BUILDING INFORMATION MODELING TOOLS: OPPORTUNITIES FOR EARLY STAGES OF ARCHITECTURAL DESIGN

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Abstract. Numerous researchers point out that in the early stages of architectural design many significant decisions are taken to directly affect functional qualities, performance of the building, aesthetics, and relationships of the building with the natural environment and climate, even if there is no certain and valid information to create satisfactory design solutions. This paper particularly focuses on the early stages of architectural design and searches for the opportunities provided by Building Information Modeling (BIM) tools, in terms of the concept of performance analysis and form seeking. The study also includes case study implementations which visualize the early processes of architectural design with benefits of BIM under different conditions to evaluate its opportunities during these design processes. A few case studies have been implemented to reveal how new BIM tools can help designers in these stages. As a result of the implementations, it has been understood that BIM is a powerful early stages of architectural design tool; not for designing, but for supporting design.

Keywords. Building Information Modeling; computational design analysis; performance evaluation in the early design stages.

1. Introduction

Foqué (2010) states that “the architect works in the field of tension between imagination and reality. The architect’s task is to convert the dreams and often unreachable wishes of the client into a buildable concept, which should be functional, technically resolved. […] But at the same time must inspire a sense of well-being and have the necessary aesthetic qualities”.

After Industrial Revolution, some of the factors which Foqué mentioned were ignored; building construction sector started to rise rapidly due to changing opportunities and needs of the new era. This rapid progress leads to massive structuring which causes some important global issues such as high energy consumption, global warming, and so on. For instance, while all consumed energy of the United States is consumed by the buildings is 48.7%, (Architecture 2030, 2011), it is 40% in European Union countries (The European Union, 2012).

One of the most important reasons of this issue is that in the early stages of architectural design, many significant decisions are taken without any certain and valid information to create satisfactory design solutions. In order to find a solution for this issue, some researchers and practitioners have started to enhance Building Information Modeling (BIM) tools, which are accepted as inefficient for the early stages of architectural design, to support these stages with their information and presumptive calculation capability.

In this paper, we particularly focus on the early stages of architectural design and search for the opportunities provided by Building Information Modeling tools in terms of the concept of performance analysis and form seeking. Within this context, we prefer Vasari (as a BIM tool) which can directly work with main BIM platforms and also constitute a new platform for conceptual design process. The main point of the study is not to offer an alternative way for traditional design practices but to seek if these kind of tools have benefits for conceptual designing and/or for supporting design.

From this point of view, we firstly review the literature on the early stages of architectural design, its characteristics, usual habits, and positive/negative aspects. The following section is related to the implementations of Vasari in the early stages of architectural design. This section also includes the assessment of the cases to be able to discuss the strong and weak features of the tool. In the last section, we also evaluate the findings of the case and literature review in the same context to constitute a new approach for the early stages of architectural design.

2. The early stages of architectural design

There are a lot of different approaches to classify architectural design stages. That is why we call it as the early stages of architectural design. It is commonly accepted that these stages have a cyclic process of processing and transformation of design knowledge to generate design solutions (Alhusban, 2012) in accordance with the design problem definition, requirements, and limitations. Design concepts depend on knowledge, thinking skills (Oxman, 2004; Chiu, 2010), information background, past experience (Wang, 2007;
Tseng et al, 2008), and implicit and explicit knowledge (Al-Sayed et al, 2010).

Design literature shows that in the early stages of architectural design, sketching and drawing with paper and pencil still has an important role for exploring possible design alternatives, evaluating the ideas, and also communication with self (Do, 2002; Lawson, 1994; Herbert, 1993; Graves, 1977; Schön, 1985; Goldschmidt, 1989). On the other hand, being digital makes CAD software more effective than traditional drafting methods in terms of time, cost and ease of use. However this CAD software which is really useful for drafting is not suitable for initial design tasks like exploring new ideas.

In these stages, designers are also expected to decide on significant factors such as building orientation, building shape, structural system, building envelope and interior finishes with inadequate and indefinite information (Gervasio et al., 2014; Granadeiro et al., 2013; Hong, Chou & Bong, 2000; Holm, 1993; Gratia & De Herde, 2003). These decisions taken with most probably inadequate information on the site, climate, and geography also provide a basis for the final performance and the aesthetics of the final outcome.

To address both the negative impacts of designing with inadequate information and the emergence of the performance requirements for the building efficiency, researchers and practitioners became aware of the need for digital preliminary design information databases. These databases are systems including all relevant statistical information about the existing environment such as temperature, sunlight directions, wind directions and so on.

Do (2002) mentions that in order to support creative design, design tools might offer additional capabilities for standard drafting and editing software. Not only does she argue about a computational sketching system but also emphasizes the importance of knowledge-based editing, simulation, and accessibility of relevant design information. Additionally, the use of these database systems as integrated parts of BIM software has been increasing gradually. Today, designers have the ability to exploit the advantages of BIM software (such as powerful drafting, visual analysis reports, scheduling and budgeting features) and also analyse their designs within the conditions of given information in the same media.

Foqué (2010) expresses that “intuitive thinking and rational thinking are not opponents; they are the twin poles between which the artist structures reality”. In addition, he also asserts that with the emergence of modernity, architecture practitioners hover between science and art (Foqué, 2011). Within this context, he states that research by design is a keystone as it comprehends possible realities, searches their attraction, shifts the existing reality by implementing a new one and evaluates the resultant reality by creating design
applications, relying on technological knowledge and artistic interpretation (Foqué, 2011).

All in all, we can underline that taking advantage of essential information in the early stages of architectural design is useful and important for the whole design process and the final product. Furthermore, BIM tools with their “information” capability, operate as an improved architecture software with powerful 2D and 3D drafting features, performance simulations, and visual analysis feedbacks. It must be mentioned that Vasari by itself, do not provide an automated design process, but analyses the alternative design solutions to enable the evaluation of the relationship between the building and the environmental factors. Then, the design relies on both the functional realities and the subjective judgments of designer.

In this section, we study the current realities of the early stages of architectural design by literature review, and then, we explain how BIM tools can offer new opportunities within the design processes. Below is the implementation of the case study to evaluate the efficiency of BIM tools within the context of basic design decisions with regards to the later stages of architectural design.

3. Case study implementations

3.1. PROBLEM DEFINITION

In this study, case study implementations which have totally different project topics and requirements have been applied. The only common point of these implementations is that all participants worked on their existing design studies and manipulated them for this specific study. They were free to use all the software that they wanted to create a very first concept model. After obtaining the very first (basic) 3D model as an initial design form, they all used Vasari to differentiate their designs and to create new alternatives with the parametric capabilities and conceptual energy analysis tools of Vasari. The participants were asked to define their variables and constants within the respect of their designs which could differ in a wide perspective such as neighborhood settlements, orientation, maximum height, area, volume, conceptual construction materials and so on.

3.2. METHODOLOGY

In that case, to clarify and to test the benefits of BIM tools in the very early stage of architectural design, the task was to create a concept model with Vasari software and to observe its reflections on the designer and design product. Case studies were realized by six undergraduate students of the
Faculty of Architecture (Istanbul Technical University) who had learned about BIM processes and tools (Revit and Vasari) for 6 weeks.

The participants were asked to design massing alternatives within the respect of performance issues. During 2 weeks; participants designed, modelled, and evaluated their design alternatives with their project requirements. We analysed their design processes and design alternatives from their weekly presentations within the respect of massing designs and performative scope in front of the class jury. Then we conducted a questionnaire at the end of the semester to understand how they felt and how they were comfortable with Vasari as a design, modelling, parametric design, conceptual energy analysis and decision support system tool. And also we wanted to know how tool provides a connection between form seeking and performance realities within their own study. In the following chapter, three of the six case studies are demonstrated briefly to exemplify the outcomes of design process.

3.3. IMPLEMENTATIONS

3.3.1. Case study A

In case study A, the design task was to design an art education centre in Istanbul. Participant A (she) designed and modelled different design alternatives within the respect of her massing design decisions and performance realities. She preferred to alternate her designs with changing solid/void ratios, orientation of building blocks (Figure 1).

![Figure 1. Some of the generated alternatives of case study A]
Satisfying with her design alternatives, she started to evaluate their performance via Vasari tools and tried to get better results without sacrificing any desirable existing decision. At the end of this iterative process, from her view, the participant found out eight different satisfying solutions having different forms and performance outputs.

3.3.2. Case study B

In case study B, the design task was to renovate a historical hotel in Eskisehir with the possibility of building additional spaces. Participant B (he) started to design with defining design parameters on the existing building to achieve different design alternatives. By this way, he obtained a lot of design alternatives which forced him to select among them. Reducing his alternatives reasonably, he applied them to solar study, solar radiation and energy analysis (Figure 2). Due to the limits of preserved building, he didn’t have a chance to benefit from solar study which actually offered him a lot of information about incoming natural light directions and its shadow. On the other hand he had a chance to re-evaluate his solid/void ratios of the facades of designs through Vasari. He also compared the outputs of the conceptual energy analysis of his design alternatives with each other and had an opportunity to improve them and to decide on which performance output was adequate for his claim.

Figure 2. Some of the generated alternatives of case study B
3.3.3. Case study C

In case study C, the design task was to design a dorm building for Bilgi University in Istanbul. Due to the neighborhood building massings, Participant C (he) had no chance to generate different form alternatives. However thanks to the solar study analysis, better natural lighting was provided by angling the facade of the building massing. (Figure 3).

Later on, he tried different alternatives of solid/void ratios and conceptual construction materials to achieve a satisfying solution. Finally, he decided to apply reasonable construction materials in terms of insulation value since the climate conditions in Istanbul is not harsh.

In this section, we briefly demonstrate the three of the six case studies and summarize the capabilities of the Vasari tool which was preferred by the participants. In the following section, we evaluate the outputs of the studies within the context of participants’ feedbacks and share the findings of the implementations accordingly.

Figure 3. Some of the generated alternatives of case study C

3.4. FINDINGS

In this implementation, we observed that Vasari could be used in five different situations owing to its capabilities which are design exploration, 3D modelling, parametric design, energy analysis, and decision support. The participants were asked to vote these capabilities from 1-10 points through their own experience and to explain the reason why they had evaluated the capabilities in this way.
The participants’ marks are given above per each situation in Figure 4. Through the evaluation of the questionnaire (it has been evaluated basically not statistically), we find out that the participants have a consensus on Vasari that it is not as good as traditional sketching and physical modelling for design exploration and creativity trigger. On the other hand, while three of all are not satisfied with Vasari as a 3D modelling tool, other three participants find it useful. But there is also another consensus that it is not easy to use it (user friendly) as 3ds Max, SketchUp, and Rhino are.

As a parametric design tool, the participants evaluated its parametric capabilities from average to good. The basic reason of this is that the participants were not always able to build true parametric connections. This situation directs them not to be able to achieve what they desire. In contrast, the participants clearly express that Vasari is a very powerful conceptual energy analysis tool which is both useful for supporting design and learning to design sustainable solutions. Even though the participants are highly satisfied with Vasari’s conceptual energy analysis capabilities, they vote it quite low as a decision support system. The main reason of giving low marks for it is that the participants believe it must have much more abilities (such as conceptual cost analysis, more information and comparisons about renewable energy sources and so on) to make Vasari a much better decision support system.

In addition to the participants’ aspects, we also observe some crucial factors that need to be re-examined in future researches. Firstly; as the users had no experience before but just learned the software for this implementation, it
is not fair to compare its user friendliness with other software which they are familiar with. Secondly; even if all of the participants tried to create some parametric alternatives of their initial model, it is clear enough to comprehend that they were not really designing an alternative but just playing with the parameters. This situation once more shows us that computational thinking and designing, which require related accumulation of knowledge and experience, are different from the traditional design. Another significant factor which we observe is that the participants were trying to avoid the capabilities of the tool (such as mechanical systems, solar radiation and wind simulation analysis) which they were unfamiliar with. Finally, it is also crucial to underline that the evaluation results of six case studies carried out by six undergraduate students are not sufficient to generalize the outcomes. Further implementations with more participants and more flexible design tasks are required to comprehend better what new BIM capabilities offer for the early stages of architectural design.

4. Conclusion

The main objective of the study is to reveal the opportunities of the BIM tools for the early stages of architectural design. To examine the features which BIM provide for the designers, six case studies have been implemented. During these implementations, we notice that Vasari doesn’t offer indispensable features for design exploration in these stages, but it offers significant and useful capabilities to judge the design product and also indicates the potential advantages which can be easily applied to the existing design alternatives without any certain and detailed information.

During the studies, we realized that the participants had a tendency to work with the tools which they were familiar with and tried to avoid the capabilities they were not familiar with. For this reason, to achieve meaningful implications by using these kind of tools, it is important that the users have adequate knowledge about parametric thinking, performance realities, and passive climate control methods.

As it can be understood from the previous examples, BIM tools provide an opportunity to test the existing design products and also offer a way to improve them. Then, the designer also has a chance to design and analyse their own ideas within an iterative process until they obtain a satisfactory design solution. This way of working proposes a connection between functional realities and designers’ subjective judgments which can interact with each other.
In conclusion, while BIM is still an ever-developing system which is one of the most popular researches, it has still a lot of more potential capabilities which lead to a better design tool.

References


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