Notes on Architectural Design

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Abstract

Design has so many levels of meaning that it is itself a source of confusion. The word design is used as a noun and a verb at the same time showing differences in meaning: when it is used as a noun, it refers to the end product; and when it is used as a verb, it refers to the activity of design itself. It also implies a systematic or intensive planning and ideation process prior to the development of something or the execution of some plan in order to solve a problem (Smith and Ragan, 2005).

This article aims to review literature about what design is and different design models. It starts with a brief discussion about design as a term, and then looks at three major design paradigms (design as problem solving, design as conjecture, and design as abduction). In conclusion, we cannot identify a single model that covers all ideas and issues in design, and that it is not simply about satisfying the pragmatic requirements of form. However, creativity can be found in every design model, if not in the apparent form of a distinct creative event, then in the development of a unique solution.

Keywords: design, architectural design, problem solving.

1. Introduction

It is not an easy task to find a clear definition for design; the word design itself is problematic (Heskett 2002). Therefore, in order to define design from an architectural point of view, one must have a clear understanding of the term itself and why it is needed.

John Heskett (2005, p. 3) emphasizes the difficulty of defining design in his book *Design: A Very Short Introduction,* as it is a word that can be used as both a noun and a verb, by saying, "Design is to design a design to produce a design." which highlights the problem with trying to define the term.

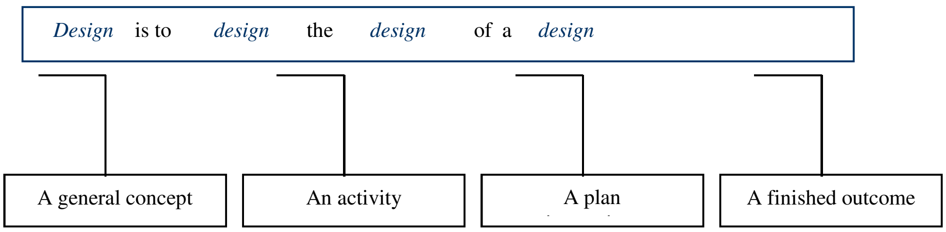

Figure 1: Design Definition According to John Heskett (2005)

According to the Oxford dictionary, design as a verb is: "Do or plan (something) with a specific purpose in mind." Webster dictionary also provides a primary modern meaning for design as: "To create, fashion, execute, or construct according to a plan."

Design as a noun is: a "Plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is made."

The verb "design" comes from the Latin word *designare*, the Latin prefix *de* and the Latin verb *signare*, which means "to mark", "mark out", or "sign" (Terzidis 2007). What might be useful, is understanding the meaning of the Latin word *disegno*. On the one hand, it might mean "drawing", "creativity" and "design", and on the other, it could also be considered a"draft of a creation" (Chuko et al. 2007). The meaning of the word changed a lot and held several meanings, therefore becoming a rather confusing term.

Similarly, the noun "design" comes from *signum*, which is not really linked to the modern root of the word "sign" (as in symbol, mark; semantics, semiotics, etc.) as it is sometimes claimed. It rather has the meaning "of something that you follow, in the sense of the specifications passed on from architect to builder" (Kockabiyik 2004). In that context, the word "design" is about the derivation of something that suggests the presence or existence of a fact, condition, or quality (Terzidis 2007).

Other definitions of design include:

- "The ability to imagine that which does not yet exist, to make it appear in concrete form as a new, purposeful addition to the real world" (Nelson and Stolterman 2003, p. 9).

- "Design is the human power of conceiving, planning, and making products that serve human beings in the accomplishment of their individual and collective purposes" (Buchanan 2001, p. 9).

- "A systematic or intensive planning and ideation process prior to the development of something or the execution of some plan in order to solve a problem" (Smith and Ragan 2005, p. 4).

- "Design is an optimized solution for the collection of real necessities in special situation" (Lawson 2006).

Archer (1976) and his colleagues from the Royal College of Art (RCA) identified design as the missing segment in education to be introduced alongside Science and the Humanities. They believed that design is "The collected experience of the material culture, and the collected body of experience, skill and understanding embodied in the arts of planning, inventing, making and doing". (p. 9)

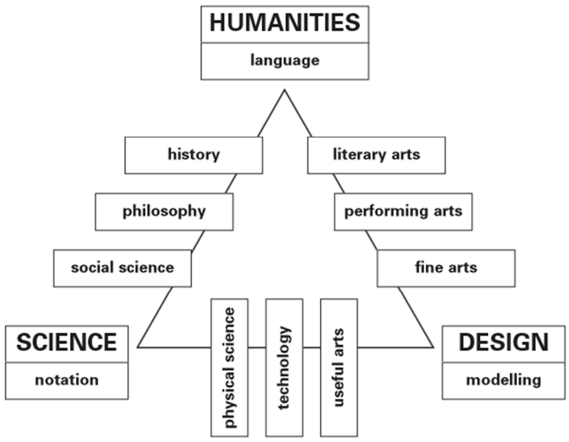

Figure 2: Proposed Relationships between Humanities, Science, and Design
Source: Archer (1976)

Similarly, Cross (1982) recognized the third culture of design in addition to the two dominant cultures of science and humanities, where one studies the phenomenon of the "natural world" in the sciences, the "human experience" in humanities, and the "man made world" in design. Therefore, design is the result of the interaction between the "natural world" the "man made world" (p. 222).

From the definitions above and what has been discussed previously, it is obvious that there is no shared understanding of what design is. Added to that, it is clear that there is no single definition that covers all the ideas, characteristics, or principles of design.

2. Why Do We Design?

It is human nature to want to create new meanings, new forms, and new realities in our man made world as an interaction between the natural world and our design will (Nelson and Stolterman 2003). We are motivated to design due to feeling a lack of wholeness; we do not see the world in a satisfying or fulfilling condition. We want to make the world our world, to bring order, and give meaning to our lives. Everything we have around us; from environments to clothes, furniture, machines, and even food, has been designed. Therefore, the quality of their design affects our quality of life (Cross 1990). Designers from different design fields formally defined or not, can relate to other designers since they all are striving towards the same goal; they are hoping to "add to", or "change", the real world. Thus, it can be said that design is a "creative act" since it aims to produce something that does not already exist (Kilicaslan and Ziyrekb 2012).

Italian author Marzona (1993) argues that design is a political statement that decides the direction the world moves towards. In his own words, "Design is a political act, and we need to become conscious of our political clout and significance. Every time we design a product, we are making a statement about the direction the world will move in" (Döngel et al 2009, p. 2349). This means that design continues to expand in meaning and connections, revealing unexpected dimensions in practice as well as understanding.

Table 1: Purpose of Design According to Nelson and Stolterman (2003)

To improve, develop, thrive, evolve and survive.
To serve others.
To make something of lasting quality.
To create something of real consequence.
To participate in the never-ending genesis.

However, design originates as a response to a problem statement provided to the designer by someone else. This problem statement, which is known as the "Design Brief", has no clear way of proceeding to the statement of solution other than through design (Cross 2000). Accordingly, design in both forms, verb and noun, represents the act of finding a suitable answer to a certain problem, and that the design act itself is not limited to one particular field. Whereas, the answer to this problem may not be definite or well-defined, as design is always intentional and never accidental (Ralph and Wand 2009). However, it should not be interpreted as a requirement that a design answer is —or can be— formally or explicitly articulated.

3. What is a Design Problem?

Problem has been defined in many ways. One simple yet meaningful definition describes a problem as "A need which must be met" (McCade 1990, P. 1). It is also defined as "the difference between the current state of a problem and the desired goal." (Nagai and Taura 2006). Thus, the process of developing a solution toward the desired goal is synonymous with the design activity.

According to the Webster dictionary, "Problem" can be defined as:

- A question rose for inquiry, consideration, or solution.
- A proposition in mathematics or physics stating something to be done.
- An intricate unsettled question.
- A source of perplexity, distress, or vexation.
- Difficulty in understanding or accepting.

David Jonassen (2004) in his book *Learning to Solve Problems* described the problem as "An unknown entity in some context," (p. 3) and accordingly, finding or solving the unknown must have some social, cultural, or intellectual value. Here we can identify two types of problems; the most common type of problems that students solve in schools and universities are "well-structured" since the start, the goal, and the process are well specified. While other problems are considered "ill-structured," because the start, the goal, and the transformation process are unspecified (Goel 1992).

In Reitman's (1964) view, problems are defined by a set of initial characteristics. Hence, a problem is well-defined if the problem solver has access to a complete set of problem requirements and all the relevant concepts, terms, or problem components. If one or more of these components are unspecified, then it is considered ill-defined. In other words, the absence of one component or more in a problem guarantees that no solution will be universally accepted (Lynch et al 2009).

Accordingly, a design problem that is ill-structured, is not clear at first, and rarely expressed in a thorough and comprehensive manner (Lawson 2004). In that sense, problems in architectural design are ill-defined (Reitman 1965), ill-structured (Simon 1973) and wicked (Rittleand Webber 1973). Table 2 summarizes the characteristics of these problems.

Table 2: Ill-defined, Ill-structured, and Wicked Problem Definitions

Ill-defined	W. Reitman (1964,1965)	A problem whose solver couldn't access a complete description of the problem requirements, all the relevant concepts, terms, and components. If one or more of these components are left unspecified**.**	1. The absence of one component or more. 2. No solution will be universally accepted.
Ill-structured	H. Simon (1973)	A problem whose structure lacks definition in some respect.	1. The problem space is too large. 2. The possible solutions cannot be counted. 3. The possible solutions cannot be objectively evaluated.
Wicked	H. Rittle & M. Webber (1973)	A problem that is difficult or impossible to solve for reasons; with no definitive formulation. Its solution can be only good or bad, not true or false.	1. No definitive formulation and no stopping rules. 2. Solutions cannot be true or false, only good or bad. 3. There is always more than one possible explanation. 4. No formulation and solution has a definitive test. 5. Every wicked problem is unique.

4. Design Models

4.1 Design as Problem Solving

Design in its essence is a problem solving activity (Stojcevski, 2005). It involves recognizing an unsatisfactory situation that needs a "certain improvement," in addition to "…the data collection, experimentation," and "development" necessary to reach the design stage (Lawson, 2004). Therefore, problem solving is based on a previously given requirements, and based on previously understood principles of form and function in order to satisfy a "design program" (Peponis et al., 2002)

However, Herbert Simon (1969) in his book The Sciences of the Artificial proposed applying this rational approach to the sciences of the artificial to economics as well as engineering, but not design. Simon claimed that the Natural Sciences are concerned with "how things are," whereas Design Practice is concerned with "how things ought to be" (Visser, 2010), and proposed filling the gap between them with a Science of Design.

This concept of Design Science was defined for the first time In Sidney Gregory's paper Community and Privacy: Toward a New Architecture of Humanism, where design is interpreted in ways similar to those in which science is interpreted (Cited in Bayazit, 2004). Here, design science is seen as a pattern of problem-solving behavior employed in finding out the nature of what exists, and its values are rooted in the notions of objectivity and rationality (Cross, 1981).

In this manner, design as problem solving is used when design ends are relatively well defined at the beginning of the design process, and design solutions are mostly informed by precedent, habit, or convention (Peponis et al., 2002). It aims to satisfy a set of 'pragmatic functions' such as use, function, and performance with previously established principles of form and function (Peponis, et al., 2003).

The Analysis/Synthesis model has been identified as an example of the problem solving model (Trebilocock, 2009). This model can be simply described as "breaking the problem into pieces", "putting the pieces together in a new way", and "testing to discover the consequences of putting the new arrangement into practice" (Cross,1981). By breaking the problem into pieces, one states the objectives, and by putting the new arrangement together we are attempting to move forward, create a response to the problem, and evaluate the suggested solutions against the objectives. It is reasoning from the general to the particular (Trebilocock, 2009).

Jones (1984) defined three stages of analysis-synthesis model as follows:

1. "Analysis": Listing of all design requirements and then reducing them to a complete set of logically related performance specifications.
2. "Synthesis": Finding possible solutions for each individual performance specification and building up complete designs accordingly with the least possible compromise.
3. "Evaluation": Evaluating the accuracy with which alternative designs fulfill performance requirements for operations, manufacturing, and sales before the final design is selected. The purpose of any method of evaluation is to detect errors at the stage that they can be corrected at the lowest possible cost, which is also the stage at which the increasingly expensive processes of drawing, manufacturing, selling, installing, and using do not have to be repeated in order to make the necessary adjustments. The traditional method of evaluation of engineering designs is by judgment and reference to the experience of engineers.

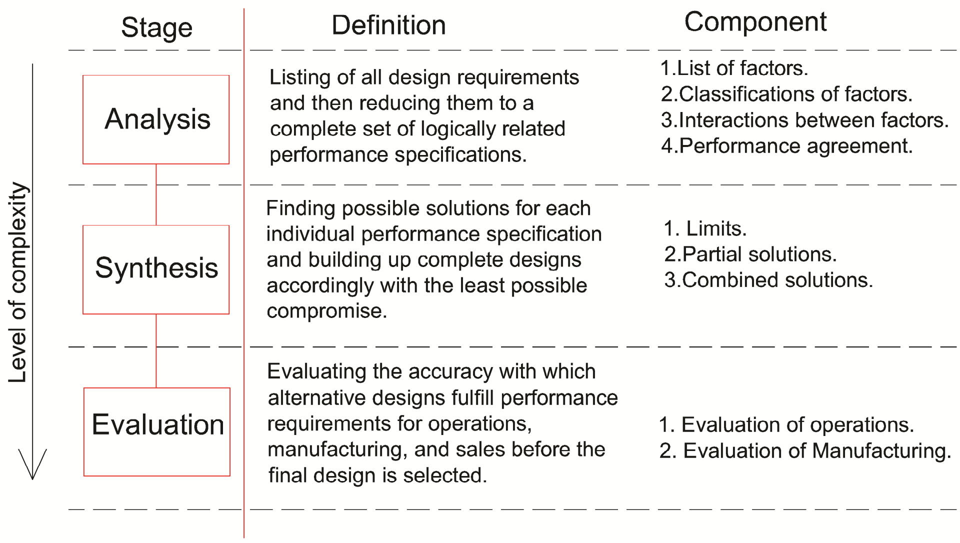

Figure 5: The Analysis–Synthesis –Evaluation Model
Source: redrawn by author after Jones (1984)

A more detailed prescriptive model was developed by Archer (Cited in Cross, 2000), where a three-phase model was suggested; the "Analytical-Creative-Executive model". The previous analysis- synthesis model belongs in the creative phase, which requires interaction with the world outside the design process. He pointed out that in practice, these stages are confused and overlapping, which may take us back to earlier stages of the process.

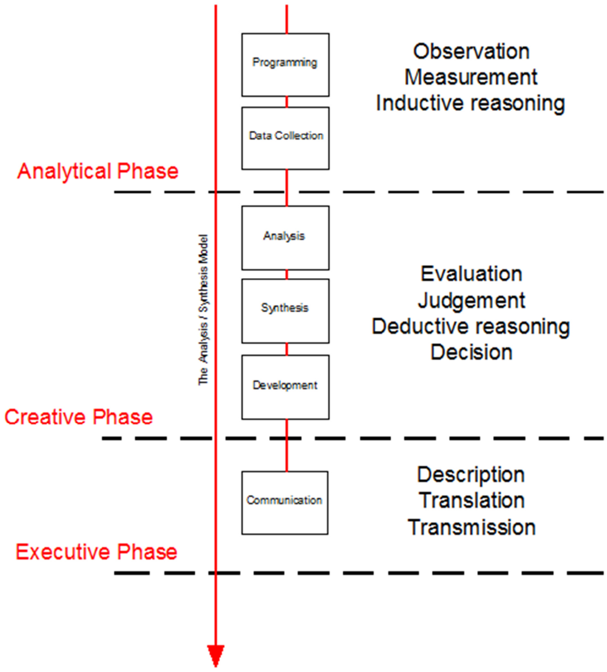

Figure 6: Archer's Three-Phase Model of the Design Process

Source: Redrawn by Author

Cross (2000) clarified that procedures as clear-cut, sensible, and rational as this one are not always followed in design, and that the design is not actually this linear. Regardless of where designers begin, there are feedback loops shifting between different parts of the process. Moreover, work in one part of the process may affect the work in another. Therefore, the approach of problem solving can only be applied to well-formed problems already extracted from situations of practice, such as engineering, mathematics, and puzzles (Dorst, 2003).

Moreover, in this approach design activity aims to find a solution, not come up with a single unique or best solution, and does not cover all the design problem features. Architectural design, however, requires considerable amounts of knowledge beyond what is stated in the design problem. Consequently, design as problem solving is not the best model to understand design if we expect designers to do more than just solve problems well, but also be innovative and add an element of surprise.

4.2 Design as Conjecture

Another approach to design was based on the philosophy of science; that science cannot progress without conjecture. This idea can be traced back to Popper's (1963) Conjectures and Refutations, where an honest scientist would rather than trying to prove his hypothesis must write it down and tries to test it in order to destruct it. If the hypothesis cannot be refuted and could helps us predict something, then it is a theory until a better one comes along.

This idea of design as conjecture started to gain popularity in the early 1970's when Hillier et al. (1972) in Knowledge and Design proposed following Popper's model of scientific method called the "Analysis-Conjecture-Test Model", instead of the old "Analysis-Synthesis Model."

Hillier et al. (1972) believed that conjecturing solutions early on in the process helps with understanding a design problem, which is based on Popper's idea that constructing hypothesis or conjecturing is essential to inquiry and that there is great virtue in making mistakes. Moreover, they explained that conjectures can appear out of nowhere, and that it is irrational to exclude them just because they are not derived from the data by induction. However, they made it clear that this model is not systematic, less rational and depends on how the designer pre-structures the problem. They argued that design was "…essentially a matter of pre- structuring problems either by a knowledge of solution types or by a knowledge of the latencies of the instrumental set [technological means] in relation to solution" (p. 7).

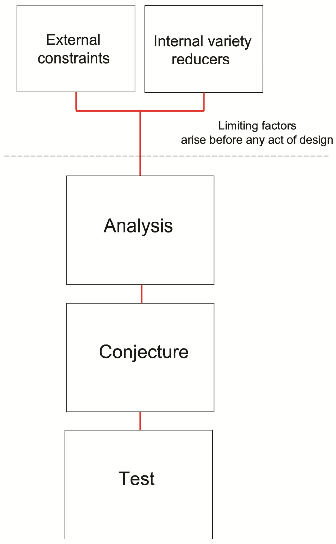

Figure 7: The Analysis-Conjecture-Test Model
Source: Redrawn by Author after Hillier et al. (1972)

In other words, conjectures, which are based on previous knowledge, help the designer to structure the vast problem space in order to narrow it down, thus making the solution space more attainable. As more data is gathered and brought into the design process, as conjectures become more defined as more data is collected and the conjecture is tested (Dahabreh and Abu Ghanimeh, 2012).

But how can we reduce the number of conjectures during the design process?

Broadbent (1988) also stated in Design in Architecture that a good architect ought to operate as much as Popper’s honest scientist is supposed to. For that reason he identified four “types of design” from which architectural conjectures are made: ‘Pragmatic’, ‘Iconic’, ‘Canonic’, ‘Analogical’, and another five attributes (questions) for which these conjectures can be refuted

According to Hiller et al (1972), the variety of possible solutions is already reduced before any conscious act of designing begins by two sets of limiting factors. The first set is external to the designer (external variety reducing constraints), such as the client's desire for a particular design, and the second is internal (internal variety reducers), like the availability of technological means, cost, etc. These internal reducers are an expression of the designer's cognitive map, which he uses to structure the problem in a way that he can work with and solve. Its role is similar to the role of theory and theoretical framework in science.

Darke (1978) proposed an elaboration of the “Conjecture/Analysis Model” by including a concept called the primary generator, where the design process is a three-step process, consisting of a Primary Generator, Conjecture step, and Analysis step. The primary generator is an expression of what is valued, it is a concept or objective that helps generate a solution, and is a component of the designer’s cognitive structure (cited in Trebilocock, 2009). It narrows the search space and generates early solution conjectures (Cross 2000). Therefore, it is usually helpful in achieving a better understanding of the problem formulation.

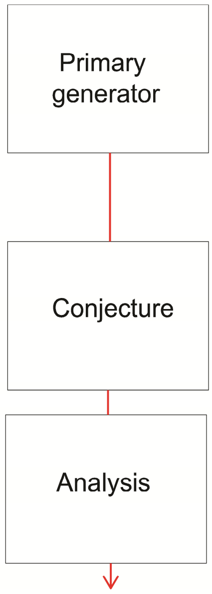

Figure 8: Darke's Primary Generator Model
Source: Redrawn by Author

In addition, Cross (2004) highlighted the fact that architects tend to use solution conjectures as a means of developing their understanding of the problem. These conjectures, which are used to create meaningful forms, are formed by image banks of personal experiences and professional knowledge (Hegeman, 2008). Furthermore, it is also obvious that designers don’t address design issues objectively, they bring their own prejudices and concerns into the design process to generate solutions (Dahabreh, 2006).

However**,** not all possible patterns of conjectural thought are rationally defensible or (would be) employed by designers. Hiller et al. (1972) made it clear that this model is not systematic and so much depends on how the designer pre-structures the problem. Furthermore, one can see that conjectures do not necessarily appear from the design information, they can brought up by an analogy , or a metaphor, or simply of what is called inspiration (Ibid.).

Moreover, Peponis (2005) explained that the conjecture-analysis model falls short in describing what happens during a design process, that is, it only addresses known solution types, and it does not explain the interaction between the design brief and the design charge, and thus, how the final form of the building is created.

4.3 Design as Abduction

The philosopher Peirce (1903) defined abduction as an attempt to identify potential solutions to problems based on the information available through the logic of conjecture. These conjectures, which were obtained via abduction, will be selected via induction on the basis of the testable consequences obtained by deduction (cited in Levi, 1997).

This idea of “Design as a hypothesis that can be tested” compliments March’s idea of “Design as abduction,” and the idea of the “Primary Generator” that Lawson developed after Darke. The designer comes up with a basic idea for a solution and the form it can take. After that a crude design is generated based on the idea, which is then tested against design requirements, goals, constraints, etc (Din, 2008).

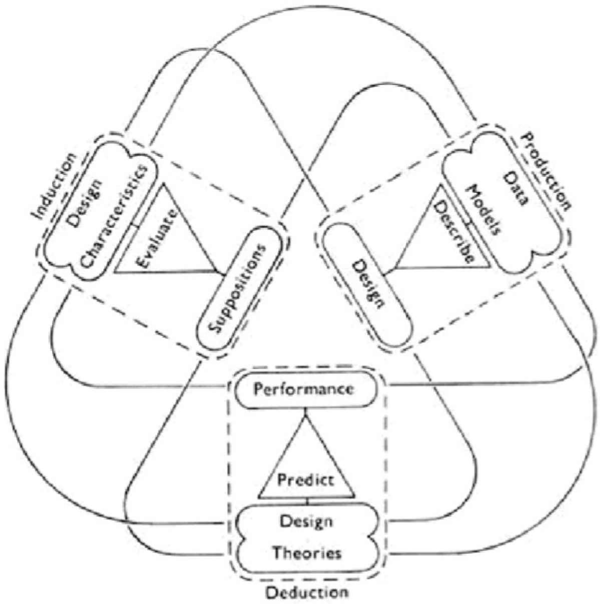

Figure 9: March's PDI Model after Peirce's Mode of Inference
Source: Din (2008)

This means that problems cannot be fully understood without considering a solution as a means of helping explore and understand the problem formulation. In other words, both design problems and design solutions have to be developed side by side. Moreover, it is difficult to formulate a design problem without referring to a solution concept (Cross, 2000).

The major difference between design as abduction and design as conjecture is that the former is based on previous knowledge and therefore it only addresses known solution types, while the latter generates new knowledge and brings it to the design (Reichertz, 2004) and therefore abduction is able to make new discoveries in a logically and methodologically ordered way.

5. Conclusions

In summary, it is clear that we cannot identify a single model that covers all ideas and issues in design, and design is not simply about satisfying the pragmatic requirements of form. However, creativity can be found in every design model, if not in the apparent form of a distinct creative event, then in the development of a unique solution. With design problems, as in many real-world situations, there is no immediate feedback from the world (Goel 1992), and there is no way to decide when a design problem has been completely solved. Architects stop designing when they run out of time or when, in their view, it is not worth pursuing the matter further (Lawson 2004).

The complex nature of design problems implies that no correct formulation can be known until a solution is accepted, and the solution should be located within the frame the designer uses. Schön, however, does not address the question of *how* a frame is made or what properties make up a good one. Design as formulation reduces the 'wickedness' of architectural problems and offers new possibilities where form is creatively constructed by refining problems to develop a solution. Accordingly, design is transformed from the routine to the creative. Accordingly, it is obvious that we need in future studies, to develop a framework for design by structuring the relationship between *architectural knowledge*, *form*, and *concept*.

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