LEARNING ABOUT SHAPE SEMANTICS: A SITUATED LEARNING APPROACH

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Abstract. Designers recognise or make sense of objects in the context "situations" of other things. Design cannot be predicted and you have to be “at a particular set of states” in order to decide what to do. The inability to determine a priori all design states implies that any design process cannot be pre-planned and design actions cannot be pre-defined. Situated learning is based on the notion that knowledge is contextually situated and is fundamentally influenced by the context in which it is used. We propose a situated learning approach in the domain of architectural shapes design. This paper elaborates the concept of situated learning and demonstrates what it produces in the domain of shape semantics.

1. Motivations

Design has many unique features one of which is that design is not an anticipative act. Design cannot be predicted and you have to be “at a particular set of states” in order to decide what to do. The inability to determine a priori all design states implies that any design process cannot be pre-planned and design actions cannot be pre-defined.

Designers recognise or make sense of objects in the context of other things, situations. Responding by saying what something is for puts that something into the context of an intended use. Specific design knowledge is made factual by the situation or, to put it in another way, that this specific design knowledge is an item of knowledge that is only useful in certain situations. A situation encompasses constraints. For example, in real world, environmental situations, the constraint that links smoke to fire is likely to be the most salient in any situation where there is a smoke. Designer’s actions are based on the situation where design knowledge is used and proven to be applicable. This leads us towards the notion of situation as the potential basis for guiding the use of knowledge.

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Situated learning is a general theory of knowledge acquisition. It is based on the notion that knowledge is contextually situated and is fundamentally influenced by the context in which it is used. Situated learning is often incidental rather deliberate.

In this paper we propose a situated learning approach in the domain of architectural shapes design. Since it is not possible to know beforehand what is the knowledge to use in relation to any situation we need to learn knowledge in the form of focus and situation. The difference between focus and situation is that focus is the recognition of certain piece of knowledge on which the attention is concentrated and situation is the environment or conditions under which this focus operates and must be present if that focus to be applied. In the domain of architectural shapes the situation is the interdependency or connections between single shape semantic as a focus and other semantics of that shape where this single semantic operates. Learning the knowledge in the form of focus and situation could be viewed as a foreground and background learning where focus works in the foreground and situation works as the background of that foreground.

This approach forms the foundation of a design tool that learns design knowledge in relation to design situations where this knowledge was learnt and guides the use of this knowledge when similar situations exist.

Viewing design as a situated activity is described further in section 2. The situated learning approach in design and the situatedness of design knowledge “what, why and how” are discussed in Section 3. An illustration of this approach to learning about architectural shape semantics and the results of learned knowledge in the form of focus and situation are presented and discussed in Section 4 and 5.

2. Design as a situated activity

Designer's action takes place in situations; designing, like many other human activity, does not exist except in relation to certain situational conditions and cannot be understood and explained in isolation from them (Magnusson, 1981). Situations present at different levels of specification, the information we handle and they offer us the necessary feed back for building valid conceptions of the world as a basis for actions. Thus, designer's actions are adapted to the environment, that is, situated, because what they perceive, how they conceive their activity, and what they physically do develop together. “Situated” has multiple useful meanings, which we can relate systematically by a framework of three views commonly used to describe complex systems: functional, structural and behavioural. Unlike the functional aspect, which broadly considers the meaning of the action, or the structural aspect, which considers the internal mechanism, the behavioural aspect considers the local feedback and time-sensitive nature of action in place where changes are not planned in advance but constructed on the spot. In this way, behaviour is reflective and continuously adjusted (Clancey, 1997).

Similar to this view Schon (1983; 1992) argues that design processes involve conversations between the designer and the situation and in a good process of design the conversation with the situation is reflective. In answer to the situation's "back-talk", the designer "reflects-in-action" on the construction of the problem, the strategies of action, or the model of the phenomena, which have been implicit in his moves. Moves involve understanding and interpretation of a new situation and making conclusions rather than the reproduction of knowledge. From the outset of a design task, designers create their early moves in accordance with an initial design appreciation. The move then might produce some unexpected consequences, which might lead to some new situations.

Design knowledge is captured in the action of designing rather than only represented by symbols in the computational model which makes explicit statements about what is being captured and why (Marr, 1982). Schon (1992) states that "designers know more than they can say, tend to give inaccurate descriptions of what they know, into the mode of doing". So the design itself is not an instance derived from a symbolic model design but rather it is an activity reflecting actual action in a situation. That is how design can be viewed as a situated activity.

3. Situated learning in design: What, Why and How?

In the following sub-sections an elaboration of the situated learning and why the situatedness of design knowledge is important for useful learning as well as the medium that facilitate capturing the situatedness of design knowledge are discussed.

3.1 WHAT IS SITUATED LEARNING?

Situated learning is a general theory of knowledge acquisition (Lave, 1990). Lave (1990) argues that learning as it normally occurs is a function of activity and the context in which it occurs, ie, it is situated. This contrasts with most learning systems which involve knowledge that is often presented out of context. Furthermore, situated learning is often incidental rather than deliberate. Brown et al (1989) emphasise the need for a new epistemology for learning; one that emphasises active perception over concepts and representations. Suchman (1987) claimed that all real-world thinking and knowing (learning) entails a form of context-bound and embodied, situational action and not plan-based interaction. Every course of actions depends in essential ways upon its material, and circumstances. Purposeful actions are inevitably situated actions. By situated actions Suchman simply means actions taken in the context of particular, concrete circumstances. So, learning is not simply a matter of ingesting externally-defined, decontextualised objects, but a matter of developing context-bound discourse-practices (Streibel, 1995).

3.2 WHY SITUATED LEARNING IN DESIGN

A popular definition or description of the process view of designing is as a goal-oriented problem-solving activity (Archer, 1965). The design process has been described as the cycle of design analysis, design synthesis, and design evaluation (Jones, 1863; Dasgupta, 1989). In this design model, well-structured knowledge is needed. Design situations, design process, and design decisions are predefined and described in some symbolic representation. In this view of designing, the relevance of all design activities is fixed beforehand; consequences can be intended with no need to reflect on design actions. Based on this metaphor, design is an action within an assembly of symbols, patterns, and planned sequences (Sun, 1993). Based on this view design has been modeled as search within a given representation of the world. Design has recently been modeled as a form of exploration, where the world which is to be searched has first to be constructed or located. Both these views are founded on the notion that knowledge exists outside of its use and only has to be applied to be useful. Thus, learning in design is concerned with finding relationships between structure and behaviour and representing that as knowledge which can then be applied later.

An alternative view is that the formulation of the design problem at one stage is not final; rather it reflects the designer's current understanding of the problem. As the design progress, the designer learns more about possible problem and solution structures as new aspects of the situation become apparent and any inconsistencies inherent in the formulation of the problem are revealed. As a result, designers gain new insights in the problem (and the solution) which ultimately result in the formation of a new view (Logan and Smithers, 1993).

There is an increasing interest in the notion of "situatedness". Situation is similar to context. Thus, the utility of knowledge is determined by its situatedness not by any absolute measure. Situated learning in design here is concerned with finding relationships between the knowledge applied and the situation within which it is was applied. The fundamental objective thus becomes one of understanding the structure of the problem (rather than the solution), and analysing interrelationships between criteria to gain some insight into the relationships between each individual design decision and all of the other decisions at that time that together provide the ability to move on to a solution.

Situated acts such as conceptual designing are different to the application of knowledge. Situated acts require that the situation itself be constructed from sensed data about the world of interest and as a consequence what is knowledge and what is situation is constructed on the fly based on need rather than based simply on previously defined knowledge. The effect of this is that the state space within which a designer is operating is potentially constantly changing as he or she constructs worlds of interest. Representations and consequent situations are not preset but are produced at the time a need arises.

There are attempts to integrate the views of situated activity with learning systems that provide a dialogue environment for designers learning from prior design such as Case-Based Reasoning (CBR) (Sooriamurthi and Leake, 1994; Oehlmann et al, 1995). CBR provides a reminding environment to assist designers to use past designs instead of designing from scratch. Since designer's actions depend upon of the current situation then the automated adaptation of a design case is a difficult. Obviously, because the situations vary over time, so it is impossible to predefine the adapting process of the system to involve unknown situations. However, the adapting process can be defined within a particular range of expected situations. A primary difference between such systems and the proposed situated learning approach is that design situations are not predefined but rather constructed and modified during the design process.

The importance of situated learning in design is founded on the notion that a designer’s actions are based on the situation where design knowledge is used and proven to be applicable. This leads us towards the notion of situation as the potential rule for guiding the use of knowledge.

3.3 HOW SITUATED LEARNING IN DESIGN IS TO BE ATTAINED?

As discussed above, the result of designing cannot be predicted and the designer has to be at a particular set of states in the design process in order to decide what to do. This means that the designer has to be there, in the situation, to decide what actions or moves to be taken. Intuitively it is clear that learning involve a wide range of representations. Much of our learning takes place in the context of actions (Someren and Reimann, 1996). Schon and Wiggins (1992) argue that designing proceeds in a sequence of seeing-moving-seeing cycles. Multiple representations follow from the notion of not being able to predict all the states of design process. It is based on the concept that designers appear to use different representations whenever it suits them. These multiple representations provide alternate paths to be followed by the learning system (Gero and Reffat, 1997). Relating knowledge that is presented in different representations is an important aspect to recognise the situatedness of that knowledge. Multiple representations appear to be a powerful platform for situated learning in design

4. Learning about shape semantics: a situated approach

Although design knowledge and design results are generally expressed graphically, drawings are described as a presentational or representational medium or as communicative tools used during the design process. More recently, the drawing itself and the way of seeing it have been explored as an indispensable part of the design process and the underlying design thinking (Liu, 1995; Suwa et al, 1998).

Shape semantics is the interpretation of predefined patterns of groups of shapes. Primary shape semantics is a visual pattern of relations of shapes, which is represented explicitly and intentionally by designers. An emergent shape semantic is a visual pattern of shapes that exists only implicitly in the relationships of shapes (Gero and Jun, 1995). There is a vast collection of possible architectural shape semantics which could be emerged. Recognising shape semantics whether primary or emergent is useful but what is more useful is learning about these shape semantics. When certain shape semantics could be recognised from the multiple representations what are the relationships among these shape semantics. These relationships are the key to discovering the situatedness of these semantics and potentially guide when they are to be applied.

In the following example we have selected an architectural design and illustrate some of multiple representations of the initial representation of that shape, some of the shape semantics that could be recognised from multiple representations and the relationships across the multiple representations that construct the situatedness of these shape semantics. Figure 1 shows the design description of a public library (Clark and Pause, 1996). The structure or the initial representation of the shape is as shown in Figure 2(a). Infinite maximal lines are used as representative primitives of shapes. Infinite maximal lines are indicated as dashed lines in Figures 2(b) to 2(j). By re-representing what has been drawn in the initial representation a number of possible representations could be interpreted as shown shaded in Figures 2(b) to 2(j).

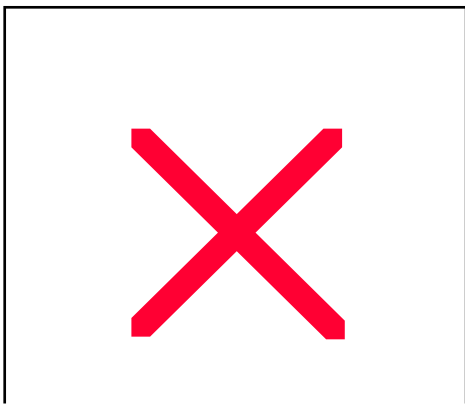
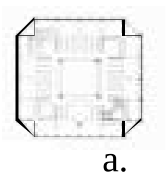


Table 1. Recognition of shape semantics from multiple representations

R. No.	Shape Semantics
b	S_m , P_r, A_d , R_c
c	S_m , P_r, A_d , R_c
d	S_m , P_r, A_d , R_c
e	S_r , A_d
f	S_m , P_r, A_d , R_c
g	S_m , P_r, A_d , R_c
h	A_d, R_t
i	S_r , A_d
j	S_r , A_d

Figure 1. Design description of public library (Clark and Pause, 1996).



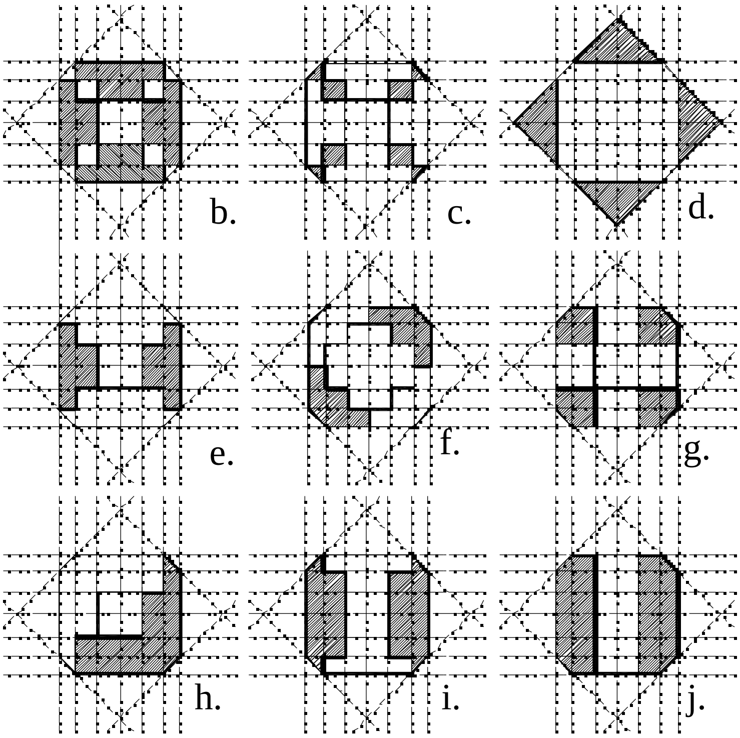


Figure 2. Some of multiple representations of the initial shape representation.

Looking at the multiple representations in Figure 2 some of the shape semantics can be recognised. The recognised shape semantics are listed in Table 1. Where $\boldsymbol{S_m}$, $\boldsymbol{P_r}$, $\boldsymbol{A_d}$, $\boldsymbol{R_c}$, $\boldsymbol{S_r}$ and $\boldsymbol{R_t}$ refer to reflective symmetry around multiple axes, repetition, adjacency, cyclic rotation, reflective symmetry and rotation respectively. Reflective symmetry $\boldsymbol{S_m}$ is a reflection of subshapes around more than one axis while $\boldsymbol{S_r}$ is a reflection of subshapes around one axis. Repetition $\boldsymbol{P_r}$ refers to a repeated subshape in the representation which appears more than twice. Cyclic rotation $\boldsymbol{R_c}$ is the rotation of a subshape more than twice while $\boldsymbol{R_t}$ is the rotation of subshape twice. Adjacency $\boldsymbol{A_d}$ refers to adjacent or attached subshapes.

Recognition of shape semantics is situation independent. Finding the relationships between the recognised shape semantics across the multiple representations within which certain knowledge is applied to construct the situatedness for that knowledge. In the previous example as in Table 1, if the knowledge in the focus of attention "foreground" is $\boldsymbol{S_m}$ we will find across the representations that $\boldsymbol{S_m}$ is associated with other shape semantics such as $\boldsymbol{P_r}$, $\boldsymbol{A_d}$ and $\boldsymbol{R_c}$ in various representations $\boldsymbol{r_b}$, $\boldsymbol{r_c}$, $\boldsymbol{r_d}$, $\boldsymbol{r_f}$ and $\boldsymbol{r_g}$ in Figure 3 which together construct the situation of $\boldsymbol{S_m}$. So, $\boldsymbol{S_m}$ is situated within these shape semantics. In other words, these other shape semantics are the environment or conditions where $\boldsymbol{S_m}$ is to be applied. The other interesting notion is the knowledge that has been in focus "foreground" could possibly be in the situation "background" for other knowledge. For instance if the focus is $\boldsymbol{R_c}$ we will find that $\boldsymbol{S_m}$, $\boldsymbol{P_r}$ and $\boldsymbol{A_d}$ construct the situation of $\boldsymbol{R_c}$. This reflects the duality between the foreground and background or the knowledge in focus and its situation. Figure 3 shows the relationship between focus and situation as well as the duality between them.

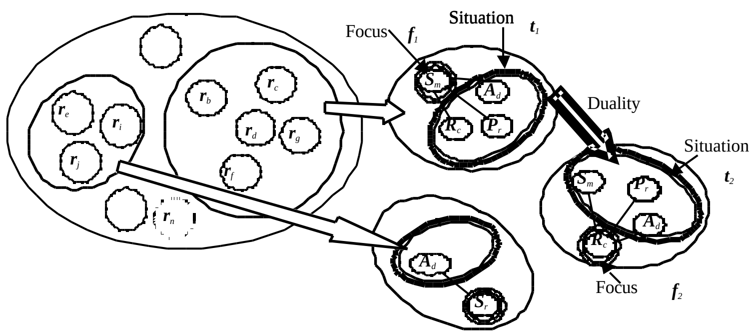


Figure 3. Duality between knowledge in focus and its situation

We can find other relationships in the representations $\boldsymbol{r_e}$, $\boldsymbol{r_i}$ and $\boldsymbol{r_j}$. In these representations we found an associative relationship between $\boldsymbol{S_r}$ and $\boldsymbol{A_d}$. So, if $\boldsymbol{S_r}$ is the knowledge in focus then we can say that $\boldsymbol{A_d}$ is in the situation as it appears in Figure 3 but we will not be able to say that if $\boldsymbol{A_d}$ is the knowledge in focus then $\boldsymbol{S_r}$ will be the situation. The reason for that came form the result of representation $\boldsymbol{r_h}$ where we found $\boldsymbol{A_d}$ but $\boldsymbol{S_r}$ does not exist. The result of representation $\boldsymbol{r_h}$ is of no use for $\boldsymbol{R_t}$ since we cannot induce relationships that costruct the situation of $\boldsymbol{R_t}$. So, the relationships between the shape semantics construct situations based upon their use and where they are applied.

5. Discussion

Situated learning of design knowledge is founded on the notion that learning design knowledge does not exist out of context or situation but rather it is based on the situation where design knowledge is used and proven to be applicable. The situatedness of design knowledge has the potential basis for guiding the use of that knowledge. For instance from the previous example if we find a similar situation where $\boldsymbol{P_r}$, $\boldsymbol{A_d}$ and $\boldsymbol{R_c}$ exist then we would be able to apply $\boldsymbol{S_m}$. The same would happen if we find $\boldsymbol{P_r}$, $\boldsymbol{A_d}$ and $\boldsymbol{S_m}$ exist in a situation then we would be able to apply $\boldsymbol{R_c}$. In other situations where we might find $\boldsymbol{S_r}$ as the situation we would be able to apply $\boldsymbol{A_d}$. On the other hand if we found either $\boldsymbol{A_d}$ or $\boldsymbol{R_t}$ in the situation we will not be able to apply any knowledge based on the learnt relationships. This might be changed after the learning system is exposed to other shapes and adds to or refines the relationships that have been learnt previously. What these results tell us is that it is important to learn the knowledge associated with its situation when it was operating and proven to be applicable. This would provide a foundation for a learning system to apply what has been learnt based on the situation. So the situation would be the guide to apply the learnt knowledge. This explains how a situated learning approach would lead to a useful learning system and its application in design.

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