Hypotheses Verification on the Role of the Medium
Computers in the architectural design studio

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Abstract. During the last few decades, the new technology has transformed the profession of architects and designers, and now significantly affects knowledge and abilities required by students and by professionals in order to realize their projects. This article presents methodologies used, experimental observations held, and results obtained in a research project aiming at verifying several hypotheses concerning the influence of computer use on the creative design process development in the architectural studio. Using the informative potential of observations on existing teaching methods and configurations, the research project aspires to reinforce the innovations and to propose recommendations for the teaching of architectural design using computer technology and communication networks. Micro experiments were performed with third year students in architecture. The scheme of the observations includes two design sessions at the beginning of the term: one with paper-and-pencil and the other one on a computer; and one design session at the end of the term – only on a computer. Thanks to this scheme, qualitative comparisons could be made between free-hand and computer-aided design on one hand, and between design on computer at the beginning and at the end of the term, on the other.

Keywords. Architectural design education, design process, paperless studio, digital assistance

Introduction

Schools of architecture are evolving in a context of transforming values, technological changes and modification of research methods and professional practices. During the last few decades, the new technology has transformed the profession of architects and designers, and now significantly affects knowledge and abilities required by students and by professionals in order to realize their projects. Yet, forty years after its introduction in architecture, the computer technology still has
not revolutionized the architectural profession, as it did in other fields of design (Kalay 2004). One of the reasons could be found in the way this medium is introduced to students at the very early stages of their architectural education. This article presents methodologies used, experimental observations held, and results obtained in a research project aiming at verifying several hypotheses concerning the influence of computer use on the creative design process development in the architectural studio. Using the informative potential of observations on existing teaching methods and configurations, the research project aspires to reinforce the innovations and to propose recommendations for the teaching of architectural design using computer technology and communication networks. The ultimate objective of this study is the definition of a digital design teaching assistant. This article focuses on its development preparation.

Background

For many years now, the design studio is the fundamental laboratory for architectural design learning. The inevitable introduction of computer technology and communication networks to it is often made spontaneously, with no special preparation. At extreme cases, students are taking by themselves the initiative to develop their studio projects on the computer, this way even going against the requirements of a more conservative professor. Fortunately, the technological framework is getting better organized at architectural schools, computer culture is integrating a larger portion of the architectural education programme, and its visibility in the professional community is being taken care of (De Paoli and Léglise 2002). However, the effect of computerised studio on the process of design education has not been studied in depth. Many design analyses have been performed, especially with expert architect and designers, but working with traditional medium and not on a computer (Cross, Christiaans, and Dorst 1996). Current drawing or design software is considered so hampering for any creative processes (Tang and Gero 2001), that no cognitive processes research has been conceived as possible. So, instead of immediately proposing a digital teaching assistant, we decided to observe design learning process when performed on a computer, in order to analyze and compare it to a traditional paper-and-pencil design process.

The research started as a rather explorative study of learning-to-design behavior in the design studio. Then, several hypotheses were defined in order to direct the experimental observations.

Hypotheses

One of the tendencies in design education that has been reinforced by the use of CAD and modeling software, is the outsized emphasis on the presentation of the project. After Akin (2002), « students are directed to a corpus of desirable outcomes rather than principles or theories ». This trend is visible in all kinds of design studio projects, but we would like to study the impact of technology use on it. Our hypothesis is that using modeling and drafting software in the design studio increases not only the strive for a glamorous presentation, but also the proportion of time spent on preparing it, thus depriving of time the exploratory phase of design.

Another question that we look at is the way in which the medium influences the design methods of the students. The design studio focuses on the development of generative and synthetic skills, based on experiential instruction which situates the knowledge to be gained in a simulated context provided by a case study. In this way students learn about the principles of the domain through the cases or acquire knowledge through action (Akin 2002). Amongst the numerous theoretical models describing the creative architectural processes, it seems to be largely accepted that in the studio, students learn “by doing”. Hence, they par-
participate in a “reflection in action” process, together with their “coach” (Schön 1983). On these theoretical premises, we explore the process of “conversation with the situation” that a student could have depending on the medium.

Another hypothesis, supported by the same theoretical bases, is that learning a modelling software while working on a design studio project, could be in some aspects advantageous for the conceptual design. This supposition is inspired by the fact that architects are used to “hands-on learning” in their professional context. So, this affinity could be present in other learning situations as well. This idea joins the opinion that CAAD teaching should be considered as an action based activity and not skill building (Mark, Martens, and Oxman 2002). Even more, exploration of the medium (the software programme) might stimulate exploration of the architectural concept and especially of its formal expression. In other cases, the student simply would represent what is already in his/her mind.

This leads us to a formulation of the hypothesis that CAAD software, even if they are more often reported to hamper creative activity, could in some cases stimulate invention by proposing unexpected solutions.

Even though we base this study on the above hypotheses, the research remains open and exploratory in nature.

**Methodology**

The methodology adopted for the exploration of the impact of the medium on the design process and for the hypotheses verification, is of a completely qualitative character. This is due both to the complexity of the domain of the study (architectural design education), and to the mostly descriptive type of outcome that is looked for, after the hypotheses validation. Another factor is the role of one of the researchers as a studio teacher, which inevitably amplifies the participative character of the study. So, the general methodology reposes on a case study approach, with some grounded-theory methods used for the protocol analysis as well as for the final restructuring of the results into a theoretical model of a pedagogical approach.

**Strategy**

Experimental observations were performed with third year students in architecture. At the moment of the observed design studio, they have already completed the preparatory years of education and are at half-way to the profession. These experiments were provoked by the fact that very few or no studies were reported in the literature, concerning the cognitive processes involved (and possibly modified) when learning architectural design on a computer. Our objective was to observe the learning-to-design process in the most possible detail and depth. But, flexible and mobile with their portable computers, students do not always work in class. So, a thorough observation of the process is not possible on their term projects. Besides, its length in time makes unfeasible a detailed data collection. A compromise was achieved by observations held at two levels: at a micro-level and at a macro-level. The first one, based on “micro” observations, seeks a comprehension of the way traditional computer use influences design process elaboration; and the second one, considering the work on the studio project during the whole term, provides the background for shaping the results of the study.

The scheme of the observations (Figure 1) includes both the long-term observation of the studio project, and the micro-experiments. The latter
comprise of two design sessions at the beginning of the term: one with paper-and-pencil and the other on a computer; and one design session at the end of the term – only on a computer. Thanks to this scheme, qualitative comparisons could be made between free-hand and computer-aided design on one hand, and between design on computer at the beginning and at the end of the term, on the other.

Both types of observations take into account three viewpoints: of the student (the first eye), of the teacher (the second eye), and of professors and researchers who do not participate in the design studio, except as critics or observers (the third eye). For example, long term data includes (1) the students’ point of view: questionnaire answers, weekly evolution of the project by updating the web-page, and presentations; (2) the teacher’s viewpoint: studio program, opinion on student’s work, etc.; and (3) an exterior perspective: the critics to the studio projects.

**Observation protocol**

The design process is a cognitive activity which is difficult to comprehend from outside. Several methods have been invented with the aim to externalize this activity and make it observable for a third party. Some researchers perform interviews with the students in order to make them talk about their design experience (Yakeley 2000). Others rely on design sessions during which the architect verbalizes his moves, considerations and intentions, while everything is video recorded. This method is called concurrent protocol study. A similar one is based on commentaries of the designer once the project session is finished, and while watching the recording of his design work. This approach is named retrospective protocol. According to literature, both types of protocol studies are not perfect and deform the reality to a certain extent, but nevertheless give similar results (Gero and Tang 2001). Another approach is to record the dialogue between two designers while working on a common project. In this case, the verbalization is naturally performed. Unfortunately, this method can not be applied in the design studio experiments, because our objective is to observe an individual design process. So, the retrospective protocol study was chosen for the micro-experiments in the design studio. Students were individually videotaped while working on a small (or limited in time) architectural project, and then, they were asked to comment their work, while watching the recording. When working on the computer, session-capturing software was used in some cases. A general view camera was added in order to witness for the students behavior during the session. The commentaries were video-recorded as well. These observations were held in two consecutive academic terms, thus allowing for a better significance of the results. Six students were observed in the first studio class and eight in the second one.

**Description of the micro-experiences**

Architectural design tasks were conceived to be comparable for all the sessions. The time for work on each of them was around 50 minutes. As we were looking for an overall pedagogical effect from the observations, along with the research objectives, all tasks were linked to the studio projects. At the beginning of the term, students were asked to develop a concept with a formal expression (parti) of a residential complex, combined with some public functions. This task had to be realised once on the site of their studio project (working on the computer), and a second time, on another site provided by the teacher (working at a free hand on paper). At the end of the term, the same group of students were given the task to design a tramway station nearby the site of their project.

**Data**

An important amount of data of various kinds was collected both from the long term and from the micro-observations. The long term observation
of the students work generated the following types of data: graphic material of the studio projects; video-recordings of the critics; digital data on the weekly-structured web-sites showing the evolution of the project; answers to questionnaires. From the micro-observations we collected: video recordings of the design session; video recording of the commentaries; graphic material of the mini-projects developed during the micro-experiences. Much of this data serves only for contextualizing the results from the more-detailed design studio observations. As such, it is attentively reviewed and interpreted by the researchers, but not especially processed. The data which is studied with the most detail is the video-recordings of the micro-design session and the commentaries to them (Figure 2).

Segmentation

The recordings of the works of two students were transferred into a textual form: the design activity was described as seen on the video film (or on the capturing software file), and the comments were transcribed as heard (and synchronised with the correspondent actions from the design session). After a review of the literature on the question, and inspired by the “grounded theory” theory (Glaser and Strauss 1967), we adopted a flexible approach to data segmentation. Thus, a segment can be of different length; corresponds to an action or to a design intention during the design session; and corresponds to a meaningful phrase in the commentaries. Our approach is based on a multiple coding of segments. Even more, the length of a segment can vary for the different coding schemes. For example, three segments of the scheme "cognitive actions" could form only one segment of the “design strategy” scheme.

Coding schemes

According to literature, coding schemes should include two types of categories: data driven, which try to present the design activity in a objective, non interpreted and unbiased way; and theory driven, that are issued from the theoretic framework and the objectives of the research study (Dorst and Dijkhuis 1996).

Two kinds of data driven schemes were used in this study: (1) an action oriented scheme (modifying an already known in the literature scheme (Kavakli and Gero 2003)) and including the following categories: draw, look, perceive, motion action, think, speak, action linked to the tool; and (2) a medium-oriented one, keeping track of software use, graphical support during design, 2D or 3D figuration technique, etc.

The theory driven coding schemes are developed in function with the defined hypotheses, but remain open and flexible to accommodate any new categories emerging during the research. These include: (1) a design phases scheme comprising the following categories: analysis, design and revision; (2) a design strategy scheme, focusing on: concepts evolution, generation of variances, and type of iterative/ straightforward design work; and (3) an obstacle/stimuli scheme including categories like: type of the stimuli, reason for the obstacle and way of overcoming it.
Analysis and interpretation

Due to the qualitative methodology of this research, and to the relatively small number of students being observed, the coding of the data is not statistically processed in order to be analysed. It serves mainly to “sharpen our vision” and enhance our understanding of the micro-level of the design process. This way, after the coding of the sample data, we could have a more accurate and thorough lecture of the rest of the data (coming from the other 12 students and not being transcribed nor coded). Hence, data is only partially analysed but interpreted as a whole.

Results

This experiment led both to some predictable conclusions, and to some unexpected revelations concerning the impact of the computer on students’ design process development. The latter include design strategies; exploration of different design variations; types of graphical representations facilitated or hampered by the computer software, importance of the medium as a creative ideas generator. Consequently, some of the hypotheses issued at the beginning of this article are validated, others only partially confirmed.

Design strategies

The micro-observations helped us create an overall portrait of the design strategies of the students in the design studio. None of the theoretical models was predominating. This means that each student was free to choose a creative approach which is best suited for him. Moreover, according to literature, the strategy does not have any incidence on the quality of the design (Kruger and Cross 2001). The hypothesis that the general design strategy changes depending on the medium was only partially confirmed. In fact, the design method of each student was almost the same, despite the different tools in use: thus, the ones who were developing variations of concepts, were working in the same way on paper and on the computer; the ones that seemed to be satisfied with the first possible solution, were adopting the same approach with the two mediums. This changed at the end of the term, due to the pedagogical encouragements to generate variances before starting the development of a final solution.

The hypothesis that CAAD use oversizes the presentation phase of the design process, was validated. A comparison between the two design sessions at the beginning of the term proved that the proportion of the time spent on representation was 3-4 times longer when working on a computer for the students who prefer developing variants. This proportion was not so high for students who normally work only on one idea. Generally, the presentation effort was taking the larger part of the whole design session. The situation changed at the end of the term. All of the students inversed the ratio between design exploration and representation. The number of variances before deciding on a final design solution sharply increased as well.

CAAD software learning while working on the studio project

The hypothesis that the “hands-on” learning of CAAD software could be successful and even advantageous for the architectural concept exploration tends to be credible. All students could choose a software sequence suitable to them and had a much better mastering of the computer-aided design at the end of the term. Strangely enough, the questionnaire answers do not confirm this statement. They show an amelioration of only about 10%. In our opinion, this might be due to the more critical attitude of the students to their computer competences at the end of the term.

Obstacles/stimuli

The obstacles provoked by the computer tool were numerous at the beginning of the term. Some of the students were changing software each 10 minutes, after being unsuccessful to develop or
represent any ideas. Finally, most of them worked on an image processing software (ex. PhotoShop), sometimes drawing a 3D picture with it. In the second group of observations, SketchUp was successfully used by some of the students.

The picture was completely different at the end of the term. Even though the small project had to be realized in conceptual phase, students did not use SketchUp, but the modeling software that they have learned during the term, and were mastering now well enough to develop a conceptual project with it. The importance of sketching is well known, and its absence is creating an emptiness in the design process for many architects (Cross 2002). Surprisingly, we noticed that at the end of the term, some students were “guided” by the software in their design explorations. Without overestimating this phenomenon, we could say with the words of Schön (1983), that they were having “a reflective conversation with the project”. However, we should mention that the functional and semantic aspects of a design object being very difficulty representable, these explorations were mainly of a formal character.

**Technique**

Several modelling and CAAD software were explored during the studio classes. Students preferred mostly modelling software for creative conceptual design (LightWave, Rhino3D, 3DS). Manipulating and modifying a 3D model interactively seems to be more fruitful for the process of “seeing as” while designing.

Design moves are less smooth and enchained when working on the computer, than when using traditional medium. Many “undo” and “erase” commands segment the evolution of the model. They are also the reason for many lost and unsaved variances of the project. Even more, the process representation is absent in CAAD tools, thus creating impossibility for design knowledge transfer.

**Conclusions**

As a general conclusion from these experiments, combining the two types of observations, we can state that many aspects of the design teaching are hampered by the currently used software. In fact, the results from the interviews at the beginning of our experimental studio showed that free hand sketching was by far the preferred method for creative design, followed by the creation of mock-up models. Imaging and CAAD software were further behind. This image was considerably changed by the end of the experimental studio; the half of the studio students stated that they will use computer software from the very beginning of the design process from now on.

According to the design studio experiments, the aspects of architectural design learning that suffer the most by the non-prepared computer use, are the expression of semantic ideas, the figuration of a process in development, and the transfer of architectural know-how. Some of the characteristics that are enhanced and facilitated are the formal representation and exploration; the overall graphical expression of the design project, and the unleashed imagination “materialization” (in the case of cyber-architecture projects).

Based on this experience, we can recommend “propedeutic” practical exercises for introducing a digital design approach at the beginning of the term. If these are not performed, either the method is not thoroughly learned, or bad habits from previous use of similar software are not suppressed. Exercises should teach variances exploration and different kinds of object transformations: formal, semantic, climatic, structural, etc. In our opinion, such a digital assistance could serve to better structure the design phases, if used for the comprehension of creative processes and precedents, rather than only aiming at the result (De Paoli 2002; Heylighen and Verstijnen 2003).
Future work

Informed by the observation results, the research project continues in the direction of the definition of a pedagogy approach and a digital design teaching assistant, based on a digital environment containing scattered and independent capsules assisting different aspects of teaching architectural design. After the development of the pedagogy assistant device is completed, its impact on the student’s design process will be evaluated by performing similar micro-observations of design tasks. This time, the digital pedagogy assistant will be used and its validation will be estimated.

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