Towards a Situated Function-Behaviour-Structure Framework as the Basis of a Theory of Designing

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1. Introduction

The *Shorter Oxford English Dictionary* defines "theory" in a number of ways:

1. a scheme or system of ideas or statements held as an explanation or account of a group of facts or phenomena;
2. a hypothesis that has been confirmed or established by observation or experiment and is propounded or accepted as accounting for the known facts;
3. a statement of what are held to be the general laws, principles or causes of something known or observed;
4. systematic statement of the principles of something; and
5. a hypothesis proposed as an explanation, hence a mere hypothesis, speculation or conjecture ("theory" used loosely).

We are beginning to have increasing empirical evidence for the processes that go to make up the act of designing. (We will use the word "design" to mean the artifact and the word "designing" to mean the processes involved in producing the artifact.) Thus, we are increasingly likely to be able to begin to develop a theory of designing that fits within the first three and the last definitions. It is claimed that insufficient is known about designing to produce a theory of principles. Current approaches to the development of theories of designing often have difficulty in explaining or accounting for the fundamental distinguishing characteristics of designing. These distinguishing characteristics include the notion of "problem making" as well as "problem solving". Yet, the results of the activity of problem making appear to be highly correlated with individuals – how to account for this is a framework which can form the basis of a theory? It appears that each designer has the capacity to interpret what is represented in different ways partially depending on their unique experiences and their view of what makes up the current context within which they are operating.

Situatedness is the notion that addresses the role of the context. This concept is founded on the work of Bartlett (1932) and Dewey (1896) and has recently been introduced into design research by Gero (1998) and less directly by others. Its integration into a formal description of designing, such as the FBS framework (Gero, 1990; Umeda et al, 1990), has the potential to provide the foundation of a theory of designing.

2. The FBS Framework

The FBS framework represents the processes of designing. The basic assumption here is the existence of three classes of variables required in a designing process: function

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variables, behaviour variables and structure variables. They are linked together by processes, which transform one class into another. Figure 1 shows the eight processes involved in designing, namely:

1. Formulation: $F \rightarrow B_e$
2. Synthesis: $B_e \rightarrow S$ via B_s
3. Analysis: $S \rightarrow B_s$
4. Evaluation: $B_s \leftrightarrow B_e$
5. Documentation: $S \rightarrow D$
6. Reformulation –1: $S \rightarrow S'$
7. Reformulation –2: $S \rightarrow B_e'$
8. Reformulation –3: $S \rightarrow F'$ via B_e

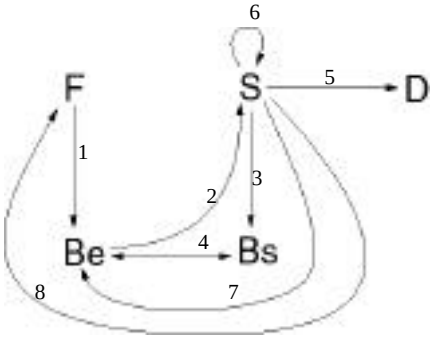


Figure 1: The FBS framework where: B_e = expected behaviour; B_s = behaviour derived from structure; D = design description; F = function; S = structure; $\rightarrow$ = transformation and $\leftrightarrow$ = comparison (after Gero (1990)).

The FBS framework has the capacity to include all the processes of designing but fails to include the notion of the role of the context.

3. Situatedness

Designing is an activity, during which the designer performs actions in order to change the external representation of the design. By observing and interpreting the results of his actions, he then decides on new actions to be executed on the representation. The designer's concepts change according to what he is "seeing" in the external representation (and in his internal representation), which itself is a function of what he has done. Schön and Wiggins (1992) speak of a process of "interaction of making and seeing".

This interaction between the designer and the representation of the developing design strongly determines the course of designing. We call this concept *situatedness*. Gero in paraphrasing Clancey (1997) described situatedness as "where you are when you do what you do matters". This view is in opposition to many existing design theories, which assume that the world is static and not related to what you are doing. In experimental studies of designers Schön and Wiggins (1992) found that designers use their sketches not only as an external memory, but also as a means to reinterpret what they have drawn, thus leading the design to a new direction. Suwa, Gero and Purcell (1999) noted, in studying designers, a correlation of unexpected discoveries in sketches and the invention of new issues or requirements during the design process. They concluded that "sketches

serve as a physical setting in which design thoughts are constructed on the fly in a situated way".

The foundational concepts of situatedness go back to the work of Bartlett (1932) and Dewey (1896). Its influence on the field of designing is just beginning to be explored, however it plays a role in developing a suitable foundation for a theory of designing.

4. Situatedness as an Interaction of Different Environments

We describe three different environments that interact with each other, Figure 2:

- *external world:* is the physical world we live in, i.e. it is the world of things that exist in terms of structure. In the context of design, more specifically, it includes *representations* of objects external to ourselves.
- *interpreted world:* is the world that we build up in our minds in terms of sensory experiences, percepts and concepts. It is the interpretation of that part of the external and internal worlds that we interact with.
- *expected world:* is the world that we imagine our actions will produce. It is the environment in which we (predict and) decide on actions according to our current goals and our interpretations of the current state of the world.

These three worlds are linked together by the following processes:

- *interpretation:* is the process that transforms variables from the external world and which are sensed, into the interpretations of *sensory experiences*, *percepts* and *concepts* that compose the interpreted world. This is done by the interaction of sensation, perception and conception processes.
- *hypothesizing:* is the process that uses some aspects of the interpreted world as goals in the expected world and suggests actions, which, if executed in the external world should produce states that should reach the goals.
- *action:* is an effect that brings about a change in the external world.

The different environments, thus connected to each other, form the *situation*, which is defined as that part of the environment that the designer interacts with. This environment consists of both the external and the designer's internal world (i.e. his interpretations and expectations).

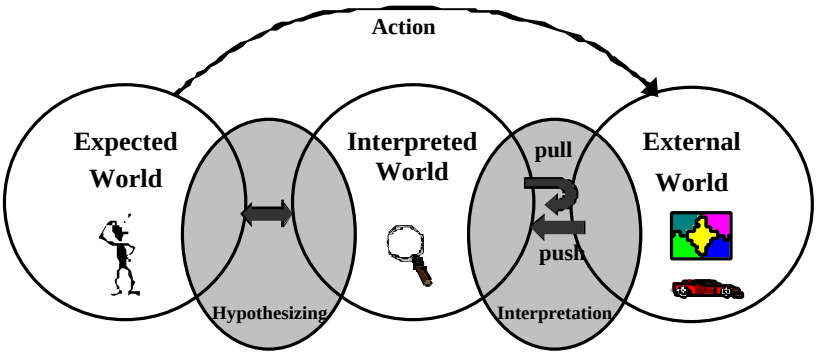
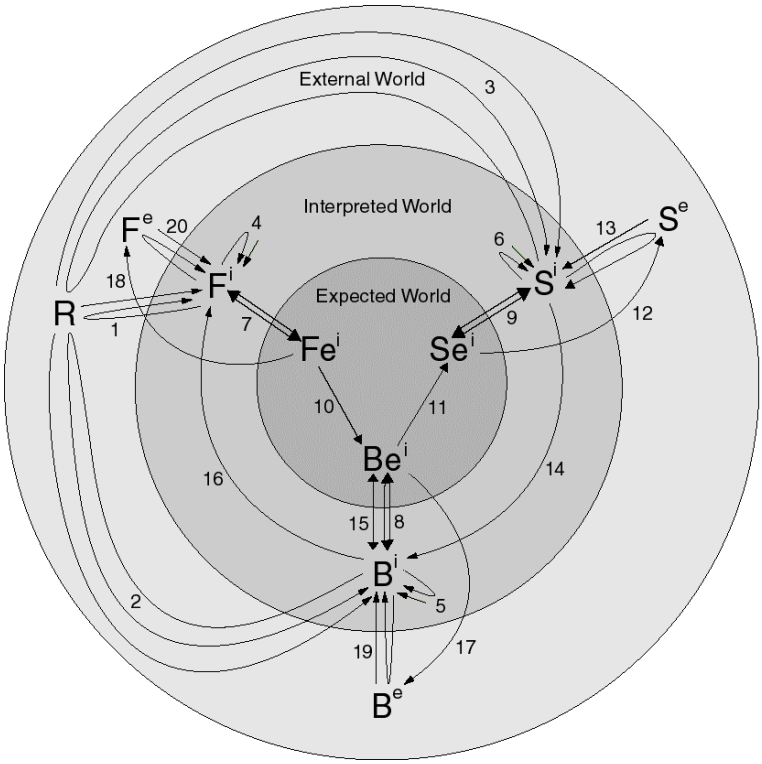


Figure 2: Three worlds in designing interacting with each other.

5. A New Framework

The new framework that extends the FBS framework to include situatedness is depicted in Figure 3 involving three worlds. This diagram can be viewed as the designer or design agent (represented through the interpreted and expected worlds) interacting with and within the external world. We define the external world as the structural environment of *representations* only. The world of physical objects is thus out of our scope. The expected world is a subset of the interpreted world.



= transformation; = comparison; = focussing; = push-pull process

Figure 3: The situated FBS framework.

Since we now have three environments, we have introduced additional states. Function, behaviour and structure, each of which was previously represented as only one or two states, have now three forms of existence: *external* function/behaviour/structure (F^e, B^e, S^e), *interpreted* function/behaviour/structure (F^i, B^i, S^i) and *expected* function/behaviour/structure (Fe^i, Be^i, Se^i). The representation of function and behaviour in the external world is often difficult to realize, due to their high level of abstraction and the lack of a formal representation language. Behaviour, in the former framework, has already been divided into expected behaviour (Be^i) and behaviour derived from structure (Bs). The latter corresponds to our new interpreted behaviour (B^i). The design description (D) is no longer explicitly mentioned, since we consider it as a special case of an external representation of structure (S^e). We now explicitly depict the requirements (R) of a design problem.

Having established this larger number of states, we also need a larger set of processes to connect them. In Figure 3 we have defined 20 labeled processes that conjointly map on to the 8 fundamental designing processes; the round brackets indicate that the process is optional, while the square brackets indicate processes at least one which is a precondition for the main process.

1. Formulation: 1, (2), (3), 4, 5, 6, 7, 8, 9, 10
2. Synthesis: 11, 12
3. Analysis: 14
4. Evaluation: 15
5. Documentation: 12, (17), (18)
6. Reformulation type 1: 9, [6], [13]
7. Reformulation type 2: 8, [5] , [14], [19]
8. Reformulation type 3: 7, [4], [16], [20]

6. Discussion

We have proposed a new framework for representing designing that includes its situatedness. The integration of concepts from cognitive science makes the FBS framework more powerful in explaining designing as a situated activity. This work underlines the importance of the context, in which designing takes place.

We claim that this enhanced framework provides the foundation for a process theory of designing since it is "a scheme or system of ideas or statements held as an explanation or account of a group of facts or phenomena".

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