The Position of BIM Tools in Conceptual Design Phase: Parametric Design and Energy Modeling Capabilities

Ömer Halil Çavuşoğlu
1
1Istanbul Technical University
1contact@omercavusoglu.com

Numerous researchers point out that, in the early stages of architectural design, many significant decisions are taken to directly affect functional qualities, the performance of the building, aesthetics, and the relationship of the building with the natural environment and climate, even if there is no certain and valid information to create and obtain adequate design. In this paper, I particularly focus on the early stages of architectural design and search for the opportunities provided by Building Information Modeling (BIM) tools, towards the concept of performance analysis and parametric form seeking. 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.

Keywords: BIM, Parametric Modeling, Energy Modeling, Conceptual Design

INTRODUCTION
After the era of Industrial Revolution, an expeditious increase in building sector started in the direction of the changing opportunities and requirements of the new era. This rapid progress brings into massive structuring which causes some crucial global issues such as high energy consumption, global warming, and so on. For instance, while all consumed energy of the United States consumed by the buildings is 48.7%, (url-2), it is 40% in European Union countries (url-1).

One of the most important reasons of this consumption is that many essential decisions which are taken at the early stages of architectural are taken without any valid and certain information. In order to resolve this situation; some researchers and practitioners began to develop Building Information Modeling (BIM) tools, which are acknowledged as inadequate for the early stages of architectural design, to support their information and presumptive calculation capability.

In this study, I specifically discuss the early stages of architectural design and look for the opportunities provided by Building Information Modeling tool (Vasari), regarding the performance analysis and form finding. The focus of this study is not to offer an alternative way for traditional design practices but to explore if these kinds of tools have advantages for conceptual designing and/or design supporting. From this point of view, first of all; I review both the literature on the early stages of architectural design, its characteristics, usual habits, and positive/negative aspects and also what opportunities BIM tools can offer in these stages. The next section presents the findings of the case study implementation. During the implementation, when participants were asked
to design an office building, I observed and analyzed how they interacted with the tool and the process, and how effective they were using Vasari as an architectural design tool. At the end of the implementation, a questionnaire was also applied to reveal the participants own feelings about their previous design experiences and how they evaluated the tool within the scope of software evaluation criteria. In this section, I also evaluate the findings of the study and literature review in the same context to reveal the existing position of BIM for the early stages of architectural design and how it might become a better design tool/media.

**IMPORTANCE OF BIM CAPABILITIES IN THE CONCEPTUAL DESIGN PHASE**

It is commonly approved that the early stages of architectural design 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).

It is true that; in the early stages of architectural design, sketching and drawing with paper and pencil still has a significant role for exploring possible design alternatives, evaluating 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, these CAD software which are really effective for drafting, are 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 which are taken with often inadequate information on the site, climate, geography, also provide a basis for the final performance and the aesthetics of the final outcome.

To deal with both the negative impacts of designing with inadequate information, and the emergence of the performance requirements for the building efficiency, researchers and practitioners become 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, sun light directions, wind directions, and so on.

Do (2002) states that in order to support creative design, design tools might offer additional capabilities to standard drafting and editing software. She discusses about a computational sketching system and emphasizes the importance of knowledge-based editing, simulation, and accessibility of relevant design information. In addition; such database systems have been used often as integrated parts of BIM software. Now, designers are able to benefit from BIM software (such as powerful drafting, visual analysis reports, scheduling and budgeting features) and also analyze 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’. Apart from this, 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 key-stone as it comprehends possible realities, searches for 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).

To sum up, it is underlined that taking advantage of essential information in the early stages of archi-
tectural 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 tool with powerful 2D and 3D drafting features, performance simulations, and visual analysis feedbacks. It must be mentioned that Vasari by itself, does not provide an automated design process, but analyses the alternative building forms to enable the evaluation of the relationship between the building form and the environmental factors. Then, the design relies on both the functional realities and the subjective judgments of designers.

In this section, I study the current realities of the early stages of architectural design by literature review, and then, I explain how BIM tools can offer new opportunities within the design processes. In the following chapter; it is explained which findings were obtained during the case study implementation and the questionnaire. Also, it is discussed how these findings can constitute not only the existing position of BIM for the early stages of architectural design, but also for the near future.

CASE STUDY IMPLEMENTATION

Participants
The case study has been carried out by twelve undergraduate degree students of Faculty of Architecture who are at their second year in architectural education. Participants indicated that all of them know at least one well-known CAD tools to use it as drafting, designing, and modeling tool. Since they had no experience about using BIM, parametric design, and energy estimation tools; a series of theoretic and practical BIM lessons were given during the semester. Later on, they learnt Vasari which was the pre-defined tool for this specific implementation.

Design Task
The task is to design an office building in Istanbul that will be used for the main department of a company. The project land is located on the main road of Sisli which has a close connection with the intercity and international road network. The design task of this study has its own requirements and limitations. Besides these regulation limitations, the office building will be used as the main department of the company which means it will not be sold or rented. Owing to this situation, a well-designed building performance with reasonable life cycle cost output is demanded.

Methodology
In this case study, to clarify and test the benefits of BIM tools in the form finding process, the task is to create a concept model with Vasari software and observe its reflections on the designer and design product. The participants were asked to design alternatives within the given requirements and limitations. Synchronously, I analyzed the process within the perspective of how building masses were shaped and also how the process affected the designer while they were designing. Later on, I observed how participants used the tool to obtain more satisfying product and how the tool provided a connection between designer’s satisfaction and the performance realities. Beyond my own observations, a questionnaire has been applied to reveal the participants own feelings about using the tool for massing design within the respect of performance realities.

Findings
Vasari is able to perform four important capabilities such as design exploration, 3D modelling, parametric design, and energy modelling which are really crucial for early stages of architectural design. While observing the case study, we notice that Vasari as a BIM tool has adequate capabilities to compete with other CAD tools for the conceptual design phase. Yet, it is not sufficient to compete with traditional sketching within the scope of creativity trigger. On the other hand, as a parametric design tool, Vasari provides a great opportunity by itself. It provides a digital media that users are able to constitute a parametric connection on 2D/3D models while they can still manipulate the model manually. In this way, Vasari offers a way of working which provides a media that users can work totally manual, parametric, and also parametric with manual manipulations. In addition, even it is not a
part of this study, it has also direct interoperability with other important BIM tools such as Revit and Dynamo which have different specialties. This situation forms a direct connection between Vasari and automated parametric design media and also other BIM tools which have more powerful capabilities for developing design alternatives.

During the implementation, the effectiveness of energy modelling and energy analysis have come out as the most powerful capabilities of the tool which are also powerful against the other competing software for the form finding. We observe that these capabilities directly affect two important factors which are supporting design process to get better design solutions from the perspective of performance and also learning to design sustainable solutions. Thus, designers have a chance to consider environmental impacts on the land and the building, and also the building’s energy consumption.

Even Vasari has a great conceptual energy modelling and analysis capability which support to design better solutions; I have experienced that it has to offer much more decision support capabilities to increase the efficiency of itself and energy analysis, too. For example, the main task of the study is to design an office building which must have a solid energy performance to get an advantage of life cycle cost expenses. From this point of view, the task is to design an office building which is profitable for the property owner. On Vasari, with all presumptive information about building materials and environmental factors; designers have an opportunity to obtain life cycle cost estimations but Vasari has no presumptive construction cost estimation capability nowadays. So, during the study, even the participant tried to obtain a better performative solution, participants had no idea if it was more profitable for property owner or not. Participants had no chance to evaluate the affordance between construction cost and life cycle cost. This situation also makes lots of design analyses outputs of Vasari less effective. Likewise my own observations during the case study, the result of questionnaire which was applied to the participants shows that the participants share similar thoughts with me. Their own rankings for each matter have been illustrated in Figure 1.

Apart from the conceptual design process, the participants also evaluated the tool in terms of software evaluation criteria. Even Vasari could not represent all other early design BIM tools, it is important to designate that how much the tool is satisfying and which conditions are not. As it can be seen at Figure 2, average ratings of the questionnaire demonstrate that the participants agreed on that Vasari had effective and functional capabilities for the conceptual design phase. They also agreed that it has still a potential for developing. On the other hand, even they thought it was not difficult to learn how to use it, participants clearly stated that online sources for learning the tool is unsufficient.

It is important to underline that the findings of this study carried out by only twelve undergraduate students is not sufficient to generalize the outcomes. But, the findings are still based on the reasonable inferences of the study which can be expendable with more case studies with more participants and complicated design problems.

CONCLUSION
The main objective of the study is to reveal the opportunities of the BIM for the form finding process. To examine the features which BIM provides for the designers, a case study has been implemented. During the implementation, I notice that Vasari doesn’t offer indispensable features for design exploration in these stages, but it offers significant and useful capabilities to design parametric forms. Vasari also offers designers 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.

As it can be understood from the previous extractions, BIM tools provide designers an opportunity to test the existing design products and then offer them a way to improve the design products. Designers also have a chance to design and analyze their own
ideas within an iterative process until they obtain a satisfying design solution. This way of working provides a connection between functional realities and designers' subjective judgments which can interact with themselves.

In conclusion, BIM is still an ever-developing system which is one of the most popular research and implementation topics of AEC industry. From the first
stage of the architectural design to the end of the building life, BIM offers many benefits to its users. On the contrary, the early stages of the architectural design are accepted as the weakest point of the BIM systems. Vasari is one of the BIM tools which is dedicatedly developed for the early stages of architectural design to improve BIM system's efficiency. In this study, a case study has been implemented to reveal how BIM can help designers in these stages. As a result of the implementation, it is understood that Vasari is a powerful early stages of architectural design tool, not for design exploration but also for parametric designing and design supporting, which visualizes the given inputs of climate, geography, material information and so on, to analyze and improve current solutions. On the other side; intriguingly, Vasari has still a lot of more potential capabilities which lead it to become a better design tool. Beyond all these inferences, I think that early design BIM tools are much more than a tool or a media. It works with its user as a partner and has a role within the process of decision making.

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