communicate and share	1	.
Volumetric study	2	5
Group spacing	2	2
Sketch section	2	5
Study with models	3	.
Draw a scaled outline of the site	3	.
Uses dark lines for the outline of the site for visual & regional clues	3	.
Alternate sketch	4	8
Backtracks	4	7
New sheet	5	1
Shade/render	6	4
Label sketch	7	3
Sketch elevation	7	6

In this case, Computer Aided Constructive Design Method can be divided in three major sections (Fig. 2):

1. E-library (using all the features of the multimedia – reference libraries, component libraries, accessing helpful links related to design)
2. Constructive cognitive design steps (the architectural design process consists of three major steps including major goals, solutions to reach the goals, and data that will be used to reach the goals. Among these phases, high level of communication and correct data transmission are as significant as powerful design imagination)
3. Communication (users will need skills such as ability to enter/update e-mail and other communication data, ability to form lists, search tools, download and upload skills, and CAD-compatible documentation usage). These applications can deliver not only data over Internet communication but also the instructions that manipulate the data into knowledge in design. The prepared web environment will enable the students to upload examples, keep update the data, share knowledge, and participate in the education environment. The goal of this environment is not only to encourage example sharing between students and lectures, but also to encourage sharing in group studies and presentation preparations.



S.Dalkilic, G.Dogan, spring 2003-2004



D.Z.Zafer, spring 2004-2005

Fig. 2 GUI has been developing in the Method last two years by master students in MIM514

In order for the computer environment to be supportive, it is necessary to develop a user-friendly, comprehensible GUI-Graphic User Interface content and design for an effective interaction/communication. Communication, on the other hand, is divided into communication between user-computer, and user-computer environment-user.

VI. PEDAGOGY

In this study, the following have been measured pedagogically:

- With the aid of the virtual environment, the students have gained the ability to observe different architectural approaches (results).
- Their tendency to focus on a single issue has been eliminated.
- They are no longer afraid of making mistakes.
- May Consciously interact with design process: Discovering the parts and their relations of design process under different circumstances
- They have learned that the design process goes hand in hand with social interaction; they have also realized that sharing their knowledge through exchange of ideas helps them gain more creative thoughts.
- They have gained the ability to find and evaluate the most appropriate solution.
- They have started developing their own style.

The system will be constantly improvement based on new experiments.

VII. CONCLUSION

The results support the main hypothesises that teaching the nature of the design process of early phases may be supported by computer technology in terms of critical and creative thinking with social responsibility. In the long term, this enhanced model can offer contributions to design research and training, and become a tool for gaining new experiences. Besides the subject matter and the accurate transfer of first design knowledge, the primary goal of design education is to equip architects with an increased awareness of their social responsibilities and willingness to create meaningful environments. It is of utmost importance to support not just architecture students, but also all design students throughout the training and learning process in order to enable them to discover their own style and develop creative thinking.

Within a reasonable frame of reference, the model under consideration can be adapted to support not just architecture design education but the training and education processes of a wider range of design disciplines. The model can also equip design educators with a unique perspective. It is hoped that this approach may lead to draw implications for epistemology, education and computation in design. We want to participate in this ongoing intellectual design education adventure.

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