A NOTE ON THE COMPLEXITY OF ARCHITECTURAL DESIGN AND ITS EDUCATION

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Summary: *Research presented in this paper addresses the complexity of architectural design, especially in terms of its education. The paper gives a brief state of the art in the field of design process and its education, and it also describes methods which can affect this procedure. The extensive field of process of architectural design can be approached and examined in variety of ways. However, this study focuses on decisive factors which constitute design process in order to gain a better understanding of mutual relations between these notions and how they induce the compound activity of learning and creating architecture.*

Keywords: *architectural design, architectural studio, design education, graphical representations, architectural diagrams*

1. INTRODUCTION

Since the 1960s, many studies have been conducted resulting in important contribution to the understanding of the design process. Research presented in this paper provides a brief state of the art in this area, it proves its relevance and shows different approaches towards perception of the process itself. Architectural design might be observed as a creative activity with the application of scientific and technological knowledge. It implies the investigation of finding the best form for sheltering necessities of variety of human activities. Owing to the complexity of design process, one cannot use precise or fixed formulas which unite form, function, context and available technologies. With an understanding of first principles, experience, intuition and spatial imagination, most designers reach heuristically their design solutions [1].

This paper displays an exploratory investigation, which started from the point of literature review, and it demonstrates manifold approaches and theories in the study of the design process, its education and other particularities coming from various fields. Research covers some of the most important aspects of the process of architectural design. First of all, an insight into the process itself will be given, and, from the historical perspective, different models will be explored that have been used to describe this process. Subsequently, the design problems and potential methods used for solving these problems will be clarified. A particular emphasis is laid on the education in the field of architectural design. Hence, the methodology of architectural studio will be investigated with reference on the potential difficulties that occur during its realization. This paper concludes by

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introducing the concept of architectural diagram as a potential tool for improving both architectural education and practice, because of its advantages over the traditional modes of architectural representations.

2. COMPLEXITY OF DESIGN PROCESS AND DESIGN MODELS

Most studies on the design process, in architecture and other disciplines, suggest that it does not follow fixed rules. Thereby, designers do not apply universal methods and the externalization of their thought process is rare [1]. Design research (DR) domain, originated in the 1960s, has long been searching methods to take design as a discipline of its own, with its inherent methods of research and communication, aiming to promote research in the process of designing in its many fields [2].

In 1984, Ledewitz stated that design process has long resisted definitions and characterizations, due to its unpredictable character marked by moments of insight, imagination and "flights of fancy" [3]. The process itself is difficult to document because "…although outsiders can directly observe behavioural and representational parts of designing, they cannot directly observe cognitive design processes taking place inside someone's head" [3, p. 3]. Furthermore, same author described the design model based on analysis-synthesis model, which is characterized by a problem decomposition into its elements, adding an information content to each element and synthesizing solution by means of a set of logical rules. In this sense, non-quantifiable and intuitive aspects of design, although important, are differentiated from its rational aspects. The process itself is divided into two stages: the rational *analysis* (problem-defining) stage, and a creative, intuitive *synthesis* (problem-solving) stage [3].

Twenty years later, Cross defined three thresholds in the evolution of design research [2, 4]. At first, the so-called *design science approach* tried to relate design methods with scientific ones, which "implies an explicitly organised, rational and wholly systematic approach to design, design in some sense a scientific activity itself" [4, p. 51]. This was the exact model described by Ledewitz [3], as well. First period was followed by the epoch of *science of design*, which made it clear that design activities are not fully scientific, but might be investigated with scientific methods [4, 5]. After 1980s, design was taken *as a discipline itself*, which resulted in "design studied in its own terms, within its rigorous culture to construct a way of conversing about design that is at the same time both interdisciplinary and disciplined" [4, p. 52]. According to Akipek [5], based on the above-mentioned description of design research, its approach in architecture can be described as an action of taking design activity out of the sole domain of architecture, and relating it with other fields of design. Moreover, same author states it was Cross [2, 4] who distanced design from art, evaluating it more with its relation to science.

The model of design as a discipline, still valid today, introduces the important concept of a reflective practitioner, whose knowing is not only rational and cognitive but also embodied in action and for whom reflection is critical to practice. This concept was brought by Schön [6], who describes the reflective practitioner as one who emphasizes problem-setting (in addition to problem solving) activities, reasons about the problem and solution through experimentation, and fluidly engages in a variety of representations to experiment with the problem. Throughout this process, the designer functions as both a creator developing a solution and an experimenter trying to understand the situation he is

creating, hence the notion of the designer as having a 'reflective conversation' with the situation. While interacting with the situation, the designer is shaping the situation. As such, Schön's model accounts for the dynamic, cyclic, and unfolding nature of design, and it introduces reflection as a critical element of professional activity and designing practice [6, 7].

3. DESIGN PROBLEMS AND METHODS

The design process can be viewed as a series of actions based on problem understanding, information gathering, information analysis, synthesis, decision making, evaluation, and others. In that process, design problems are considered as wicked or ill-defined, in terms that as such cannot be clearly formulated [8]. As stated by Goldschmidt [9], distinction between well-structured and ill-structured problems has gained wide acceptance among researchers in the field of problem solving. Design problems are prime example of ill-structured problems, meaning they are unique, complex, and cannot be solved exactly like previous similar problems. Moreover, Goldschmidt outlines the terminology connected to designing as solving problems, which is of use for this paper, hence it will be briefly described.

Essentially, design problem solving consists of moving operators from an initial state to a goal state through intermediate states which fall within the notion of a problem space. These constituents can be used to compare well- and ill-defined problems. Namely, in a well-defined problem, the initial state is given and the goal state specified. On the other hand, in an ill-defined problem, the initial state is usually vague, and the goal state either unknown or ambiguous. While solving an ill-defined problem, designer must generate additional information for importing into the problem space in order to construct paths which might lead to the goal state [9]. It is difficult to know what information can be considered as useful until a solution is attempted [8].

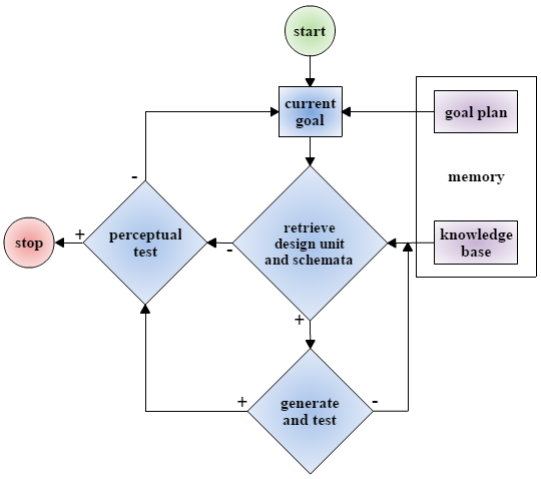

Figure 1. General model of design process. (according to [10], *redrawn by author)*

Moves in the problem space are the small steps in which reasoning proceeds: i.e. they are representations of states and operators. These moves can be modelled as a series of transformations which generate a sequence of problem states. According to Chan [10], in a problem state designer/solver knows a set of things, thus it can be referred to as a knowledge state. All design tasks can be broken down into a sequence of goals, while the various ways of changing one state into another are operators (Figure 1).
For the further development of the topics covered in this paper it is of considerable significance to define the design method. Following Andreasen [11], a method is defined as a goal-oriented rationalization of designers' work in the form of standardized description. In design education, methods are introduced as means of providing students with important learning experiences. In a study on method usage, Daalhuizen et al. [12] focus on two different types of methods: systematic and heuristic methods. Just to mention, from a historical point of view, first two epochs in the evolution of design research described in Section 2 of this paper, were recognizable as inquiry of providing designers with universal instructions for design. Anyhow, in design methodology, all methods are heuristic in nature since they enhance success but do not guarantee it [11, 12]. The significant differentiation of methods is given in [12], where systematic method is described as one which prompts a designer to incorporate as much information as possible for reaching optimal rather than satisfactory results. On the contrary, heuristic methods encourage designer to focus on particular pieces of information in order to achieve satisfactory results.

4. ARCHITECTURAL DESIGN EDUCATION AND THE CONCEPT OF STUDIO

In order to design buildings, architects ought to put themselves in a position of a building's future users and to predict the expected patterns of use in a particular building. While investigating user needs, they must simultaneously generate shapes and forms which correspond to those needs. As stated by Schneider et al. [13], the process of designing buildings is difficult due to several reasons. Firstly, no adequate model of human behaviour is taught in architecture schools; and secondly, no systematic approach is known on how to use this information to generate form. Without the criteria of user behaviour there is no knowledge of how a spatial configuration functions, therefore one can "design shape but hope for its function" [13, p. 2].
Many scholars in the field of design research strongly agree that, over the past few decades, architecture schools have made important efforts to improve design education. This advancement mainly consists of enriching the pure artistic vision of architecture, through the insertion of scientific knowledge and social responsibility [1]. Traditionally, the design studio is acknowledged as the most important part of the educational curriculum in schools of architecture. It provides a cultural forum to code, construct and enrich the understanding and perception of space based on knowledge which is collected, compiled, described and reproduced [14]. The design studio is the place where the students are expected to grasp, present, and defend design ideas, and acquire new techniques and skills [8].

The studio has a primary task of teaching three basic aspects of design education. These aspects cover the skills of visualization, representation, and ability to "think architecturally". In architecture, this "way of thinking" refers to a particular domain of problems and solutions that characterize, and are fundamental to, professional performance [3, p. 6]. The fact that learning these aspects has to occur simultaneously, since each becomes means of learning the others, brings difficulties in an already complex teaching objectives.

4.1 Studio methodology

From the pedagogical perspective, architectural education is grounded on the constructivist methodology which considers learning as an active process where learner constructs knowledge through practice and interaction with the environment. These rules are explicitly articulated, in sense that students of architecture need to be educated toward self-directed, holistic, profound and reflective reasoning of the environment and their role in it [15]. However, as Casakin [8] points out, main characteristic in experience-based and case-based educational approaches is that they only judge the quality of final solution, while disregarding the knowledge acquired by students during the process itself. The reason for this, as Oxman [16] claims, lies in the fact that traditional educational models are based upon the replication of professional task performance. Hence, the measure of learning is equated with the design product rather than learning increment.
According to [16], it was Schön who presented two important modifications to the traditional model of design education. His idea of reflection on the problem in the medium of conceptual drawings introduced a cognitive orientation to design reasoning. The second modification implies the definition of the distinction between the interactive modes of visual reasoning and design ideation. Nonetheless, despite these changes, the educational focus still remains on the representation of the design object, rather than on a clear articulation of knowledge.
Every studio project is usually divided into two identifiable parts – analysis and synthesis. Although not necessarily formally entitled like that, these two phases characterize working process in the studio. The analysis phase may usually take from few days to few weeks, and it focuses on the site, program, building typology, context and surroundings, and other examinations which are to be carried out. During the analysis phase, all preconceived design concepts are discouraged as premature, which tends to bring students to become impatient to get into designing. At one point, the focus shifts to design concepts, and assignments change from analytic exercises to design proposals. The synthesis phase tries to make references back to previous phase, while no new analysis assignments are made. The analysis stage of a studio project is commonly characterized by well-defined, explicit procedures, while the synthesis stage is relatively unstructured [3].

4.2 Issues of the studio setting and its pedagogy

Despite the fact studio presents a primary mechanism for teaching architectural design at university-based schools of architecture, it still has some substantial problems and shortcomings which were addressed by few of the most influential researchers in this field [1, 3, 17, 18, 19].

Firstly, as stated in [3], design studio lacks clarity and is characterized by sometimes contradictory objectives, implicit theories and inherent conditions. Secondly, students are rarely given robust principles upon which they can construct designs that may be judged as error-free. Instead, they are given precedents from which to learn variety of heuristics [17]. Based on these precedents they are expected to produce similar results with novel features. In this respect, they are directed to a corpus of desirable outcomes rather than principles or theories. However, in order to produce 'good' designs, physical elements of the building originated in precedents, "must be integrated with one another based on globally constraining variables (loosely called 'concepts' or 'design concepts'), dealing broadly with such criteria as structural integrity, clarity of circulation, appropriateness of proportions, and so on" [17, p. 410]. Akin also describes three kinds of weaknesses in design instruction which are: motivational difficulties, insufficient instruction of the design process, and inefficiencies in learning.

Furthermore, as stated by Curry [18], designing involves more than developing innate abilities in a studio setting, where students solve incrementally more complex design problems over a set period of time under the guidance of an experienced tutor. According to his statements, learning the process of design requires a shift in the way one thinks about the problem. This stance was also confirmed by Oxman [19], as he states that the development of thinking skills is critical in design education. With these skills developed on an advanced level, students will create an organizational structure of knowledge (meta-knowledge), which will help them to apply specific kind of knowledge in particular situation.

Finally, in line with [1], special attention in the design studio has to be paid to the struggles of progressing from whole to part and *vice versa* in a conscious and efficient way. By producing design which have combinatorial qualities, students might overcome problems in moments of lack of progress.

5. REPRESENTATIONAL ACTIVITIES IN THE DESIGN STUDIO

During the conceptual stages of architectural design, different types of drawing are widely used to develop and express ideas. In his seminal work, Schön suggests that through drawing, designers construct a 'virtual world' where the drawing reveals qualities and relations unimagined beforehand. In this sense, the design sketch can be considered as the basis of mental and visual transaction between the designer and the representation, which evokes a discrete graphical response [20].

Meaningful insight in the significance of drawing within the studio context was given by Crowther [21]. According to this author, it was Cross [22, p. 201] who described the "use of drawings as designerly ways of knowing, thinking and doing". Furthermore, Crowther noted that Ulosoy [23] pointed out the direct relationship between drawing and designing, and described understanding designing as being related to the linguistic faculties, and the act of designing as being related to visual thinking. Thus, the analysis presents a verbal activity, and synthesis a graphic activity. Schön [6] also differentiates between learning about design and learning to design, while relating these two activities as they make up a single language – language of design. This language results in process of verbal and visual communication in the studio class, where students and tutors discuss concepts and ideas through verbal and visual dialogues (Figure 2).

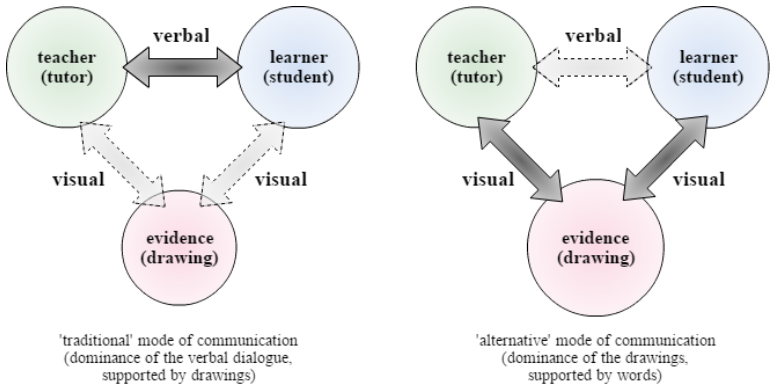

Figure 2. Verbal dialogue vs. drawing dialogue. (according to [21], *redrawn by author)*

In order to increase levels of drawing dialogue and student participation, it was advised by [21] to have students and tutors drawing during the class itself, rather than relying on between-class drawing activities. In-class drawing activities are allowing more immediate feedback for students to respond to, thereby providing better results in the studio.

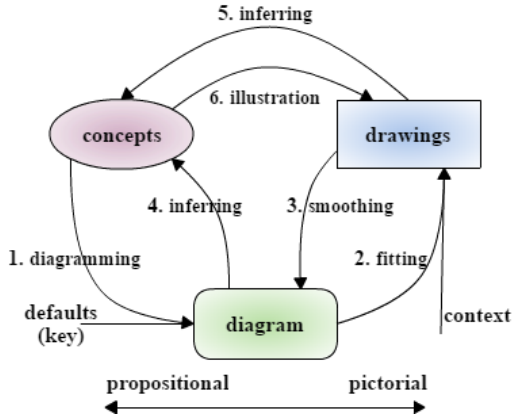

Figure 3. Concept – diagram – drawing transformations. (according to [24], *redrawn by author)*

At this point, it would be of a particular importance to introduce different types of representations in the context of architectural education and practice. In this respect, Ervin [24] distinguishes between two types of graphics – pictorial and propositional. Photographs, sketches and maps fall under the category of pictorial graphics, since they are powerful data that exploit visual ability for parallel processing, but make no commitment to use or structure. On the other hand, propositional graphics – plans and diagrams – constitute information and embody some media-independent abstractions, and

are associated with some particular inference-making uses (Figure 3). Thus, they require commitment to some models of the knowledge structures which are being conveyed.
Additionally, Ervin [24] proposes an assertion for distinguishing representations. Pictorial ones are concerned with shape, shape-like and detail attributes, while propositional graphic are concerned with form, and attributes that are abstract and topological. The former are appreciated visually, judged 'holistically', and generally defy symbolic translation; the latter may be represented symbolically, judged 'logically', and are designed for visual inference rather than appreciation *per se*.

6. DIAGRAMMATIC METHODS IN ARCHITECTURAL EDUCATION AND PRACTICE

Architectural design process requires visualization of initial ideas, recalling of historical examples, synthesis of complex systems into manageable wholes, testing and comparison of multiple solutions. All of these procedures require diagrams and diagramming operations, which are the part of highly developed visual language that architects use in design development [25].
According to Eilouti [26], diagrams are essential modes of representation in design communication, and serve as tools of exploration in design derivation. Their advantage lies in their ability to concisely convey problem interpretation, pre-design reasoning, problem solving, design conception, form evolution and product evaluation. Larkin and Simon stated diagrams can make it easier to find relevant information: one can scan from one element to another element much more rapidly than one might be able to find the equivalent information in a list of numbers or verbal assertions. An iconic representation can be recognized faster than a verbal description, thus diagrammatic symmetries can reduce the number of cases that need to be investigated [27].
Despite the emphasis on interactionist and constructivist models of learning, diagrammatic exercises are often assigned to students with the assumption that the presence of the diagram alone should facilitate learning. The use of diagrams in architectural education might promote conceptual understanding, since constructing diagrams aids inference making. As stated by Akipek [5], architectural education today operates with diagrams and diagrammatic exercises as types of advanced visualizations which map and decode various kinds of data. One of the most important features of diagrammatic tendencies is that design with diagrams enabled abandonment of the design development over traditional plan-section-façade trilogy, and suggested one using sections and strip models as a substitute.
From a more discursive point of view, we may acknowledge diagram as a tool that has been central to design process for much of the last century, but with a new status given by contemporary theoreticians in architectural domain. According to Somol [28], diagram appeared as the final means of architectural production and discourse. Contemporary architects use diagram as a starting point in the design process – as a technique for visualization the input data that generates the essence, i.e. the concept. In its capacity to merge form with ideas, the diagram is considered an essential tool in the development of designers' critical capacities.

7. CONCLUSIONS

The study presented in this paper has stopped short of proposing new interpretations on the complexity of architectural design and its education. It rather has sought to reframe an understanding of that process and of current studio practice. This paper aimed to bring together, in a brief form, many different factors that constitute architectural design. An attempt was made in trying to investigate all these elements separately, in order to get an entire perspective on this complex problematics.
The detailed literature review has opened up many new research questions which could be analysed in the future, while this paper might serve as a foothold and theoretical basis in this area. In the interest of developing a better understanding on the design process, further studies on the studio setting and its representations should be followed.

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БЕЛЕШКА О ПРОБЛЕМУ СЛОЖЕНОСТИ АРХИТЕКТОНСКОГ ПРОЈЕКТОВАЊА И ЊЕГОВОГ УЧЕЊА

Резиме: *Истраживање приказано у овом раду бави се сложеношћу архитектонског пројектовања, поготово у смислу његовог учења. У раду је дат кратак преглед стања у области процеса пројектовања и његове едукације, те су описане методе које потенцијално утичу на овај процес. Широка област процедуре архитектонског пројектовања може се испитати на више различитих начина и кроз многе приступе. Међутим, ово истраживање се фокусира на одлучујуће факторе који сачињавају процес пројектовања у циљу бољег разумевања међусобних односа између ових појмова, као и на испитивање њиховог утицаја на активност учења и стварања архитектуре.*

Кључне речи: *архитектонско пројектовање, архитектонски студио, учење архитектонског пројектовања, графички прикази, архитектонски дијаграм*