Designing Representations, Affecting Reality: a Meta-Model Proposal to Address the Question of Design Epistemology from the Perspective of Cognitive Science

Andrea ZAMMATARO
Department of Architecture, Built Environment and Construction Engineering, Politecnico di Milano
Milan, MI 20133, Italy

ABSTRACT

The paper concerns representation intended as abstraction of a model from reality through perception. The relation between reality and its model is a key issue to design because while the project is thought on models, it always affects reality, and this epistemological gap is the reason for many design failures.
In particular, models are adopted in top-down approaches to abstract only what decision-makers consider useful information to pursue their objectives. The bottom-up approach, instead, adopts as model reality itself intended as the total set of physical stimuli passed intact to agents which react by spontaneously transforming their environment.
This approach lacking representation proves itself automatically reflexive and contingent. Nevertheless representations which make top-down approach strategic make it also rigid and vulnerable to changing conditions.
The present paper outlines a research path to solve this contradiction by positing that the two approaches are not mutually exclusive but the extremes of a scale which can work as meta-model to regulate the relationship between reality and model in design activity, thus defining an intermediate design object which would determine neither a passive nor an active role of the subject with regard to his environment, but a reciprocal encounter at the phenomenal level.

Keywords: Design Epistemology, Design Uncertainty, Representation, Top-down Approach, Bottom-up Approach, Affordance.

1. INTRODUCTION: ADDRESSING UNCERTAINTY BY DESIGN

Representation is the main tool used in every domain to grasp those aspects of reality which are interesting in relation to a certain problem that must be addressed by any design activity: the resulting selective abstraction is called model and on the basis of this model a design decision is made. Nevertheless, there are problems which can be constructed from several points of view, usually complementary ones. These problems are called ill-defined [13]. In its common use the term identifies a particular kind of problem, mostly concerning complex situations involving several stakeholders both spatially and temporally, each of them bearing his particular point of view, which is also open to future evolution. But uncertainty can be considered a condition of contemporary design activity in general, as the designer is provided with many alternatives due to the increased availability of design approaches and technical tools to meet requirements. Finally, the promotion of indeterminacy in the first steps of the design process, even when dealing with potentially well-defined problems, can be a methodology to envision unexpected possibilities which could not be considered from a specific perspective eventually adopted from the beginning [1].
A different type of representation is therefore needed to encompass all the possible perspectives entailed by ill-defined problems in an inclusive rather than selective way, contrary to what normally occurs in the case of scientific models. Of course, the paper does not aim at criticizing modelling as a scientific tool: the question is rather if models which proved to fulfil scientific problems can also fulfil design ones, and this paper posits that the answer is negative. Indeed, since science adopts the logic of 'what-is' while design adopts the one of 'what-is-possible', scientific models are meta-representational, i.e. communicational representations of a cognitive representation of the world, while design models should be pro-presentational, i.e. representations of what does not exist yet but which possibly might exist. What kind of model can represent what could virtually exist in the nexus of possibilities wide open in front of the designer?
The paper suggests that such a kind of representation would not be purposed in order to prevent the adoption of a single perspective looking at a specific trajectory and would consequently question the idea of representation as model itself. This representation would constitute an epistemic boundary object: 'epistemic' in the sense that it produces disinterested knowledge and 'boundary' in the sense that it crosses intersubjective gaps.
The epistemic boundary object has meanings which are not unequivocally attributed but, on the contrary, which can be freely discovered by the subject independently of the object producer's intentions. Through this disjunction between the object and any predetermined meaning, boundaries are crossed. The disjunction can only take place at the phenomenal dimension, i.e. the one concerning the way an object is present to the subject (macroscopic level of description) rather than the way an object is conceptually or materially produced (microscopic level of description). Moreover, the phenomenal dimension is the same one the subject will assess the design activity upon, i.e. on the basis of its outcome at the moment of interaction, independently of practitioners' intentions.
The single object enabling the subjective knowledge of the described thing concerns the phase of design ideation, while design realization requires a series of technical representative objects: 'technical' in the sense that they provide tools for an objective and 'representative' in the sense that they adopt a specific perspective.
These representations are models in a common sense and they address a microscopic level of description, i.e. the procedures to produce the design object. They are based on information abstracting only those elements which are necessary to deal with the specific technical issue of interest, and their meaning must be unequivocally attributed, so that they can be read

exactly as the one who produced them expects them to be read, usually according to conventions.

The epistemic boundary object and technical conventional representations describe the same design object with different roles within the design process. Indeed while the former is used to define how the design object must result, the latter must describe how to produce this result. Therefore a meta-model is needed to use these representations dynamically so that the level of ideation and the one of production can be bridged. The two levels and associated types of representation can be imagined as occupying the two extremes of a scale of representations where each step is characterized by a decreasing level of validity and an increasing level of specificity when the scale is covered toward the representative objects starting from the boundary object, while in the opposite direction each step is characterized by an increasing level of validity and a decreasing level of specificity.

The degree of validity refers to the amount of viewpoints a representation can contemporarily encompass. Since validity and specificity are inversely proportional, keeping the different representations together is of uttermost importance. Moreover the direction to cover the scale must be from the boundary object to the representative objects, because the latter are functional to the realization of the former.

After this introductory description of the research framework, the paper will address the main objectives of a possible investigation related to the meta-model: the definition of the epistemic boundary object and of the derivation process of technical representative objects. But, first of all, the state of the art related to the relationship between modelling and design will be briefly reviewed, with a specific focus on the ability of different approaches to integrate the users' many perspectives.

2. STATE OF THE ART: REPRESENTATION, DESIGN AND PERCEPTION

Design failure can be defined as the difference between design outcomes assessed once the design object is deployed in reality and the outcomes expected during the object conception based on representations of that reality. Therefore the proneness of different design practices to failure can be measured in terms of the distance they entail between the design intentions on paper and their actual outcomes, which directly depends on the degree of modelling adopted by the specific design practice. Present practices have been divided into three categories in relation to this aspect: top-down approach, participatory design and open design paradigm. These practices also demonstrate how different degrees of modelling imply different roles of the users in the design process. The various practices have been subsequently analysed and assessed to understand how the previously outlined framework can improve them.

Top-down approach is characterized by the figure of a designer without bias able to understand and represent the situation and users' needs thus making decisions at their place. The user is modelled as an ideal person defined in relation to the enjoyment of a service or a good having a specific purpose. In this case representation is supposed to completely comprehend reality, and this belief leads to trust representation to the extent that reality in its contingency and multiplicity is totally ignored: the distance between reality and its model is the greatest one.

Participatory design is based on the idea that decisions must be made through consensus upon requirements, objectives and assessment methods in order to deal with the designers' inability or disinterest in reducing the distance with the ones affected by their decisions. Therefore the user becomes an actor, i.e. a single representative of a whole class of stakeholders collectively engaged in a decision process. In this case reality is approached in terms of multiplicity of perspectives addressed, but in a specific instant decisions are made also for the future, thus making permanent in the representation of the problem a requirement that is contingent in reality.

Open design paradigm has established a different approach promoting the gradual emergence of a design object starting from a complete but light meta-structure which evolves over time so that it can adjust itself before becoming strong and robust [2]. The actor becomes an agent, i.e. an user who transforms the design object according to his evolving needs. In this case, there is no representation in design activity and reality itself is used directly as model: the distance between reality and its model is the shortest one.

Every previously mentioned approach is characterized by its own degree of proneness to failure. Indeed the idea of an ideal designer as in the case of the top-down approach can be questioned because of the very narrow perspective adopted to define the problem, so that the requirements and related solution envisioned by the designer can fail to meet the users' need especially when dealing with complex problems, such as big-scale and long-term ones.

On the contrary, the participatory approach proposes the engagement of different stakeholders during the design process to broaden the spectrum of considered perspectives, but it is distorted by the unquestioned postulate that actors are transparent to themselves, so that they are able to assess the consequences of their decisions and to forecast their future needs. Actually, this is not the case of complex problems.

Finally, the open design paradigm simply prevents the problem of how making decisions by leaving the design object unfinished so that agents can adjust it to conditions over time, but the serial addition of contingent interventions results in inconsistent wholes. Moreover, once the design object has become robust, it cannot be adapted anymore unless it is dismantled and reassembled again into a more fitting object.

There is still one way left to deal with the epistemological gap, even if all the approaches among the ones covering the whole range of distances between reality and its model proved to be unsuccessful. This way is to transpose the problem from the physical to the phenomenal dimension. To introduce this necessity, a fact must be pointed out: that in the evolution of the concept of user from the actor to the agent, there is something that persists, and this is the abstract distinction between the user and the design object he uses, in the sense that the definition of the former is not affected by any situated relationship with the latter and vice versa, because they only exist as physical entities. The consequence is that, since the design object can physically be only one, the way to address the growing amount of viewpoints across the three paradigms is to define future users in terms which are increasingly generic, thus leading to a growing level of indeterminacy related to the definition of the design object too.

But on a concrete dimension the user and the design object are complementary and defined together at a phenomenal level, i.e. the one of situated perception and action. In this framework, the design object can be used to influence the many in a same way, thus reducing them to the specific definition of a single subject or, contrarily, the design activity can be aimed at promoting the many manifestations of a single design object in relation to the subject. The following section will concern the way of producing such a phenomenal openness as opposed to the physical one.

3. PROPOSAL: FROM MODEL/REALITY DUALISM TO AFFORDANCES AND THINGS

The phenomenal dimension refers to the world as it is perceived by a subject.

The classic idea of perception in design theory is based on a very mediated concept of the relationship between the observer and the design object where the object is a sort of text and the observer is a reader. Phenomenal openness is here applied as the multiplicity of textual interpretations, as proposed by Colin Rowe with regard to phenomenal transparency through the gestalt idea of multistability [12].

Instead an experiential approach considers perception as mainly based on its immediate sensory aspects, by focusing on the physical properties an object is able to induce in its field of action and which affect the state of the users in an unconscious way.

Both concepts are incomplete. The idea of perception as textual reading ignores the very immediate and sensuous character of perception associated to less intellectual activities. Moreover, it assumes a shared code which is usually missing between the user and the designer, and in any case the possible meanings are reduced to the few controlled by the designer and allowed by multistability.

Nevertheless, the idea of an unconscious sensory relation between users and design objects posits at the centre of the design activity the control of the users' behaviour, in the ways studied by psychologist Kurt Lewin [9]. The more experience is specified, the more design activity assumes a constraining stance towards users, while the research objective is not to reduce all viewpoints to a single one, but on the contrary to represent all the possible perspectives.

The mentioned practices are based on two extreme theories about perception which can actually be encompassed in order to recovery the sensory and immediate qualities of perception without losing its meaning, which is a mandatory aspect to allow interpretation and therefore openness.

The classic idea is based on the mind-body dualism, a paradigm positing that consciousness and the world exist independently of each other and therefore objects have an identity and are out there to be recognized by the observer who reads a sort of photograph projected in his head by the eye considered as a transparent lens. The other idea is based on the assumption that there is no photograph to be read, that what we perceive is a set of discrete stimuli passing through the optic nerve considered as an opaque apparatus, and that objects do not exist in themselves as they are only symbols which stand for sensation-complexes [10]. Since objects are constructions depending on the subject, this paradigm is called embodied model.

Of course the correct understanding of the way perception physiologically occurs is not the scope of this paper. What can be useful, instead, is that the dichotomy between mind-body dualism and the embodied model parallels the dichotomy between model and reality, which can be also called by their raw material, i.e. information and stimulation.

Indeed the usefulness of these parallelisms is due to the fact that, since information and stimulation are both valid forms of knowledge with different applicability, the two theories and consequently the model-reality pair too appear not to exclude each other, but to simply apply to different situations where different cognitive activities are elicited, notably the upper ones based on representations deriving from information processing in the case of mind-body dualism and the lower ones based on automatic reflexes due to stimulation in the case of the embodied model. The idea of lower and upper activities recalls the concept of a scale, thus suggesting the idea that those theories exist not only together but also in continuity. Henri Bergson recognized this continuity when studying Leibniz's monadology, i.e. a theory of oriented representations, together with experiments concerning hyperaesthesia, i.e. a state of unmediated perception in terms of chemical and physical stimulation of perceptual organs [3]. His intuition constituted a revolution in cognitive theories: while in the Cartesian tradition partial representation is the starting point to access reality by means of an additive consciousness, Bergson posits that reality is accessed in its entirety from the beginning by every observer in terms of stimulation and only later it is reduced into information by a subtractive consciousness, thus allowing different understandings of life (levels of cognition) with regard to the type of attention to life (levels of perception) required by the specific activities observers are engaged in.

These activities were scientifically organized into a scale by the Piagetian theory of cognitive development, which associates them to the developmental ages of the child [11]. Commons, Crone-Todd & Chen extend the validity of this scale through their model of hierarchical complexity, where activities are simply scored in terms of complexity occurring on the basis of the situation a subject is engaged in independently of his age [4].

The scale allows to encompass the extremes of mind-body dualism and the embodied model by moving them towards intermediate stages. There are two ways this can happen. The first one is when representation makes objects present to the subject in new ways through the suspension of habit which degrades them into what Martin Heidegger terms 'thing' [8], i.e. an object which loses its socially encoded value and then sets a new object-subject relation which is not given a priori. The second way is in the opposite direction and consists of the condensation of sensations affecting a situated subject into what James Gibson terms 'affordance' [6], i.e. the suggestion of environmental uses in relation to the subject's actual need. These two concepts allow to overcome the limitations of representation due to preordained objectives and the limitations of sensation due to its reflexive passiveness. A project thought in terms of affordance or thing can only be designed through an epistemic boundary object which is a thing itself (not purposed) and presenting affordances itself (emergent in relation to a subject). This leads to the substitution of a project definition based on objectives and procedures with a project definition addressing directly the result, for deriving only later how to produce this result and why the properties of the form make the different perspectives agree: agreement upon form does not require any other form of agreement [7].

Affordance and thing, as infinitesimally distant concepts deriving from opposite directions, are between the sensorimotor and the operative stages of the Commons' scale. Actually, the scale is made of sixteen stages, but for the present paper purposes we can group them into three main categories: formal reasoning, operational activities and sensorimotor reflexes. Formal reasoning requires an absolute perception representing from a single perspective many viewpoints in an abstract way, operational activities are based on a customary perception perpetuating communal practices emerged from experience over a long period of time, sensorimotor reflexes depend on a situated perception affecting a single viewpoint in a specific way which would be the same for anyone exposed to the same situation.

To sum up, the possible path to bridge the epistemological gap

between reality and its model is to address the phenomenal dimension, where models and reality are substituted by things and affordances: once the design object is ideated in terms of its affordances by means of the epistemic boundary object, models are used only later for its technical realization.

4. CONCLUSION: TOWARDS A META-MODEL

Future research on this topic must identify the nature of the epistemic boundary object presenting affordances, in order to consequently derive its technical representations by covering the gap between project conception and manifestation through the idea of scale.
The identification of the epistemic boundary object can follow different lines.
1) The first one is the study of abstraction, i.e. the movement from stimulation to information, in order to understand and operate its mechanisms. These mechanisms consist in the ways of selecting both the geometry and the cues of representation: how can cues and geometry be used in an inclusive rather than selective way?
2) Abstraction mechanisms are adopted by the observer in relation to his schemata, i.e. the inner model which he unconsciously uses to interpret the environment. The factors influencing these schemata are notably of individual, cultural and universal kind depending on the type of activity the subject is engaged in among the ones categorized by Piaget, i.e. intellectual, operative and automatic respectively. For this reason environmental psychology, geography of perception and social psychology are disciplines related to the research: how can schemata be suspended?
3) The last research line is related to the idea of presence as opposed to the idea of representation, in the sense that the medium would not concern information about something else but would be directly meaningful in terms of the stimuli it produces, which is the only way to stand for itself. Insights in this direction can derive from the concept of sign as opposed to symbol, from semiotics which is the related discipline, from Minimal art as it redefines the relationship between art and objecthood: how can a medium stand for itself?
The derivation process, instead, could build upon the Felix Klein's architecture of geometries which is able to relate in a sort of scale representations having different degrees of validity as each of them adopts a specific geometry type which can be converted into the geometry adopted by another representation through a series of transformations. Indeed in Klein's theory different types of geometry are ordered hierarchically from the bottom to the top as the number of transformations they are invariant to grows. For instance affine geometry is invariant with regard to angles and therefore occupies a higher level than euclidean geometry, while it is variant with regard to parallelity and therefore occupies a lower level than projective geometry. The architecture of geometries is therefore a scale, and it is related to the Piaget's cognitive scale, i.e. there is a correspondence between the environmental cognition by the subject and the kind of geometry the subject himself would adopt to represent that environment. Therefore it can be used to understand how different kinds of geometry are able to represent a varying amount of points of view, thus answering the question related to the characteristics a boundary object must possess, and then, by applying the transformations, it can be also used to transform the single boundary object into the many technical representations.
Here the scale reveals that the design object can be defined neither in terms of the many abstract models representing the many specific perspectives nor in terms of the single contingent reality materially affecting the totality of subjects, but only in terms of the meta-model bridging the gap between the two extremes. For Umberto Eco :'the object, to be defined, must be transcended towards the total series of whom, as one of the possible apparitions, is member. In this sense the traditional dualism between to be and to appear is substituted by a polarity of finite and infinite, so that the infinite is located in the very center of the finite' [5, p. 54].

5. REFERENCES

[1] O. Akin, "Variants in Design Cognition", C. Eastman, W. Newstetter & M. McCracken (Eds.), **Design Knowing and Learning: Cognition in Design Education** , New York: Elsevier, 2001, pp. 105-124.

[2] C. Alexander, S. Ishikawa & M. Silverstein, **A Pattern Language**, New York: Oxford University Press, 1977.

[3] H. Caygill, "Hyperaesthesia and the Virtual", J. Ó Maoilearca & C. De Mille (Eds.), **Bergson and the Art of Immanence: Painting, Photography, Film**, Edinburgh: Edinburgh University Press, 2013, pp. 247-259.

[4] M.L. Commons, D. Crone-Todd & S.J. Chen, "Using SAFMEDS and direct instruction to teach the model of hierarchical complexity", **The Behavior Analyst Today**, Vol. 1 & 2, No. 14, 2014, pp. 31-45.

[5] U. Eco, **Opera Aperta. Forma e indeterminazione nelle poetiche contemporanee**, Milano: Bompiani, 2009.

[6] J.J. Gibson, **Un approccio ecologico alla percezione visiva**, Bologna: Il Mulino, 1999.

[7] N.J. Habraken, **The Structure of the Ordinary: form and control in the built environment**, Cambridge: The MIT Press, 1998.

[8] M. Heidegger, **Building Dwelling Thinking. Poetry, Language, Thought**, New York: Harper Colophon Books, 1971.

[9] K. Lewin & D. Cartwright (Ed.), **Field Theory in Social Science: Selected Theoretical Papers**, New York: Harper & Brothers, 1951.

[10] E. Mach, **Contributions to the Analysis of Sensations**, Chicago: The Open Court Publ. Co., 1897.

[11] J. Piaget & B. Inhelder, **The Psychology of the Child**, New York: Basic Books, 1972.

[12] C. Rowe & R. Slutzky, "Transparency: Literal and Phenomenal", **Perspecta**, Vol. 8, 1963, pp. 45-54.

[13] E. Subrahmanian, Y. Reich, F. Smulders & S. Meijer, "Designing: insights from weaving theories of cognition and design theories", **International conference on engineering design, ICED11**, Technical University of Denmark, 2011.