A DYNAMIC METHODOLOGY FOR EMBEDDING GENERATIVE SYSTEM APPROACHES IN ARCHITECTURAL DESIGN EDUCATION

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ABSTRACT

The generative systems have been discussed in many fields such as computer science, architecture, natural and social sciences over the last fifty years. Different approaches such as Cellular Automata (CA), Agent Based Design (ABD), Swarm Intelligence, Genetic Algorithms (GAs), L-Systems (Ls), Bio-Mimetics (B) within generative design paradigm show a potential to enrich way of thinking, particularly in architecture. However, generative design accompanied with computational thinking has not been embedded enough into the architectural curriculum. In this paper, we focus both on discussing how to introduce generative design theories to the students of architecture and how to observe the short term reflections via students' term projects.

Keywords: Generative design, generative systems, dynamic systems, architectural design education.

1. INTRODUCTION

Over the last fifty years, depending on the rapid changes both in production and in design technologies, new design approaches emerged in the field of architecture. The generative design approaches can be assumed as some of the new concepts which enrich way of thinking via their own potentials. While extending new methodologies, generative systems also require new points of view, new vocabularies and a new philosophy. McCormack et. al. (2004) consider generative systems as a new paradigm shift in terms of Kuhn's terminology.

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The inspiration of generative design system approaches is derived from the nature. The common dominator of the generative design approaches is that they are all related to the complexity theory. McCormack et. al. (2004) underline that generative systems are related to dynamic systems and their outcomes. Cellular Automata (CA), Agent Based Design (ABD), Swarm Intelligence, Genetic Algorithms (GAs), L-Systems (Ls), Bio-Mimetics (B), Shape Grammars (SG) are considered as a subset of generative design systems in the literature (Singh and Gu, 2011). Singh and Gu (2011) indicate that these subsets of generative design approaches have potential advantages for different phases of the design process (Singh and Gu, 2011). Knight (1999) highlights the potentials of shape grammars in architectural design education and practice. Oxman (2006) discusses the influence of new emerging technologies in the fields of architectural design.

The main aim of this paper is to discuss and to evaluate our own teaching methodologies within a master level compulsory course, titled "Generative Systems in Architectural Design" held in Istanbul Technical University, Graduate School of Science, Engineering and Technology, Department of Informatics, Architectural Design Computing Graduate Program, through the program of the course and the students' studies of the 2011-2012 spring semester.

2. GENERATIVE SYSTEMS IN ARCHITECTURAL DESIGN

2.1. Description of the Course

One MSc course including lectures, literature reviews, reflection writings and discussions about reviews and one term project were selected within the scope of this study *(Figure 1)*. In this course, students were first donated by lectures driven both by the instructors and by the guests having expert knowledge about the issue of the week. Readings relying on conventional generative design frameworks were also given in order to build up a direct support for theoretical explanations detailed during the lectures. The content of the lectures and literature reviews can be listed as below:

- Epistemological descriptions about Generative Systems,
- Practical descriptions concerning ways that Generative Systems are used in design field,
- Interpretation of Generative Systems related to the particular design problems chosen by students.

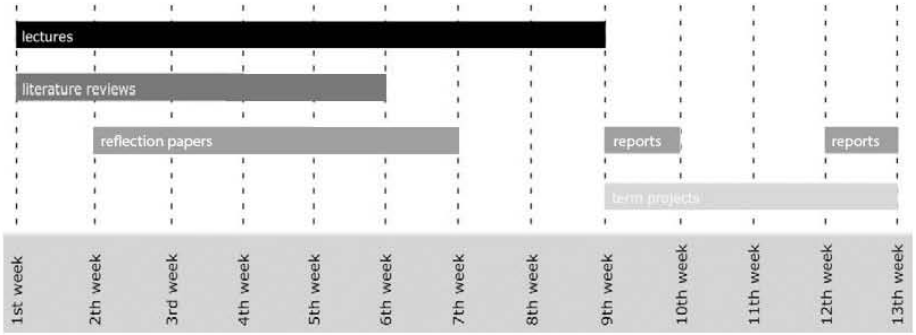

Figure 1. Timeline of the course

In order to be able to develop their own point of view, insight and ability of interpretation, students were oriented to keep a critical distance to examples and to theories via written reports. They were expected to submit 5 reflection papers based both on the detailed descriptions of different Generative Systems which are Cellular Automata (CA), Agent Based Design (ABD), Swarm Intelligence, Genetic Algorithms (GAs), L-Systems (Ls), Bio-Mimetics (B), Shape Grammars (SG) and on the examples including the integrated use of these systems. The main purpose was to encourage them to find out their own design strategies related to a particular design problem of various scales (urban, architectural, object scale) using one or more generative design approaches which were introduced them in lectures and readings. At this juncture, students were expected not only to solve specific problems given by the instructors but also to explore knowledge about problems they found out.

2.2. Methodology of the Course

As Watanabe (2002) underlined, to clarify the design process, you need to write down what was good about something, why you selected it, you need to exteriorize what went on in your mind so that other people "and also you" can understand it, to describe on white paper a fraction of what happened in the black box that is your brain. Therefore we asked students for retrospective decoding of their own projects revealing their strategies via written reports. With the reflection papers and the final retrospective reports we aimed first to build up a general awareness of the issue by re-experiencing it within a different domain and second to fill the gap between learning a theory and interpreting it. In reports, we examined the verbal similarity, discontinuity, conceptual matching and mismatching between theoretical feedback and design strategies of term projects. According to analysis, we explored how the theoretical instructions affected the way of both thinking and doing in design process. In this regard, we propose here a dynamic observation method concerning students' feedbacks in order to understand theory and praxis cycle.

3. METHODOLOGY AND EVALUATION

3.1. Methodology

The main data for evaluating the course were the reflection papers of the students, examples as midterm presentations, final design projects and their reports. Since the outputs were dominantly in verbal decoding, we filtered the specific terms/concepts both depending on literature and in relatively subjective manner. Afterwards we compared the terminology regarding (i) verbal similarity/discontinuity, (ii) conceptual matching/mismatching criteria.

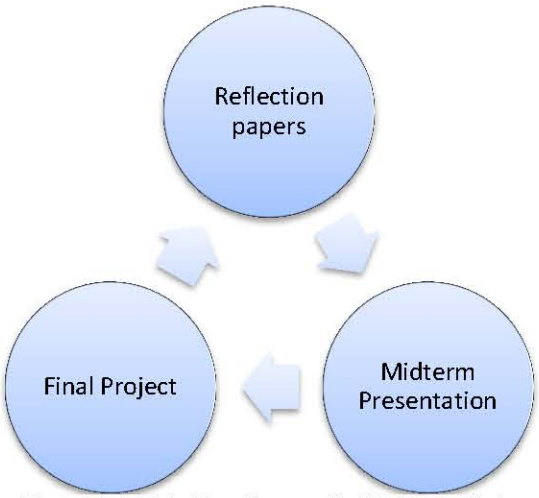

Figure 2. 3 Main Data Sources for Verbal Analysis

The interaction among the different data source is shown in *Figure 2* and *Figure 3.* The first two modules (reflection papers and midterm presentations) can be considered as more objective and comparable outputs; however the final report of the final projects were more subjective. On the other hand, reflection papers provided us subjective information about how and with which concepts the students interpreted the discussion topics related to the generative design approaches. In addition to the verbal data, design processes of final student projects and their preliminary outputs were also taken into consideration.

Reflection Papers	Midterm Presentation	Final Report
Term1	TermA	TermX
Term2	TermB	TermY
Term3	TermC	TermZ
TermN…	TermN…	TermN…

Figure 3. Comparison of the Verbal Data

3.2. Student Works and Evaluation

In this part, we focused on the studies of four out of eighteen students registered in 2011-2012 Spring Semester to the "Generative Systems in Architectural Design" course. We selected these students because firstly, they had worked in design problems (Term Projects) of various scales (sitting component, schools in city scale, structure design and nature inspired systems) and secondly, they both integrated computer programming into their work. In order to understand and to apply generative design rules, algorithmic thinking was encouraged. Students were coded as numbers such as 'student 1', 'student 2' in the figures. Five reflection papers were coded as symbols from a to e. The visual outputs with different phases of the design process belonging to 'student 1' and 'student 4' are shown below (*Figure 4 and Figure 5).*

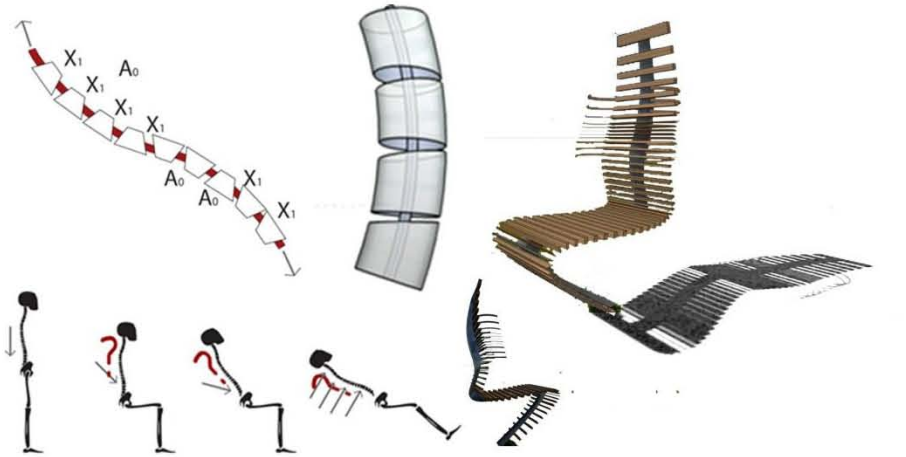

Figure 4. Diagram and renders of 'student 1'

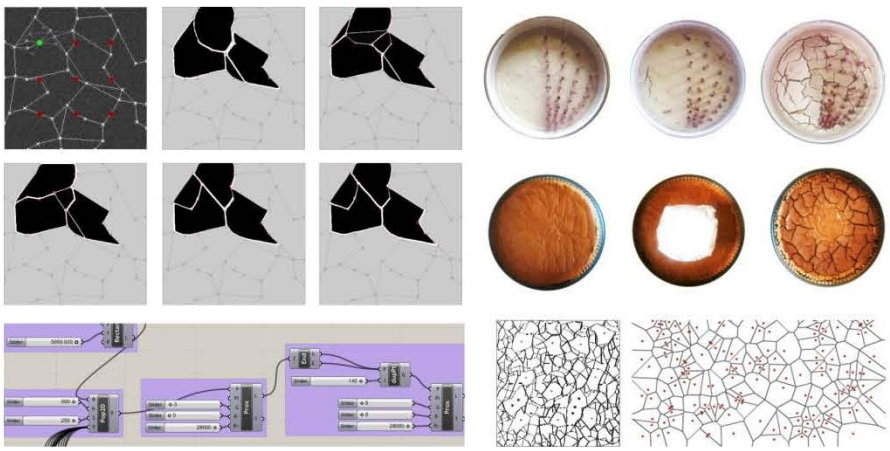

Figure 5. Images of 'student 4' belonging to the different phases of design process

One of our initial observations was that there were positive contributions of interpretation process of the theoretical aspects such as extending the conceptual terminology and understanding the semantics of existing vocabulary both in writing/reading exercises and in exploring by doing.
Besides that, it is possible to see in *Figure 6* that there is no one-to-one correlation between the vocabulary of midterm presentations and the other parts. In other words, the midterm presentations depending on the example review did not limit final projects' scope, therefore did not directly limit students' way of thinking.

Student	Reflection Papers	Midterm Presentation	The Term Project
1.a		shape grammar interpreter, parameter, shape, rule, geometry, space layout, rule based shape generation, geometric translation and union seperation addition, perception, creation transformation, scale, distance	interactive sitting component spinEAT, spinal system intelligent agents, user interaction, movement , nervous system, biologic and mechanic systems, sitting and lying, cellular automata, genetic algorithm, neighbourhood
1.b	digital media,digital design, formulas, mental interface, file-to-factory, productivity, rationality		
1.c	shape grammar, language, prototype, analyse- transformation-sythesis, paralel grammar		
1.d			
1.e			
2.a	classes of design, abstraction, vocabulary, syntax, semantics, context and style	procedural city modeling, algoritmic, shape grammar, virtual city	agent based models, swarm behaviour, patterns, parameters, dynamic shell, agent, algorithm, attraction point, array, route, pedestrian movemet simulation
2.b	performance, generation, representation, evalutaion, implicit explicit design,		
2.c	shape computation, grammar		
2.d	shape grammar, l-systems, cellular automata, genetic algorithhms, swarm behavior		
2.e	emergence, new materialism, morphogenesis, simulation,		
3.a		shape grammar, symmetry, parallelism, geometric representation, rule, addition, seed germ, transformation	rule based, digital design, parameter
3.b	digital design		
3.c			
3.d	dynamic system, digitalmedia generative systems,		
3.e			
4.a	reasoning, algorithmic flow, complexity, solution space	shape grammar, digital fabrication, manifacturing, rapid prototyping, computable construction, personalization.	crack, city, growing, voronoi, optimisation, algorithmic, partial control, iteration, pattern, transformation
4.b	performance, intergrated design, digital media,optimisation		
4.c	shape grammar, analytic, synthetic, implict, emergence		
4.d	transreality, algorithmic, symptom, digestion systems, circulatory system, respiratory system, subsystems		
4.e	digital design, simulation, vision, shape grammar, systems, fractals, algorithmic, cellular automata		

Figure 6. Comparison of verbal data of four MSc students

4. CONCLUSION

Many disciplines have long advocated the benefits of Generative Systems in different fields such as computer science, architecture, natural and social sciences etc. This study specially focuses on studies in Generative Design paradigm in a master level compulsory course titled "Generative Systems in Architectural Design" held in Istanbul Technical University, Architectural Design Computing Graduate Program in 2011-2012 spring semester.
We consider that each writing and/or doing process build up another interpretation layer. Therefore, we would like to indicate the importance of constructing a dynamic balance between learning by reading/writing and learning by doing. Moreover, we also underline the significance of literature and/example review in the field of generative design approaches.

ACKNOWLEDGEMENTS

The authors would like to acknowledge 16 students of the course, especially Tuğçe Darcan, Cemal Kahraman, Aslı Aydın, Zeynep Enhoş as well as Zeynep Gürbüz Ata, Yazgı Badem and Güzden Varinlioğlu for their participations and presentations during lecture parts.

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