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The changing customs of architectural design: The effects of building information modeling in a local context

Funda TAN[1], Nurbin PAKER KAHVECİOĞLU[2]
[1] ftan@gtu.edu.tr • Department of Architecture, Faculty of Architecture, Gebze Technical University, Kocaeli, Turkey
[2] pakernu@itu.edu.tr • Department of Architecture, Faculty of Architecture, Istanbul Technical University, Istanbul, Turkey

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Abstract

The tools used in architectural design processes have always been effective in design activities. BIM methods, which are used as new technological tools and design modes by an increasing number of architectural firms today, have the potential to make a similar impact because they introduce a new logic Therefore, it is a critical issue to examine the change created by BIM in the design processes. In this context, this study examines the potential transformations that BIM can create in architectural design processes with a theoretical approach; It also explores the practical validity of theoretical assumptions. In line with these objectives, a three-pronged methodology was adopted in the study. First, the transformation created by BIM was conceptualized as a holistic digitalization in the field of architecture. Secondly, previous studies on BIM were examined, according to this, the possible effects of BIM on architectural design processes were gathered under three headings and the possible direction of the effects in these three areas was explained theoretically. Finally, the theoretical assumptions were reassessed through interviews with people actively working in the practical field. The inferences obtained at the end of these three stages are evaluated in the discussion section. In consequence, the paper attempts to reveal the transforming mechanism of architectural design practice under the influence of BIM as a new form of knowledge that enables the storage and management of design data. In this context, it aims to be a source for future studies on the orientations of architectural design practice and education.

Keywords
Building Information Modeling, Design knowledge, Design simulation, Collaboration in design, Performance in design.

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1. Introduction

Architecture is undergoing a profound change due to the advent of information technologies and the demands of the building industry. Building Information Modeling (BIM), which is a digital design approach that enables a design to be embodied in a digital, associative, parametric, three-dimensional (3D) environment, is one of the most influential factors of this change. In BIM applications, design information is stored on a digital model that can be shared among designers, consultants, contractors and asset owners. Any two-dimensional (2D) projection of a design can be created from this model, and so, the need to produce 2D drawings by hand or by digital applications that allow 2D drafting gradually disappears (Atkins & Mendelson, 2016; Eastman et al., 2011; Tan & Paker-Kahvecioğlu, 2019). In this way, 3D information models replace conventional orthogonal drawings and become one of the central themes in the computerization of architectural practice (Andia, 2012).

This substantial change in architecture is an important topic to study because the profession is mainly built upon the process of producing 2D design documentation. Drawing sets such as plan–section–elevation triplets and the labor to prepare these representational documents have been a determinant of the design process, design approaches, and the priorities of architects (Carpo, 2014, 2011, 2001; Evans, 2000; Pelletier & Pérez-Gómez, 2000). The structure of design offices and workflows, social image, and the professional relationships of architects and their clients and employers have been based on the labor of creating 2D projections. Therefore, the replacement of drawings with digital 3D information models changes many conventions in the profession (Kalay, 2006; Oxman, 2006).

Different stages of the design and construction of a building strongly interrelate with each other; and BIM has minor or major impacts on all these phases, as well as design processes. However, this study only focuses on the changes that BIM has made in architectural design processes in practice, associated with the end of the effort to produce 2D technical documentation.

There is plenty of research that addresses BIM from a technical point of view, however, studies on how BIM can alter the architectural design practice are still rare. There is almost no study that sees BIM as a method that ends the production of manual two-dimensional technical drawings and examines its effect in this sense. Architectural theorists have comments on the subject (Cardoso Llach, 2012; Carpo, 2014; Scheer, 2014), but there is no study examining these theoretical approaches in the practical field. In the literature, studies related to BIM in architecture have either focused novelties brought by BIM in various topics such as collaboration in design processes, object-oriented design, optimization of design and construction processes, etc.; or research has been conducted on the integration of BIM into design and engineering education curricula. However, before considering the integration of BIM into design processes and design education curriculum, it is critical to question how BIM methods and processes differ from traditional design methods and processes.

In accordance with this purpose, this study both presents a theoretical approach to possible transformation that BIM, as a set of tools and methods that eliminates the labor for the production of 2D technical drawings, creates; and investigates whether theoretical assumptions have practical counterparts.

In this context, the paper is structured in five chapters including the introduction. In the second part following the introduction, the research approach and methods are explained. In the third section, the background of the theory revealed by the study is explained, and in the fourth section, the inferences obtained from the field research carried out to reveal the counterparts of the theoretical approach in architectural practice are given. Finally, the fifth section is the conclusion section.

2. Research approach and methods

In regard to construct a theory about the transformation created by BIM and to find the practical reflections of these theoretical assumptions, a three-stage methodology was adopted in this study.

First of all, BIM was considered as the key to the transition from modern

Table 1. *The characteristics of different forms of knowledge.*

Pre-modern Narrative Knowledge	Modern Scientific Knowledge	Postmodern Information
Holistic	Fragmented / Hierarchic	Fragmented / Reticulated
Multicentered distribution	Single centered distribution	Centerless distribution
Culturally legitimate	Scientifically (based on proof) / Legitimate	Legitimization is inessential
Determines proficiency measures	Proves proficiency	Testable
Shows application	Determines application standards	Applied, tested and reapplied

period techniques and approaches to digital age techniques and methods in design processes; and this transition was conceptualized on the basis of ideas by Jean-François Lyotard in his book Postmodern Condition: A Report on knowledge (1984). In this study, Lyotard unveils the relationship between the common form of knowledge and the legitimization mechanisms in the organization of society. If Lyotard's discourse is applied to architecture, it can be seen that the transformation of the way design information is stored and transmitted has effects on architecture, similar to the changes experienced in other sub-structures of a society.

In this regard, three main forms of knowledge were taken from Lyotard. These are summarized as narrative, scientific, and informative knowledge. The main features of each form are briefly given in Table 1.

Second of all, BIM is investigated as an informational form of knowledge in architecture, in accordance with Lyotard's views and the transition from the scientific form of knowledge to the informational form of knowledge in architecture is inquired based on discourse analysis; and a theory is constructed accordingly.

Finally, semi-structured interviews with people from four different local design offices were used as a field research method and the inferences obtained from these interviews were evaluated in comparison with the constructed theoretical approach.

The offices were chosen from among a selection of architecture firms in which BIM tools are employed at different stages. Two of these offices are medium-sized (with 5 to 15 employees) offices (Office1 and Office 2). Although BIM tools have been used in these offices for more than 10 years, they are not used as an integrated design method, but rather as a set of tools that accelerate in-office production. The other two are medium-large-sized companies (with more than 15 employees) and they have used BIM tools in large-scale projects as a means of collaborating with other stakeholders of the projects (Office 3 and Office 4) (Table 4).

In the next section, the theory based on Lyotard's philosophy and developed with inferences from discourse analysis will be explained; in the following section, the answers obtained from the interviews will be addressed.

3. Background and theory

According to Lyotard (1984), the proliferation of information-processing machines would have a huge effect on the decision mechanisms of a system. Lyotard (1984, p.14) stated that: "Increasingly, the central question is becoming who will have access to the information these machines must have in storage to guarantee that the right decisions are made?" These circumstances are also valid for architecture as an organization. The person with the information, who can manage that information, will have control of the design and the realization processes. Since BIM requires as much information as possible to design the buildings' well-defined digital equivalents, it emerges as the dominant form in terms of informational knowledge in the architectural field, and hence, its use causes a paradigm shift.

There are various views in the studies on the possible effects of BIM in different areas of the architecture and construction industry. David Ross Scheer (2014) argues that among the differing and plenty of digital tools, especially BIM methods and tools have the power to radically transform professional practice, as they offer a new simulative medium. Scheer especially drew attention to the visualization capacity of BIM tools in detail and in different projection planes. Mario Carpo (2014) have described BIM as a digital transformation with the potential to realize the utopia of collaboration in design. In addition, there are plenty of various studies on the use of BIM systems for collaboration (Andia, 2012; Azhar et al., 2012; Briscoe, 2015; Idi and Khaidzir, 2018; Ma and Sacks, 2016) or buildings' performance evaluation (Kang, 2020; Na et al., 2020). As a result, the effects and potentials of BIM in the AEC industry have been examined and discussed excessively in speculative or research-based studies.

This study is aimed differently to deal with all aspects of the effects that BIM tools can create especially on the design processes. For this reason, all possible modes of affection discovered in literature review are grouped under three main headings. One of these is the "notation", the other is "the social role of the architect", and the last one is "the tendencies of architectural design" (Table 2).

These three areas of transition are explained below, and the possible direction of the shift in each area with the effect of information modeling is demonstrated. While theorizing the transformation in architectural design practice in the transition from a scientific knowledge form to an informative knowledge form, previous architectural design mediums are discussed to present a comparison.

3.1. Notation: From representation to simulation?

The change in notation can be conceptualized as a shift in modes of expressing design, from representational indication to simulative substitution. This replacement changes the way of creating an architectural form and causes skepticism about the emergence of meaning in this creation.

Representation and simulation can be conceived as forms of notation that are variations of each other. Although, in broad terms, they can be considered as a way of perceiving the world, in a narrow sense, they are modes of expression (Scheer, 2014). For instance, since the Renaissance, the mode of notation in architectural design has been representational and the dominant form of representation has been drawing (Tschumi, 1994). Before the Renaissance, architectural information did not have a projected form that could enable the exchange of information between practitioners prior to construction (Carpo, 2001).

Table 2. *Main areas of BIM affection in architecture.*

Change of Notation	Change of the Architect's Social Role	Change of the Design Tendencies
From Representation to Simulation	From Author to Leader / Team Partner	From Function to Performance

Table 3. *The effects of different forms of knowledge on architecture.*

	Pre-Modern	Modern	Post Modern (Digital)
Dominant Form of Knowledge in Society	Narrative	Scientific	Informational
Architectural Notation	Verbal	Drawing	Digital Information Modeling
Characteristic of the Notation	Descriptive	Representational	Simulational

Italian humanist architect Leon Battista Alberti first put forward the idea that a physical object could be drawn and depicted before it was built (Carpo, 2013). As buildings in the modern era have become more complex, drawing methods have grown to be sophisticated, drawing catalogs have become more comprehensive, and the separation between design and construction have expanded gradually (Luce, 2009). Architecture has therefore undergone transformations in the historical process in relation to its media. The main shifts and effects taken from the literature review are given briefly in Table 3.

When these transformations are examined, although certain breaking points are revealed, it cannot be claimed that any form of knowledge that is periodically dominant for the transmission of design information later disappears completely. However, there are periodically dominant forms of information transfer. For example, the birth of modern architectural design is highly correlated with drawing, which is the dominant knowledge transmission tool of modern architectural design.

Alberto Pérez-Gómez (2005) states that architecture has been divided into a fragmented representational environment since the Renaissance to the present, with the aim of standardization. To delineate buildings so they may be realized more precisely, new ways of producing more defined expressions had been sought and drawing systems developed in parallel with the growing complexity of construction. CAD applications have been basically based on imitating paper-based design (Oxman, 2008). However, in 1975, Chuck (Charles) Eastman, who is considered one of the founding fathers of BIM, stated that drawing was no longer able to provide the necessary information for construction (Eastman et al., 1975). The search for an alternative tool to replace drawing for architectural notation, started in the 1970s, gave birth to the BIM methods (Eastman, 1999, 1976; Eastman et al., 2011; Eastman and Henrion, 1977). Even though this quest has its origins within the architectural profession, the main demand comes from the desire of the construction industry to ensure the production and transfer of more precise, testable design information. This transition parallels the change experienced by other industries in the information age (Castells, 1998; Crotty, 2013). In the information age, where the form of knowledge is informative, not narrative or scientific as Lyotard claims, architectural information is also expected to be stored and transferable in data form by information models. Unlike drawing, which is a representational notation mode of architecture, information models are simulative.

According to Baudrilliard (1994), to simulate means being able to imitate a reality in a way that is indifferent to its origin, and to replace reality—and beyond that—to create a field of truth that is more perfect than the reality itself. Independent of the processes that lead to a situation, a simulation creates a realm of truth by providing merely the symptoms of same situations. This area of truth is what Baudrillard (1994) calls hyperreal. This applies to building information models that aim to be a digital–artificial twin of a building, with the accumulation of a large amount of information on a digital model (Tan & Paker-Kahvecioğlu, 2019). These simulative models equate with reality to the extent that they have a certain consistency. Therefore, there is a perceptional shift in the production and transmission of design information from representation to simulation. The representation is a notation that emphasizes certain features of the object or situation. It is open to questioning and therefore has a productive effect for the design. In simulation, the experienced object is copied. Imitation presents itself as reality, and no information is given about the origin or the development processes of the object. Therefore, the simulative experience is superficial and has no causality (it only refers to itself). It does not encourage any questioning which may create a meaning (Scheer, 2014).

However, this does not mean that there will not be any creativity in a simulation environment. Architectural production in a simulation environment does not have to depend on the dynamics of modern architectural design such as conceptuality and theoreticality. The validity of the design depends on its own digital tectonic presence in a simulation environment that is the new repository of architectural knowledge composed with algorithms and data structures (Clayton, 2015). Therefore, from a Lyotardian point of view, it is inappropriate to worry that the dominant knowledge in architecture is no longer narrative or scientific. Rather, one should understand this new form of knowledge and discover the possibilities of meaning created within it.

3.2. The social role of the architect: From author to leader?

Due to the free dissemination of information, the possibility of cooperation and the simultaneous content production of different groups on a project undermine the social role of the architect as an author, and a new role called team leader/partner emerges. After the Renaissance, the use of abstract representation, drawing in particular, to make decisions about buildings caused architects to gain autonomy. With control over buildings granted by drawing, tool architects have become the authors, as they decide why and how buildings should be built in a certain way. Especially in the first half of the twentieth century, mass production and the use of standardized materials such as steel and glass required more precise documentation for the construction of new buildings. Thus, drawing skills became essential in the profession (Johnston, 2008; Woods, 1999). Later, a new generation of architects, who received an elite education in architecture schools and were equipped with a knowledge of history, theory, and technical drawings, demanded to be accepted as architects in society as soon as they graduated (Cardoso Llach, 2012). These are architects in the modern sense of building authors, and their productions form and define professional modern architecture.

In Turkey throughout the twentieth century, architectural education evolved under the influence of foreign architects who trained in Europe and the U.S. The characteristics of the profession are no different from its western counterparts (Bozdoğan and Nalbantoğlu, 2002). The western architectural tradition was transferred to Turkey by some pioneers who trained young architects at the prominent architectural schools of the time. Architectural offices were established in parallel with Europe and the U.S., and architectural practices based on drawing also prevailed (Kafescioğlu, 2019).

Consequently, architects have been recognized as a professional group and as a building's author; who can master modern architectural knowledge—legitimate because it is tried and proven—and by using this knowledge, they can transfer the information through technical drawings. However, in a society where many systems have been automated via digital data accumulation, the relationship between design drawing and authorship also undergoes a dissolution with BIM. The fact that technical drawings are produced not by individuals but automatically by programs affects the modern architect. BIM recombines the architect and the construction of the building not physically but in a digital environment, causing the architects to exchange the role of the author with a new architect figure with abilities other than drawing (Carpo, 2014). With the use of BIM tools in architecture, design and construction are no longer linear processes that follow each other; the processes of designing, expressing and building overlap, assisted by the computer.

In so far as producing solutions for today's highly complex buildings that require different specializations has become impossible for architectural groups alone, consultant groups are more involved in the design process and at an earlier stage, and BIM—especially cloud based BIM platforms—facilitates such collaboration (Ma and Sacks, 2016). Although collaboration and interoperability support later stages of design development, when the information is well structured, collaborative working methods have an impact on the development of design (Bernal et al., 2015). In this context, the most important feature of BIM is that it proposes a new participatory model for the unification of design and construction that exceeds humanistic, modern, conventional modes of design (Carpo, 2014; Idi and Khaidzir, 2018). Therefore, BIM has been called "one of the strongest manifestations of the collaborative spirit that has pervaded digital culture and technology (and upended whole swaths of the global economy) in the early years of the new millennium" (Carpo, 2014). Garber (2014) argues that BIM technologies are loyal to our conventional concept of design, in addition to all their advantages. This contemporary design mode opens up interactive possibilities of simulation, collaboration, and optimization that were previously impossible. He claims that these digital tools do not limit but extend the authorship of architects. They only need to learn the rules of this new game.

However, it can be argued that it would not be absolutely correct to describe this new architect as the only author of the building anymore, since there will be many decisions that cannot be derived directly from the architect's initial idea, and the notion of singular authorship will lose its meaning in this new collaborative production. Therefore, in architectural practices, authorship gives way to a new type of leadership.

The most prominent feature of the leading co-architect is that the architect can capture and employ information freely. In this sense, BIM enhances design processes (Briscoe, 2015). However architects should decide how to use the data in line with their design intentions—which factors to make variables, which factors to focus on—and determine the stages and the method of the information modeling process (Ottchen 2009,). In this context, the leader/cooperator architect of the BIM method is also a strategist who determines how the factors will be applied and how they will be effective on the design.

3.3. The tendencies of architectural design: From function and program to performance and optimization?

Because the information form of knowledge does not need a legitimization mechanism to have an approval in society (Lyotard 1984), BIM alters the design priorities. Prominent principles of industry/machine age architecture, such as functional programming and sterility, are replaced by targets such as performance optimization and optimal operation. The functionalist design movement emerged from the Industrial Revolution and mechanization in construction during the late nineteenth and early twentieth centuries. Conditions such as the need for rapid production to meet demands for various types of buildings led to the development of a functionalist design approach that required conceptualizing buildings in compartments. According to Gandelsonas (1976), functionalism was perhaps the most progressive ideology in the history of architecture up until then. It transcended both the complementarity of classical architecture and provided the most effective architectural language for design. However, Eisenman (1976) claimed that functionalism was not a knowledge or a way of doing derived from architecture itself. Instead of discussing the socio-cultural problems of the modern period such as the emancipation of the individual and the end of humanism, architecture had blindly followed a machine-engineering aesthetic. According to Eisenman, this attitude was a transformed continuation of the classical humanism that came along with the program. Based on this view, it can be clearly said that functionalism was an attitude that architecture followed under the influence of the modern period and can be replaced by another trend that changes the form and the way of transmitting knowledge. In this context, a similar relationship between industrialization and function/program can be seen between digitization and performance/optimization.

Performance emerges as an important theme of the post-modern world. Scheer (2014) explained performance by establishing a link between simulation and technology. Technology reduces human vulnerability against the destructiveness of nature. Humans try to cross the physical, spatial, and temporal boundaries imposed on them by nature with technology. The ultimate goal of technology is to create a world over which we can have absolute control; one of maximum efficiency for our needs. In other words, we aim for a world where we can get maximum output with minimum input (Lyotard, 1984). Technology sets performance targets and tries to reach them. And simulation displays an ultimate environment where one can achieve all the performance targets. In this regard, performance orientation is the foundation of the simulative world. As notation moves to simulative modes in the field of architecture, performances begin to be the only goal for a building system.

Scheer (2014) underlines that metaphysics, ethics, and ontology are excluded when it comes to performance, and the only question becomes how something works well against the performance criteria. Since an important pillar of modern architecture and design is the theory arising from problems of aesthetics and meaning, it can be thought that performance and performative optimizations carry the danger of reducing the architectural experience. However, according to Ottchen (2009), the large amount of data that can be collected from different fields such as social, historical, cultural, and aesthetical, provides a new meaning. Since it is possible to make a performance analysis, the traditional methods for producing meaning collapse, and big data as a new agonistic tool opens a new realm for the designer beyond theory and nostalgic semantics. As architects can use data from many sources, they will be able to delve deeper into superficial theories and explore new possibilities.

There is an increasing pressure on architects to use both data from different areas and more sophisticated digital graphic simulation techniques in the early design stages. In this context, the effective use of data and BIM becomes characteristic of the architecture of the era (Clayton 2015; Garber

2014). BIM's penetration of object-oriented architectural design turns it into process-oriented action. This influence changes the focus of architectural design and reveals optimization as an important criterion. Although it can be argued that performance-oriented optimization endangers the experiential depth of the architectural object, it should be accepted as a reality, and a response to this situation should be considered. Ottchen (2009), for instance, suggests that the architect should be a strategist who uses data creatively. As a result, while the architecture of verbal conveyance brought a symbolic order, the architecture of representation brought conceptuality, functionalism, and a sterile aesthetic. Simulation brings a new meaning through performance-oriented architecture.

3.4. Conclusion to the background

In conclusion, the main possible effects of the penetration of BIM into architectural practice in the three main areas within the architectural discipline can be summarized as below:

- A new way of creating thoughts and meaning comes with simulative notation
- A role change to being a leader/partner in a collaborative design environment
- Performance-oriented optimization in design

The office interviews were done based on these assumptions. In the following section the early reflections of the shifts in four design offices from Istanbul, Turkey will be shown.

4. Interview answers and interpretation

As discussed earlier, a modern architectural tradition is present in Turkey. Today, however, BIM methods and digital tools are used to overcome the uncertainties of construction documents and ensure that speed and efficiency increase, as in many countries.

Within the scope of the study, 5 designers from these 4 design offices were interviewed. All the interviews are conducted face to face in the designers' offices. The interviewed designers and the firms were coded as designer 1, designer 2, ... and office 1, office 2… as in the Table 4.

Table 4. *Codes, companies, and positions of the interviewees.*

	Designer 1	Designer 2	Designer 3	Designer 4	Designer 5
Company	Office 1	Office 2	Office 3	Office 4	Office 4
Position	Co-founder	Founder	Co-founder	Architect, Project Coordinator	Architect, Project Coordinator

Currently, the number of architecture firms using BIM technologies in Turkey is small (BIMGenius, 2020). The reason for choosing these four offices is that they are architectural design firms that produce work with BIM methods and have also mastered conventional methods. Since the main target of the study is tracing the change of conventional methods to BIM, expertise in both ways of working was an important factor in the selection.

The three theoretical headlines of the study shaped the interviews that are done with practitioners. Questions were asked in three groups in relation to three headings of the study in order to reveal whether the practitioners felt three theoretically suggested effects or in which direction they felt them. Approximately 12 open-ended questions were asked, 3-4 in each group. The questions opened topics about the office operation, at what level BIM is used, and the designers' future predictions about BIM. All the significant answers given are presented in the tables below (Table 5, Table 6 and Table 7). Answers were interpreted within the framework of the theoretical background of the study.

4.1. Notation

One of the prominent findings from the interviews on notation is the difficulty in switching to BIM applications. Although practitioners feel an urgent need to employ BIM methods and applications in their offices, they usually falter in the adaptation (Table 5,1).

Designer 1 (D1) states that they have been trying to adapt BIM software to their office operations for about 10 years, but that this was not possible until the last year or two. He explained that the primary reasons for the instrumentalization of BIM in the office are for making the project production stages more effective, to provide automation of the digital model, and to liberate the design process from the burden of two-dimensional drawings by using

Table 5. *Featured Statements on notation.*

	Simulative Notation	
1	**Difficulty in first adaptation:**	Need to create two-dimensional projections and the difficulty of creating them to desired levels
2	**Time for Design:**	The ease brought about by BIM's automation capacities as simulations of a design
3	**Manufacturing oriented design:**	Digital production of design resembles the construction in reality
4	**Expanding scope of project:**	Expanding the project concept from the design of a purely physical object to the design of a process that includes the entire lifespan of a building
5	**Restriction of creativity:**	Dealing with too much information in the early stages of the design

BIM tool features that enable images to be viewed from a model on different projection planes. However, he claims that it was not possible to obtain the desired level of two-dimensional projections from a three-dimensional model in the early period of adaptation. In the interview with designer 4 (D4) and designer 5 (D5), they similarly attributed this failure to the fact that offices in Turkey cannot switch to BIM methods because they cannot obtain two-dimensional information from the model they produce in BIM programs at a level that would satisfy architects who have years of expertise in two-dimensional project drawing. According to D4, the employer's and the construction site's request for two-dimensional drawings is one of the obstacles in advancing 3D information model production. He explained that "If the two-dimensional drawing is reproduced by drafting, because a two-dimensional output at the standard level expected by the site team cannot be obtained from the three-dimensional model, then the time and effort spent on producing the model becomes pointless." Designer 2 (D2) stated that even though they actively use information modeling tools and facilities in project development processes, they print the project on paper for delivery. According to designer 3 (D3), technical drawing is insufficient to express a building from different aspects. He states that they directly share the model with other stakeholders. D3 believes when a project is put forward, not only its physical existence, but also its financing, lifetime, and usage pattern should be expressed. He claims that a simulation is needed to make such an information transfer (Table 5,4).

So, the difficulty of mastering the export of 2D projections is a drawback of BIM tools. Since the projects are still delivered in either digital or printed 2D layouts, not as info models (except at O3), high quality two-dimensional outputs are needed. In this regard, producing in a simulative environment is not internalized totally by practitioners who are used to representational notation, so, representations are still sought.

However, the simulative logic of BIM models are well understood. The comments of the interviewees show that, besides from their display capacities, the automation capacities of BIM tools are also an important factor in the transition to this simulative notation (Table 5, 2). Although different groups use the automation facilities of BIM at different levels, these capacities are utilized. D2 emphasizes that, when the project is digitally modeled, the data obtained automatically from this model provides significant time savings. While the production of project information such as zoning and material lists in conventional methods have to be written manually, one by one, the given identity of an object in the building information model accelerates the process of creating these documents and reduces errors, which increases the time for thinking about the design and generating design ideas. A similar case is expressed by D1. He stated that the ability for quick calculations of wind, light, and shade insolation conditions puts the project on real grounds and allows time for thinking of the design. The users described this situation as being rewarded with "time to design" in the interviews.

BIM tools also offer architects manufacturing-oriented design direction, which they cannot master with representational notation. (Table 5, 3) All the architects interviewed emphasized the relationship between BIM tools and construction. D1 stated that the production of the information model is similar to the construction of the building in reality and that if it is not produced correctly, the digital model also fails, just as the structure will collapse. D2 points out that the inability of some BIM tools such as Revit to produce some surface geometries means that those geometries cannot actually be produced. Thus, BIM tools make the structure "real". These comments address the relational data structure of BIM platforms (Eastman et al., 2011).

When asked whether the use of BIM tools in design processes restricts creativity, since it requires large amounts of information, D4 explained that Revit may limit the design to some extent, but in the early stages of design, while the initial idea is generated, using Revit is not mandatory (Table 5,5). From D2's explanations, it is understood that at Office 2 BIM tools that allow information modeling (such as Revit) are not used in the conceptual stages where the architectural idea is generated and presented, but in the development processes of the project. D3, however, disagreed with the view that too much information may pose the risk of disrupting design, saying that too much information means being open to a larger world and being able to calculate very different effects. In this context, he also stated that producing in the simulation universe established by BIM tools in design development processes does not reduce creativity.

4.2. Social role of the architect

Although the software that we consider as BIM tools was developed with a focus on modeling the design and exporting representations in different projections from this model, today, sharing the 3D design information of a building information model with other stakeholders during the project development process is also possible, and this allows for integrated project delivery (IPD) (Eastman et al., 2011). Therefore, the digital construction of a design evolves into a collaborative production.

In this regard, architects need to define their new position in an organized team on a project. (Table 6, 1). D2 stated that they do not perceive BIM as a computer program, but as an idea and a production concept; and that BIM is essentially not a single tool but a set of platforms. D2 used the "round table" metaphor for the collaborative working model of their team on a task. In her firm, BIM is considered as a process in which all stakeholders meet around a round table to manage the stratified information. She emphasized that

Table 6. *Featured statements on the social role of the architect.*

	Leadership	
1	**Changing status of the architect:**	Need to replace the phrase for the modern metaphor of "maestro" to define the architect's position in a project team
2	**Expanding scope of building design:**	Engineering problems are also considered as design problems, so engineers are expected to be involved in the project in the earlier stages
3	**Various methods to share digital models:**	Instead of sharing drawings, formulating ways to share models with stakeholders

the most important aspect of this new generation organization is "horizontal hierarchy". The most critical difference of this process from the conventional method is that the information is not left to one person to manage (Figure 2c).

Similarly, D1 states that BIM leads to a group collaboration, as experienced in their offices. This new organization prioritizes a design environment which is not the intellectual property of a single designer. What is important is that design teams from different disciplines work together and efficiently. He also stated that, while the architect can take a leadership role in such an organization, it is different from the former leadership role. D1 defined this new organization using the metaphor of an octopus (Figure 2b).

D3 underlined that the most troublesome situation in the traditional organization is the role of the head architect and explained that an architectural design project also involves "design problems" outside the expertise of architects. D3 sees the engineering problems of a project also as design problems (Table 6, 2). Engineers usually analyze the system in the direction indicated by the architect in conventional workflows. However, in the BIM workflows at O3, engineers are expected to be involved in the project at the early design stages. So, in as much as they comprehend the design through three-dimensional digital objects, they can engage with the design problems. D3 stated that the architect can no longer be described as the maestro in this workflow, but as an orchestra member at best, like a pianist, and that, when the score is taken up by the string section, he should stop and wait for his part (Figure 2c).

D4 explained that to produce optimally integrated projects with BIM, they share their models in IFC format for static calculations. Engineering

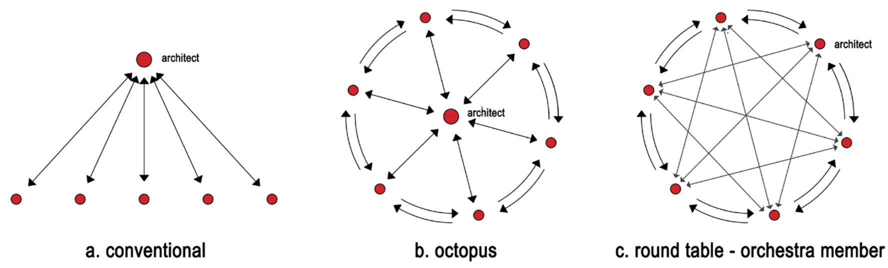

Figure 1. *Workflow types of project development.*

Table 7. *Featured Statements on design tendencies.*

	Performance	
1	Design optimization	Using BIM models to analyze and optimize design according to some performance criteria
2	Alienated forms	Raising the level of constructability increases clients' demands for alienated forms that are not achieved through architectural expertise

groups usually open this model in Tekla to produce their own models by taking architectural models as a reference and then send it back to the design team (Table 6, 3). D4 explained that this method is very useful in the development of the project, and added that coding the design information in a simulative BIM environment enables better communication with the consultant groups. BIM models increase the mastery of 3D among the consultant groups on the project, and thus, allow a democratic collaboration among all the stakeholders in the project.

However, it is also underlined by D4 that "today, despite all its benefits, it is not possible to establish a horizontal organization between architects and consultants in small-scale projects. Setting up such a control team also incurs a cost on the employer's side. For such a control mechanism, many people such as a BIM manager or a quality control specialist should be assigned. Small companies do not prefer to establish a corporate structure for a single project. Instead, the preparation project as a whole, with its coordination and solutions, is left to the architect."

In this regard, it is clear that producing projects in the horizontal organization of the BIM method is only widespread in large scale projects but may become a habit over time. If sharing information through BIM models becomes prevalent, the architect may be completely relieved of the burden of project coordination.

4.3. Design tendencies

A feature of BIM notation is the goal of gathering the maximum level of information about the project on a single model. The fact that all the data belonging to a project is stored in one model also makes the design analyzable against various performance criteria. The important finding related to performance is that all the practitioners' statements show that they analyze and optimize their model according to various performance criteria.

D1 stated that they use lighter BIM tools or BIM applications that contain relatively less information than a design tool, with the aim of analyzing the model for performance criteria such as lightning, shading, and wind exposition, and to create mass studies accordingly. Moreover, D1 related that they can make cost estimates from mass analysis by rapidly entering information into the models at the early stages of the design, thereby making a difference (Table 7,1). D2 stated that analyzing tools are an important part of their designs, especially in considering environmental factors. She explained that these data are determinative on how the building is placed in the area at the earliest stages of the mass design. D4 and D5 stated that the information model is also widely used in professional analysis by simplifying it to shorten the processing times or by adding new information when necessary. They share the model with consultancy groups who are experts on subjects such as lighting and/or acoustics to conduct a professional analysis of whether the project meets certain standards, and the results are reported (Table 7,1).

The decisions that used to be made intuitively by the architect in conventional methods depend gradually on the data obtained from the analysis of the offices that use BIM tools. D3 emphasized that the main reason for using BIM is performance-oriented targets. He believes that performance goals should be a primary preference in an architectural design, and explained that performance is always a priority when performance criteria and aesthetic preferences conflict in his design approach (Table 7,1). He underlined that when the buildings do not perform well, they cannot avoid making interventions that the architect does not anticipate. On the other hand, according to D2, these analyses do not draw a very different conclusion from the intuitive ones, but strengthen the validity. According to D2, it is inevitable that optimization concepts will come to the fore in a world, in twenty years, with a population of 15 billion people. She underlined the need for concepts such as optimization when the project needs to be democratic and accessible to everyone(Table 7,1).

D5 underlined that, with the development of construction technology and BIM technologies that allow more information to be transferred, many forms that could not be done in the past could be constructed, and that this has evolved architectural design into a showcase (Table 7,2). This interpretation of D5 parallels Lyotard's argument that claims that since "a universal metalanguage principle has been replaced by the principle of plurality of formal systems in the information age, things assumed as a paradox or even a paralogism in classical and modern science, can find a new persuasive power in any of these systems and obtain the approval of the community of experts" (Lyotard, 2014, p.85).

5. Discussions

The statements clearly show that offices initially resist adapting to BIM methods because it is a new, simulative form of design information. However, once they have adapted, simulative tectonic models that produce fast, automated design information have enabled early users in Turkey to use the data for rapid analysis. To the extent that they can dominate a certain level of information, novel information modeling tools have allowed architects to save time on their projects. However, the phrase "saving time" shows that, although offices employ these models for some analysis, they still save time for the early stages of a design for which they mostly rely on intuitive, conceptual representations to generate the initial idea (or the meaning) of the design. Designers prefer more abstract representations in the early stages of a design because BIM requires a high level of information, and thus resembles a real built object. However, this does not mean that BIM tools should not be considered as a design tool. BIM constitutes an important part of the architectural design process to the extent that it is used to produce and develop architectural solutions. In the O3 example, BIM tools are employed in all stages of the design. Based on D3's comments, it can be said that the transition of the architectural notation from representation to simulative information models brings a new design method in which the designer manages huge amounts of information. This extends the scope of the architectural project concept from the design of a purely physical object to the design of the entire lifespan of a building.

In the context of changing the social status of the architect, although the offices apart from O3 do not see themselves at the ideal level for integrated project delivery (IPD) with BIM tools, the use of BIM tools and data sharing in a project has already affected the position of the architect in a project organization. All of the interviewed architects were aware of a shift in the author role of the architect and attempted to define the new organization with metaphors such as "octopus", "round table" or "orchestra member". They also stated that the involvement of the consultant groups in the early stages of the project would lead to a more effective and lean design. Of the offices interviewed, O3 was the only one that has implemented BIM tools and methods at a level that can provide IPD literally. However, O3 was able to do this by incorporating all the other disciplines. In as much as BIM increases the level of cooperability, the architect is placed more in a leader/project partner position. However, the loss of authority in these processes does not mean that the architect is devalued. On the contrary, it can be claimed that their word is better understood and becomes more valid and valuable due to the transparency of the process. It can be claimed that producing projects according to the horizontal organization of BIM can possibly relieve the architect completely of the burden of project coordination, which will be done automatically by the sharing of information. In consequence, BIM methods transform the organization and accordingly transform the role, position, responsibilities, and business tradition of the architect. This transformation has begun, albeit to a small extent, in Turkey's architectural environment. However, it cannot be said that there is a complete shift since offices work in different organizational structures for different types of projects.

Regarding the design tendencies, BIM enables the design optimization for performance criteria. In all four offices these features of BIM are used and the final design is optimized to some extent. Although this may pose a risk of losing the authenticity of the design, it also brings a level of democratization. Besides, the level of constructability brought about by BIM risks diminishing the importance of the architectural design knowledge inherent to architects and achieved through formal education. As a result, even though the data from the analysis made in the advanced stages of the project do not have a major impact on the design, for good or ill, performance is increasingly becoming a prerequisite for architectural design. While buildings were thought of as "a machine to live in", today they are becoming shells adapted to environmental conditions. In this context, it can be said that the building form, which has followed function for a period, now pursues the target of meeting certain performance criteria in aspects such as material, structure, organization, and configuration performances. As a result, the design becomes gradually performance oriented, as seen in the design offices form Istanbul, Turkey.

6. Conclusion

The primary and most substantial result of this study is that BIM should be understood as a new form of knowledge in architecture. Secondly, it was shown that this change in the form and transmission mode of knowledge affects architectural practice.

First, due to the agency of BIM and its complementary technologies, a new type of architect is emerging who can translate design into data and can thereby engender meaning in a simulative environment. In the offices of the interviewed designers, although architects use the advantages of digital simulation mostly to shorten revision and documentation processes, there are those who complete whole project phases in BIM. These groups experiment with a new type of digital tectonic creativity in simulation. Secondly, BIM presents a collaborative environment where the interdisciplinary development of a project is possible. In the offices of the interviewed designers, architects use this opportunity to involve engineering groups in the project at earlier stages. This way, they aim to minimize the mistakes regarding the technical requirements. As a result, a new type of organization emerges. Architects who are interviewed for this research described this organization with metaphors like "octopus" and "round table", or the position of the architect as an orchestra member. It is clearly observed that in these organizations, it is not the authority but the traditional contractual position of the architect that is eroded. Finally, the building's performance emerges as a crucial design criterion for the future of design. In the interviews, all the architects mentioned that in both the early and late stages, the 3D information models are subject to several performance analyses. Even though these analyses do not create very different results to the architect's initial intuitional decisions, they are gradually becoming the de facto steps of design, and affect the direction of architecture.

In conclusion, BIM is the new method of architectural project development that affects architectural practice. Therefore, architects cannot neglect its listed impacts and behave as if BIM is just another computer aided design tool. BIM, as a new form of design knowledge, should be well understood and instrumentalized accordingly for an enhanced, enriched, and advance architecture.

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