Nature of Design from an Architectural Point of View

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1. Introduction

This article characterizes the constructive nature of design in terms of a model of design process, the classes of features of the things involved in design, the nature of law, polysemic dualities in design, and scientific inquiry[+1] . Some examples are given from a point of view of architectural design.

Whatever an activity of design would be, a certain thing is produced in an environment as the result of the activity and a certain phenomenon is promoted as the consequence of the interaction between the product and other things in the environment. The user of the product is one of the other things. We call a thing that is produced with the purpose of promoting something as an artifact. An artifact doesn't exist without the activity of generating it. An artifact is generated by making or performing a thing as well as by giving significance to the thing. One of the essential significances is to change existing situations into preferred ones [1]. By definition, an artifact cannot be independent from such kind of significance. However, the made or performed thing is not necessarily new one. An existing thing could be a new artifact if certain significance is given to the thing. For instance, a cave became a house, which is the artifact providing a place for living, when our ancestors settled there even though it has been naturally made and already existed before the settlement. Our ancestors practically generated a house by living in a cave. They gave meaning as a place for living to the cave by actually living there.

2. A Model of Design

The notion of design refers to an activity of forming a new schema coupling things and its assigned significances as well as of embodying the schema in a certain artifact, concurrently. A schema describes the constitution of an artifact, the mechanism how the artifact brings about certain situations, and the course of events where the artifact is embodied. Beliefs about the nature of law related to the things are employed to determine the features of the schema and those of the artifact. The immediate products of design are a new schema and an artifact as an instance of the schema. The indirect products of design are the expected phenomena as instances of the given significance and the unpredicted phenomena as secondary effects. The secondary effects could be either favorable or not. If the effects are favorable then they may be expected explicitly in the succeeding design. If not, the schema and the artifact are improved so as not to bring about such phenomena.

An image of design is depicted in Fig.1. Design is the combination of generation and analysis. The two processes are performed sequentially or synchronized with each other. In generation, a scheme of the artifact that is expected to have the potentiality to change the current situation into preferred one is formed. Generation produces a course of actions to embody the artifact, too. In analysis, it is predicted what if the artifact is embodied and implemented in a particular environment to let the artifact interact with the environment. The beliefs about the nature of law are used as grounds for the prediction. If it is convinced that the artifact has the expected potentiality based on the consequence of prediction then design finishes. A course of action to change the current situation into preferred one is determined. If not, the schema of the artifact and some beliefs are modified to fill the gap between the preferred situation and the predicted situation. The figure emphasizes that the products of design are not only an artifact but also some phenomena brought about by using the artifact.

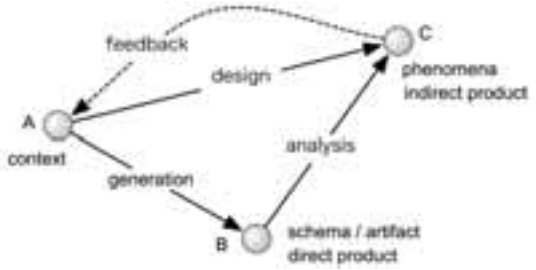

Fig.1. An Image of Design

Design is constructive. The crucial nature of design is that a new schema has to be formed on the basis of the current

[+1] Hideyuki Nakashima discusses constructive design process in this special issue.

beliefs and hypotheses about the nature of law. The beliefs and hypotheses are constructed without the new schema. They will probably be modified when the interactions between an artifact with the schema and its environment are analyzed. If the schema is not consistent with the modified beliefs, the schema loses some of the grounds. It is hard to consider all of important aspects prior to generation. Some aspects that have not been noticed are found to be important through the interaction. Therefore, the concurrent cycle of generation and analysis is repeated until design is almost completed. This means that design is constructive and has dialectic nature.

3. Features of Design Objects

We assume that a thing is differentiated from the other things by its features. The features of a thing define the characteristics of the thing. A thing is identical to the thing whose features are entirely the same. A thing and another thing are different from each other if some features of the former differ from some features of the latter. On this assumption, a process of design is formulated as a process of making the features explicit.

The features are classified as proximal features or distal features depending on the level of the granularity, scale, and abstraction adopted for the observation of the thing that has the features. The classification is relative since the level for the observation changes. A proximal feature is the feature that articulates a distal feature. A distal feature is the feature that emerges as an appearance of the unified totality of proximal features. The proximal features are recognized as the constituents of the distal feature, but the distal feature cannot be explained completely in terms of the proximal features. For example, the comfortableness of an architectural space could be a distal feature whose proximal features are the thermal comfort of the space, the safety from fire, earthquakes, and intruders, the usability, the beauty, and so on. The thermal comfort of a space could also be a distal feature whose proximal features are the temperature, the humidity, the wind velocity, the metabolic ratio of the occupant, and so on.

The features are also classified accessible features, controllable features, inaccessible features, or emergent features depending on the level of accessibility to the features. We assume that a feature can be directly determined or controlled in design if it is perceived as a proximal feature. A feature can be determined directly in the sense that it can be specified whether a schema, an artifact, or a phenomenon in question has the feature or not. We call such a feature as an accessible feature, or A-feature in short. A feature can be controlled in the sense that it is possible to specify the feature indirectly but conclusively by determining other features. We call such a feature as a deducible feature, or D-feature. It is presupposed that an A-feature and a D-feature have a causal relation that an A-feature is the cause of a D-feature. For example, the material, the shape, and the dimension of a wall of a building are A-features since they can be directly determined. The heat conductance and the heat capacity of the wall are D-features since they are conclusively specified if the material, the shape, and the dimension of the wall are determined. An inaccessible feature, or I-feature in short, is a feature that cannot be determined, controlled, or affected. An emergent feature, or E-feature in short, is the feature that emerges as an appearance of the unified totality of A-features, D-features, and I-features. Those features can give influence on the E-feature. The thermal comfort of a space can be affected by controlling the temperature by determining the structure of the walls of the space. An E-feature, here, is a distal feature whose proximal features are the A-features, D-features, and I-features. As it is relative to observation whether a feature is proximal or distal, a feature seen as an E-feature in an observation can be seen as an A-feature, D-feature, or I-feature in another observation.

Two types of classifications construct a hierarchical structure of the duality of proximal features, i.e., A-features and D-features, and distal features, i.e., E-features. Fig.2. depicts the hierarchical structure.

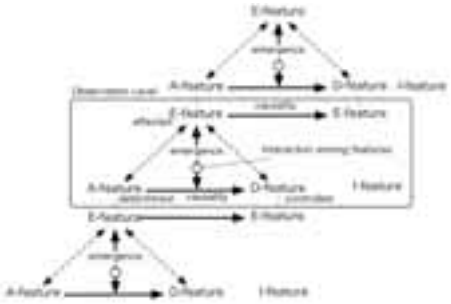

Fig.2. Hierarchical Structure of Features

It is often the case that the significance of a thing being designed is described in terms of E-features promoted by the thing. In design, A-features are determined directly and D-features are controlled under the constraints described by I-features in the expectation that the E-features emerge upon the interaction among the features. An artifact is specified in terms of A and D-features. The significance of the artifact is described

in term of E-features. The schema embodied by the artifact is described as the relation among A, D, I, and E-features. Design explores the specific features towards the preferred situation as well as the relation among the features. A process of generation in design is formulated as a process where relations among features are assumed and A-features are determined with respect to the relations. A process of analysis is formulated as a process where D-features are deduced from the A-features and it is predicted, on the basis of the relations assumed in generation, whether the expected E-features emerge upon the interaction among the A-features, the D-features, and the I-features or not. The assumption about the relations is modified to fill the gap between the prediction and the expectation in the succeeding generation process.

4. The Nature of Law for Design

A process of forming a schema and embodying it as an artifact is not an arbitrarily or randomly performed activity. All of A-features are not determined arbitrarily or randomly. Some A-features are determined on certain grounds. The relations among the features derived from the nature of law are consciously applied to form a schema with the conjecture that an artifact with the schema facilitates the expected features. It is essential for the success of schema forming to refer the nature of law that governs the features. It is preferable but not necessary to know what exactly the content of the nature of law is [2]. It is important to do something with he consciousness of existence of the nature of law. The nature of law could be subjective, or private, in the sense that it represents personal understandings of the world formed through the experience. It is not necessary that the nature of law is objective or public in the sense that it is verified in a so-called scientific manner, either. Even though it is subjective or private, it plays an important role to define the direction of design. To form a schema is to construct the hypothetical relations among the features. The hypothetical relations should be consistent with the relations among the features that are governed by the nature of law. We assume that the objective type of the nature of law navigates the designer towards a rational direction and that the subjective type of the nature of law navigates the designer towards a creative direction.

The nature of law is expressed in some ways. (A) Some laws are expressed in the form of an equilibrium governing A-features, D-features, and I-features. The features must be in the same proximal level. A distal feature is not expressed in the equilibrium since a distal feature is defined as the feature that cannot be described by its proximal features completely. Formal and scientific knowledge is expressed in this form. Heat balance and dynamic system are expressed as equilibriums. (B) Some laws are expressed as qualitative or quantitative causalities between two things. A thing is expressed as the cause of the other thing, or a thing is expressed as the effect of the other thing. Procedural knowledge, which couples means and ends and is applied to plan a course of actions in generation, is expressed in this form. The relations between the emergent behavior of a system and the behavior of the constituents of the system are also expressed in this form. At least one of the two things can be an action. When an action is the cause of the other thing, the thing is the result or consequence of the action. When an action is the effect of the other thing, the thing facilitates the action. Proximal features as well as distal features can characterize the things involved in this form of expression. Therefore, vertical causality [3], which bridges different conceptual levels, is expressed in this form. The notion of vertical causality refers to the causality among the features in the different conceptual level. The relations among the proximal features controlled directly and the distal features brought about as the consequence of the control are expressed. (C) The rest of the nature of law is tacit and not expressed explicitly in the forms described above. It could be expressed implicitly in a narrative form. Intuitive beliefs about the nature of law, which determine which features should be focused in design, cannot be expressed in the form of either equilibrium or causality. The focused features are important to determine the direction of generation and analysis.

5. Polysemic Dualities

The discussion above suggests that there are polysemic dualities in design. Design aims at producing a schema and an artifact as well as promoting a certain phenomena as the significance of the artifact. The significance is evaluated from a practical point of view concerning whether existing situations can be changed into preferred ones as well as from a theoretical point of view concerning how the relations between the artifact and the phenomena are understood on the basis of the nature of law. Design applies the nature of law for generation and analysis as well as constructs the nature of law in generation and analysis. The schema associating an artifact

with the significance is formed with respect to the nature of law as well as the nature of law is modified constructively to understand the consequences of forming the schema. The proximal features as well as the distal features describe the things involved in design. It depends on the conceptual level of observation if a feature is proximal or distal. The dualities of the proximal and the distal features organize the hierarchical structure corresponding to the levels of observation. Design produces an individual schema as well as a general schema.

A schema defines the composition of an artifact, from which artifacts in the same class are embodied, and formulates the mechanism underlies emergence of the expected situations upon the interaction between the artifact and the environment. A schema is individual in the sense that it is formed so as to fulfill particular expectations in a certain context. A schema is general in the sense that it is possible to apply the schema to different contexts so as to produce similar individuals that fit the contexts. The individuality and the generality are mutually necessary even though they vary in accordance with interests in design on which the emphasis falls. A general schema is an abstraction of the interested features from an individual schema. The significant features of interest are selected for the abstraction. The general schema should be transmitted to instantiate other individual schemata. Adding some features to the general schema in accordance with the context where the individual is being formed forms an individual schema.

6. Design as Scientific Inquiry

We model a process of design in terms of the forms of inferences, i.e., deduction, induction, and abduction. Peirce [4] modeled a process of scientific inquiry as cycles of abduction, deduction, and induction. We will see that the model of a design process is similar to that of scientific inquiry if we focus on the forms of inferences employed in scientific inquiry and design .

(Step-0) Every design is motivated by the consciousness of one's will to produce an artifact so as to promote preferred situation. An exploration into the schema that realizes the will begins. (Step-1) The designer imagines, based on the past and present experiences, how the situations will change if a certain schema is embodied. The designer invents some hypotheses that shall fulfills the will, and selects the one that seems promising. A schema that is consistent with the hypothesis is formed. There is no logical way to invent or select the most plausible hypothesis and to design the consistent artifact. (Step-2) The designer predicts the conditional experiential consequences that would be logically or probably derived in accordance with certain inference rules if the selected hypothesis were true and the schema were embodied. (Step-3) The designer actually embodies the schema and verifies how far the predicted consequences are consistent with the experiential observations as estimating the proportion of truth of the hypothesis and judges whether the schema and the hypothesis are sensibly correct, or require some inessential modification to fulfills the intention, or must be rejected. (Step-R) Step-1, 2, and 3 are repeated until the designer forms the schema that enables the preferred situation.

Either abduction or induction doesn't have logical inference rule that guarantees the truth of the consequences in spite that deduction does. Therefore, the success of design as well as scientific inquiry depends not only on the procedural schema like the rules of deductive reasoning but also on the heuristic capacities to be employed to select the most plausible hypothesis, to classify the empirical observations, and to imagine a course of action towards the goal.

7. Summary

We characterized the constructive nature of design in terms of a model of design process, the classes of features of the things involved in design, the nature of law, polysemic dualities in design, and scientific inquiry.

Acknowledgment

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