THE FOUR F'S OF ARCHITECTURE

A conceptual framework for understanding architectural works

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Abstract. This paper presents a conceptual framework for understanding architectural works. This framework provides an understanding of an architectural building through qualitatively discerning the complexity of issues involved in its design and enabling their systematic integration into a theoretical construct. The premise behind this framework is that in design a better understanding of 'what' to design leads to a more informed base to 'how' to design. Using a grounded theory method, the paper postulates an ontological framework that recasts the Vitruvian triad of *utilitas*, *venustas*, and *firmitas* into spatial, intellectual, and structural forms respectively, and more importantly expands the triad to include context and architectural thinking as formative ideas, as integral components in any architectural work, thus closing a gap that existed in many frameworks dealing with architecture. The paper concluded that this framework offers a level of robust understanding of architecture that can be used in structuring the generation of architectural form as well as the description and analysis of existing works of architecture. Its value exceeds theory framing and extends towards architectural pedagogy as a theoretical framework in teaching design studio.

1. Introduction

As a social phenomenon, architecture is characterized by complexity and linked to multiple bodies of knowledge; architectural design typifies a multidisciplinary design domain where architecture, engineering and construction come together as one, each dealing with a particular feature of the building design and each with its own concepts and interpretations (Rosenman & Gero, 1997). Furthermore, architectural design is an integrative and interdisciplinary process with complex requirements that

calls for a deeper understanding of 'what' to design in order to better inform 'how' to design (Friedman, 1992; 2003). A better understanding of such complex phenomena requires a multidisciplinary approach that distills concepts across domains and organizes them into a coherent structure. This requires the development of a conceptual framework that elucidates the basic concepts of architecture, develops an essential common language within and provides uniformity leading to a better understanding. This paper postulates such a meta-level conceptual framework. This framework facilitates the understanding of architectural form through expounding its underlying constituents and integrating them into a coherent whole, thus allowing for a more structured description, interpretation and generation of proposed works of architecture, and consequently leading to a more structured discourse of architectural design.

Many researchers and theoreticians have attempted to formulate a definition for architecture through determining its ruling principles; however, most of these attempts are traced back to the three enduring sets of architectural principles proposed by Vitruvius in his treatise De Architectura in the first century B.C: venustas, firmitas, and utilitas – translated respectively as beauty, firmness, and commodity. Researchers emphasized one or more of these aspects as bases for understanding architecture (Semper, 2011: p. 1851) emphasized the technical aspect of architecture focusing on four distinctive elements of architecture: hearth, roof, enclosure and mound. Frankl (1973; 1914) proposed analyzing architectural styles based on spatial composition, treatment of mass and surface, treatment of optical effects, and the relation of design to social functions. In design research relevant to architecture; Stiny and Gips (1978) presented an 'aesthetic algorithms' machine for the analysis and generation of designs in art and design. Stiny and March (1981) presented 'design machines' as an algorithmic schema to model the design process. Gero (1990) presented function–behavior–structure (FBS) framework as formal representations of a designed object. In characterizing architectural designs, Tzonis (1992) developed the P.O.M. system defining performance, operation, and morphology as representation of information contained in precedents. Economou and Riether (2008) presented 'Vitruvian machine' that mapped Vitruvius' triad into formal studies of architecture.

However, most of these models did not account for two crucial constituents; first, as a building's symbolic performance is inseparable from time and place (Piotrowski, 2001), the relation of the work of architecture to its context and the dynamic role the context plays in shaping architectural form and influencing design thinking necessitates the inclusion of context as an integral component in understanding 'what' an architectural design is. More importantly, architectural design is a reflexive process that involves critical reflection of the constituents of a design situation (Peponis, 2005),

thus framing it in a different manner that goes beyond beauty, firmness and commodity. Accordingly, design reframing makes it imperative to introduce design concepts as part of 'what' an architectural work is and an integral component of any architectural design framework.

Through qualitative description, this paper aims to develop an architectural framework. By no means is the framework intended here meant to be a fully detailed account of what architecture is; rather, it lays out the key concepts and constructs and posits relationships among them. These concepts are the building blocks through which designers reason about architectural form schematically. Besides clarifying concepts and relating them, such a framework structures and frames academic debate about architecture in terms of basic taxonomy of concepts, relationship between concepts and propositions, and accordingly allow sensible debate to take place.

2. Setting the stage: definition of a conceptual framework

Jabareen (2009: p. 51) defined a conceptual framework as *"a network, or 'a plane,' of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena."* The aim of the conceptual framework is to provide an organizing scheme for a phenomenon through the organized structuring of concepts that constitute that phenomenon (Shields & Nandhini, 2013). Of interest to this paper is the formation of an ontological conceptual framework. In the field of design computing, ontologies are structured conceptualizations of a domain in terms of entities in that domain and their relationships (Gero & Kannengiesser, 2007): they present a knowledge set about a subject, and they describe individuals as the basic objects, classes as collections or types of objects, properties and characteristics, and the relations between objects (Aksamija, 2009).

One of the strongest features of conceptual frameworks is that they assimilate knowledge from multiple disciplines and integrate them into a theoretical construct (Jabareen, 2009). As such, for a multidisciplinary domain such as architectural design where art, theory, engineering and construction, among others, come together, conceptual frameworks become an excellent mechanism for relating different concepts and structuring them as a conceptual construct. As conceptual frameworks are formed through qualitative analysis, they do not provide knowledge of 'hard facts' but rather 'soft interpretations of intentions' or concepts (Levering, 2002) that aim at neither providing explanations nor predicting outcomes that address questions of 'how' and 'why', but rather providing an understanding of 'what' constitutes a certain phenomenon.

3. Understanding Architecture: Identifying Concepts

According to Ulrich (1988) the ability to reason about any artifact rests on the ability to abstractly categorize that artifact and provide a minimal description of its structural or salient aspects. For Tzonis (1992) the core of any intelligent design system describes how artifacts work, how they are made, what they do in respect to what is expected, how they fit into the surrounding environment, and how all these aspects are related to each other. Hillier *et al.,* (1984) defined buildings as cultural artifacts that can be regarded as material constructions, spatial organization, and objects in a particular style. According to Markus (1987) for any building to function effectively, it has to accommodate function/s required by an institution occupying the space of the building. The fundamental function of the spatial organization defined by a material structure, labeled by Frankl (1973) as spatial form, is to accommodate human activities.

Spatial form is governed by explicit rules about how people, objects and activities are disposed in space (Markus, 1987). In that sense, spatial form is both trans-spatial and spatial: "the trans-spatial aspect defines purposes, activities and roles for different groups of people. In this sense, program can be understood as a social script. The spatial dimensions of program refer to the ways in which this social script is embedded in space through a pattern of distribution, affordances and labeling." (Capille & Psarra, 2013: p.18).

The material construction or structural form of a building shapes space and signifies how to construct the physicality of the building. It involves structural engineering to address stability and support of the building, mechanical and electrical engineering to address the operation and serviceability of the building in terms of the provision of suitable conditions for the functioning of the architectural building, and the materialization of the building via construction utilizing existing engineering knowledge and technical know-how (Rosenman & Gero, 1997).

At the same time, this material construction has visual qualities, e.g. materials, color and surface texture, as well as construction detailing including moldings, grooves and change in materials etc., which characterize space, thus adding cultural significance and aesthetic appeal. This becomes the perceptual form of the building that transmits social meaning through its physicality. Yet, the formal attributes of the material construction have a cognitive, conceptual and affective dimension (Peponis, 2005); the material construction has an abstract and architectonic aspect, usually expressed geometrically (Unwin, 2003). It signifies how to logically and formally structure the materiality of the building. In that sense, there is/are underlying conceptual system/s (Unwin, 2008) that structure design elements and organize the material construction, thus generating the formal properties of the building. This distinction between the abstract and the material was made

500 years ago by Alberti in the 15th century in his Ten Books on Architecture. Alberti distinguished between geometry and material construction of the building where the function of geometry, lineaments in Alberti's terms, is to "prescribe, and appropriate place, exact numbers, a proper scale and a graceful order for whole buildings and each of the constituent parts" (cited in Dahabreh, 2006).

Consequently, the form of the material construction can be read as: a structural form of utilitarian nature that supports the building and structures space, a perceptual form related to the articulation of surfaces and pertaining to sensory perception and experience, and a conceptual/logical form that orders the elements and regulates the material form. The former three types of form related to the material structure correspond to Vitruvius' structural, sculptural, and geometric forms respectively, as identified by Agudin (1995).

Spatial form (SF) of an architectural building along with its structural (SF), perceptual (PF), and conceptual forms (CF) are interrelated and cannot be separated; each affects and conditions the other and all exist simultaneously in every work of architecture. It should be noted that the categorical distinction between spatial and physical form or between the two aspects of the physical form i.e. structural and intellectual, is not treated as one intended to capture two or more kinds of organization, but rather as one of recognizing the different aspects of building that become important depending upon the kind of question one asks. Hendrix (2012) made a distinction between the functions of form in architecture; a 'communicative' function in terms of expression and representation fulfilled by perceptual and conceptual forms, and an 'instrumental' function in terms of utility and technology as performed by spatial and structural forms respectively. Accordingly, the constituent forms of architecture can be regrouped into three forms: spatial form (SF) related to utility, intellectual form (IF) combining conceptual and perceptual form and related to the agency of the 'intellect', and a structural form (SF) related to technology and construction.

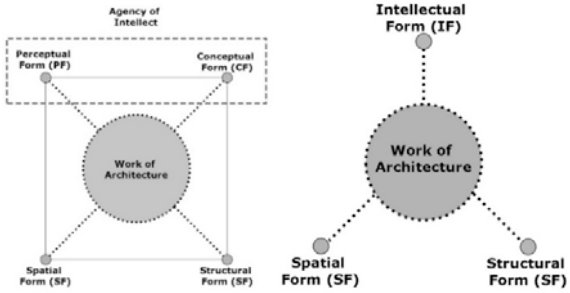

Figure 1. The four forms of architectural form understood as spatial, intellectual, and structural forms

The three forms identified above are synthesized through a design process. This process involves a critical reflection upon that situation that goes beyond its immediate conditions, thus leading to new understanding of it (Dahabreh & Abu Ghanimeh, 2012). This new understanding necessitates the reformulation of design constituents i.e. SF, IF, SF, in an innovative manner to address the conditions of the intellect. This type of thinking utilizes what is referred to as design concepts; they refer to "how the various aspects of the requirements of a building can be brought together in a specific thought that directly influences the design and its configuration." (McGinty, 1979: p. 215). As such, design concepts are formative ideas (FI) designers use to influence or give form to design (Clark & Pause, 1996). Furthermore, formative ideas include additional aims, or inflections of aims brought about by designers themselves, in the course of design as well as the aims of design as intrinsic to the designed object that cannot be initiated before the design process itself (Peponis & Wineman, 2002). According Schumacher (2011) it is this type of theoretical reformulation and innovation that differentiates architecture from mere building. Consequently, an architectural building has an abstract and conceptual aspect i.e. formative idea (FI) that integrates spatial, structural, and intellectual form into a unified whole, providing a logical order that governs and organizes its material construction and expressing how a designer reasoned about the design situation, including what they added. Thus, the diagram of architectural form in Figure 3 can be recast to integrate formative idea (FI) as the heart of any architectural work (Figure 2).

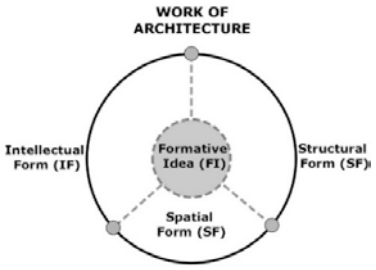

Figure 2. Intellectual form as the integrator of architectural work

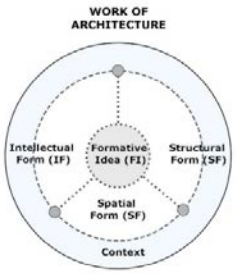

Figure 3. Architectural work as an integration of the five concepts

Kolodner (1993: p. 13) defined a case as "a contextualized piece of knowledge representing an experience that teaches a lesson fundamental to achieving the goals of the reasoner." Conferring with Kolodner that reasoning about any case cannot be separated from its context i.e. the situation under which the case evolved and took place, the final constituent of the conceptual framework is the context (C) under which architectural

work is conceived and in which it exists. When the conditions of the surrounding environment – natural-physical we exist in and socio-cultural we operate in – do not meet the aspirations of humans, humans create new artifacts that belong to a techno-physical environment (Rosenman & Gero, 1998). Thus, the surrounding context defines the requirements that state what properties, functional or constructional, an artifact should have (Greefhorst & Poper, 2011). Additionally, the context plays a proscriptive role in architectural design, where through being constrictive in terms of its physical or techno-physical nature, e.g. topography and climate, or being controlling through setting rules and regulations for design, e.g. building codes and zoning, context constrains the design by saying what should not or could not be done. Furthermore, the building operation and performance are conditioned by the circumstances of the surrounding context. But most importantly, context defines the theoretical framework of any work of architecture. As such, understanding 'what' a work of architecture is cannot be complete without understanding under what conditions conception, formation and materialization took place. The final conceptual framework is presented in Figure 3.

Within the conceptual framework presented in this paper, an architectural building can be understood as a material construction molded though a formative idea (FI), structured by intellectual requirements (IF) that regulates functional requirements (SF), and mathematical and physical necessities (technology and construction) (SF), all within the constraints of a context (C). In order to elaborate on the practical application of this framework, a case study will be described and analyzed using the main components of the framework.

4. The Bhāva: A Case Study from the University of Jordan 2015

The conceptual framework proposed in this paper was used to structure the work of fifth year students at the University of Jordan in 2014–2015. Two of the projects won international regional awards, and one of them won another international award and was published in several respected architectural websites. This project, the Bhāva designed by Rasha Al-shami will be presented as case to elaborate on how this framework can be used in teaching an architectural design studio (Figure 4).

The project was to design a Community Technology Center (CTC) in downtown Amman. The thesis started by reformulating the design situation and researching a deeper theoretical context. Theoretically, the project was based on the premise that humans occupy a multiplicity of worlds, e.g. from the physical to the abstract, and from the real to the virtual. Nevertheless, gaps and clashes exist between these worlds. Researching a narrative that

acknowledges the parallels and divides between the physical and abstract worlds and brings them together became the theoretical context of the design (C).

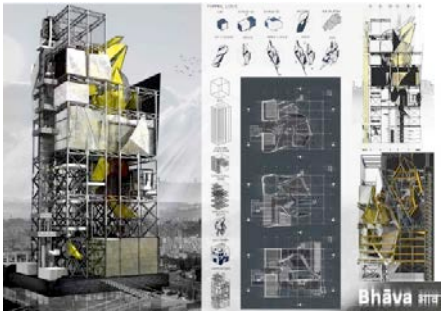

Figure 4. The Bhava

The basic conception behind the design was to collapse real and virtual worlds into one through the creation of a gaming universe that is a hybrid of virtual elements and physical objects (HVP). In this universe, the outer world of reality merges and interacts with the inner world of the mind. Such a designed universe creates a state of spatial immersion, a state of being physically present in a non-physical, non-abstract world giving rise to the state of multidimensional consciousness where one is conscious on more than one dimension and more than one level. In such a universe, the concrete and abstract, the real and virtual, no longer constitute a duality; rather the two become one. To design this state of becoming, of transition, of transcendence is to design a Bhāva. As such, the design of a CTC is conceived as the design of orders in collision: an order of existing reality confronted and challenged by an order of the new materialized virtual, nevertheless forming a Gestalt. That became the formative idea of the project.

Formally, the design of the project became the design of field conditions in which a Cartesian system of modular elements establishes structure and boundaries of materials echoing the memory of the site are disrupted by a parasitic tectonic structure that moves and transforms portraying a world in a perpetual state of change. Geometrically, the design is seen as interplay between the Cartesian grid and deformed tectonic structure that disrupts and challenges the omnipresence of the Cartesian grid and launching towards the fourth dimension (Figure 5). The geometry of the tectonic structure is scripted by mathematics of space and time as demonstrated by Lorentz transformations, i.e. stretch and squash. More pertinently, the curvature and breaking of the structure is stirred chromo dynamics and lattice theory to calculate the rotation, coupling, and splitting of the various components of form. The interaction of the ideal vs. monstrous, script vs. form, and proportional vs. recursive produces a heterogenic masterpiece that acts as

frozen frame in a continuous process of variations. The in-between interior spaces become contour spaces freed from the constraints of historical reality and of any predetermined meaning and purpose, functionally ambiguous and conceptually open; they aim to expand the scope and depth of users' experiences (Figure 6). Moreover, these spaces are transformational; they show the transformation of one system to another.

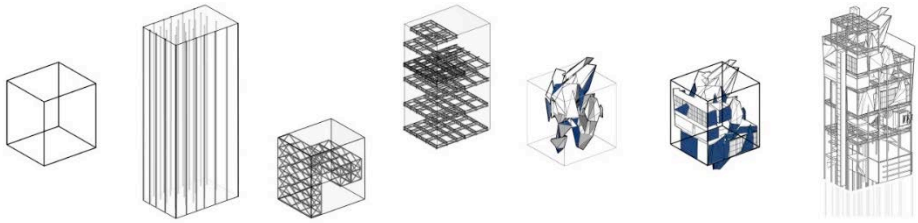

Figure 5. The formal manipulation of the two systems (conceptual form)

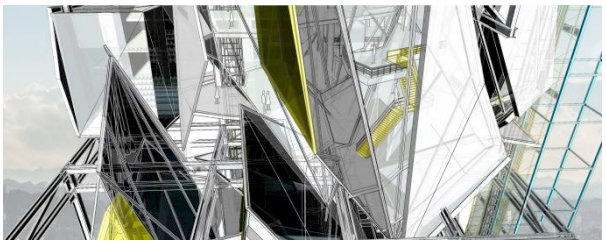

Figure 6. Interior spaces

Structurally, the Cartesian system is made up of modular columns and beams forming the main structure. This system of beams and posts is made of Architecturally Exposed Structural Steel (AESS). The parasitic system based on a lattice division that disrupts and challenges the Cartesian system is a kinetic structure that constantly evaluates its surroundings and reconfigures according to changing site conditions. The insertion and location of the lattice grows according to varying site conditions and functional needs bringing a dialogue of hierarchy and tectonics. The initial module of the lattice is made of flexible carbon tubes and holds elastic ETFE panels incorporating photovoltaic cells to generate electricity.

The overall design is a dynamic constructivist composition of ordered structure and splintered surfaces and twisted wiry forms creating a fantastical scene depicting an alternative world that glimpses into a parallel universe. This composition is not without merit; it is governed by the interaction of *faktura*, the particular material properties of an object, *tektonika*, its spatial presence and underlying laws of physics, chromo dynamics, and lattice theory.

5. Discussion

As can be seen from description above, the theoretical density and repleteness of the Bhāva can be made discrete through the application of the conceptual framework. The constituents of the framework provide an explicit and systematic review of specific concepts that form the bases of the design. They frame and structure the qualitative description and stipulate the type/s of representation/s needed to express it. Furthermore, the conceptual framework has two added values: firstly, the use of spatial form instead of function or utility shifts the focus towards the quality and geometry of space in terms of 3D volume and visual articulation as can be seen from the figures. Secondly, the transferal from aesthetics as appreciation of sensible characteristics of an object or as emotional response to these characteristics to the intellectual form of an object signifies an intellectual shift towards seeing beyond the sensible appearance and accessing the principles of creation and underlying logic through the application of intelligence. Accordingly, the description and generation of the project is more concerned with identifying its elements of design, their relationships and principles governing these relationships, than providing a description of the physicality of the project.

More importantly, if the description and analysis of the project was based on the Vitruvian triad alone, the concept behind the design of the project would not have been addressed. As we have seen, the concept of Bhāva guided the design of the house, structured the interaction of the intellectual, spatial and structural forms, and united them in the final form of the building. Through its main constituents, the framework answers the four basic questions pertaining to analyzing, synthesizing or evaluating any architectural work: what a building does and the logic of it spatial organization, how a building is physically constructed, how a building is intellectually, i.e. formally structured, and why a building took its final form and under what conditions.

6. Conclusions

This paper proposed a conceptual framework for understanding architectural works. The conceptual framework made up of a spatial form, intellectual form, structural form, formative idea and context, bridges the gap between the different domains to present a structure of different concepts making up an architectural work and enables the understanding of ‘what’ a work of architecture is. The main thrust of this framework is that it expands the traditional triad of *venustas*, *firmitas*, and *utilitas* of ‘what’ architecture is, which deals with what to design, how to design it and how to construct it, to

include how to conceptually think about it, and reintroduces context as an integral concept in understanding 'what' a work of architecture is.

This framework, through the clarification of concepts, depicts the underlying status quo of an architectural work and enables its communication between interested communities. By explicating the status quo, a platform is offered for structured debate concerning the nature of architecture and architectural works. Further, shortfalls within existing bodies of knowledge can be depicted accordingly, opening up venues for further reflection and investigation. Such a framework is of a pedagogical value where it can be used as a priori framework supporting architects in the conceptual stages of design, as can be seen from the presented case study. Furthermore, it can act as a posteriori framework that can be used in architectural analysis and criticism through providing a systematic description and interpretation of built works of architecture. In that sense, it can be used as a didactic tool whether in teaching in design studios or in the field of architectural morphology.

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