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S-CREATIVITY IN THE DESIGN PROCESS

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Abstract. This paper utilises the notion of situatedness from cognitive science. We elaborate the concept of situatedness in the context of design, and further examine our empirical data for evidence of it. We propose a method to measure the novelty in the design process and a modified model of creativity called situated or s-creativity.

1. Creativity versus Novelty

There is often a gap between computational and cognitive models of creative designing. One of the characteristics of designing being its unpredictability. This unpredictability, however, can lead to novelty in the design process and then contributes to the creativity of the design. Most computational models tend to be deterministic so that modeling creativity in these models inevitably encounters the problem of modeling unpredictability. To explore this issue, this study examined the novelty produced in the design process.

Within Csikszentmihalyi's (1996) creativity triangle this study focuses on personal level novelty. Personal novelty is called P-creativity by Boden (1990) and is contrasted with H-creativity that needs socio-cultural evaluation and acceptance. This paper aims to establish another dimension to describe novelty in the context of the design process.

This novelty is situated in the process. We have found many instances of this in the empirical data; a designer recognizing a new relationship in his sketches that he did not put there is one such example. Other examples include a designer inventing new meanings from his sketches that already had functionality. Also, a designer changing the requirements that were given by clients or invented by himself. These unpredictable instances contribute to the generation of novelty in perceptual, functional, and conceptual aspects of the design cognitive activities.

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The questions we ask are: what is the novelty in the design process? How does it contribute to creativity? What roles does it play in our understanding of creativity?

2. Novelty in the design process

In this study, novelty in the design process refers to something generated for the first time in this process. They can be new visuo-spatial relationships perceived from sketches, new functional references attached to sketches and visuo-spatial relationships, and new goalsetting driven from the progress of the design process.

Two different types of novelty in the design process are distinguished. One is the first response to a design situation, for example, seeing the distance between two new-made depictions. The other is the response that overrides the first response, for example, perceiving a new visuo-spatial relationship from existing depictions and re-interpreting the sketches. We claim that the former novelty was provoked by the design situation and the later one was by the design situatedness.

2.1 DESIGN SITUATION

The concept of design situation is derived from *situated cognition* (Clancey, 1997). Gero (1998) pointed out that "where you are when you do what you do matters", and described conceptual designing as a sequence of situated acts.

2.2 DESIGN SITUATEDNESS

From the constructive memory standpoint (Clancey, 1991), the sensory experience of an event might be the function of the most related experience and the situation where the memory was requested. The situated interpretation of the experience then is added into the experience as part of the memory, "value adding" in Gero's (1999) terminology.

One example from our study serves as an illustration. This occurred when a designer reasoned about the view of the building. He reported "When people go out, saying it's good because café is here and the gift shop is there. They see the pond and views, and it's directly leading to the sculpture garden."

This designer had seen these sketches several times, and produced two ideas about the views based on the same group of depictions. At this moment, he suddenly recognized a new visuo-spatial relationship from the existing depictions, and invented a new functional reference attached to it.

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As a result, the original functional reference was re-interpreted. Both the new visuo-spatial relationship and functional reference were situated, and both the new and old interpretations of these sketches became part of the experience. They caused a re-construction. This is what we regard as novelty provoked by design situatedness. It is a phenomenon we can see but yet to find a casual relationship between it and design activities.

In the literature, we found reference to this concept in different aspects of design activities. They have been called unexpected discoveries in the perceptual level, the re-interpretation in the functional level, and the renewal of goalsetting in the conceptual level (Suwa et al, 2000). They constitute an instance that happened for the first time in a given situation and reconstructs a previously existing representation.

We believe that the novelty provoked by design situation and design situatedness is essential for creativity in the design process. Without the evaluation of the fields and domains, we regard this kind of creativity as situated creativity, labeled S-creativity (similar to S-discovery in Suwa et al, 2000). It might not pass the evaluation of fields and domains, being regarded as creativity in social level. S-creativity, however, provides something new in a single design process.

The following section describes the methodological issues and the experimental data and procedures.

3. The Design Content Oriented Coding Scheme

The process and methods of protocol analysis in this study followed the series of retrospective protocol studies in sketches produced by Suwa and his colleagues (Suwa and Tversky, 1997; Suwa, Purcell and Gero, 1998; Suwa, Gero and Purcell, 2000). Consequently, the procedure, segmentation and the coding scheme are inherited from his original setting, but minor modifications were made in response to our findings and experimental data. The two set of data we analyzed in this study were from the experiments using architectural experts and novices carried out by Suwa and Tversky (1997). Sixty per cent of the encoded results were obtained with the cooperation with Dr Suwa, and thus had inter-rater reliability. The rest of the results were verified by the authors to secure its reliability.

After encoding, the design process was represented by a series of symbols according to the segmentation and encoding scheme. Some outline details are provided below.

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3.1 SEGMENTATION

The entire verbal protocol was divided into small units, called *segments*. The definition of segments in this study was that one segment accounts for a designer's single intention, and therefore consists of pieces of information that appear to have occurred simultaneously in the designer's mind.

3.2 THE CODING SCHEME

A *coding scheme* is the collection of the codes used to represent the design process. The coding scheme we utilized was well-established by Suwa, Purcell, and Gero in 1998 and further modified in 2000. It has been applied by the authors in a series of experiments (Tang and Gero, 2000; Tang and Gero, 2001a; Tang and Gero, 2001b; Tang and Gero, 2001c). This coding scheme consists of four cognitive levels that imply the sequential process a stimulus goes through from the external world to the internal world and vice versa. It is called the design content-oriented coding scheme, in short DCOCS (pronounce as dee-cokes). The four cognitive levels in DCOCS are physical, perceptual, functional, and conceptual.

3.3 INSTANCES

The *instance* in DCOCS refers to an observed occurrence of a specific activity in a level; for example, depicting a line is a drawing instance in the physical level. There are two kinds of instances in the physical level; they are drawing instance (D-instance) and looking instance (L-instance). For the rest of the levels, there is only one kind of instance that has similar name with the level. Each level may have more than one instances.

3.4 INDEX

An *index* is given to show the occurrence of the instance in the physical, the perceptual, and the functional levels. A *new* indicates the first occurrence of an instance in the design process observed, and an *old* indicates the any occurrence of an instance after the first one. This index plays important role in observing S-creativity. S-creativity indicates the change of the content of the connection that might be stored in designers' mind as experience. The change of index demonstrates the change of experience during the process of S-creativity.

Using segmentation, DCOCS, and index, the design process we observed is transformed into a series of information matrix. Figure 1 is one of 144 segments of the novice data we encoded. It consists the transcript and four cognitive levels, each level has instances of its own. For example, the

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perceptual level has a P-instance with a new index, and it depends on a D-instance with an old index in the physical level.

Transcript

FIrst, I was drawing over the site line to see waht kind of form the siteline is.

D_TYPE	INDEX	BASEON	L_TYPE	L_CONTENT
Dtd 1	old	L1	L1	given

P_TYPE	INDEX	P_CONTENT	INDEX	BASEON
Pfp 1	new	siteline	old	Dtd1

F_TYPE	INDEX	F_CONTENT	INDEX	BASEON

G-TYPE	F_CONTENT	TRIGGER
Type1.2 -1	to see the form of site line	Pfp1

Figure 1 The example of an encoded segment

In the following sections, we examine our encoded protocol for the instances of both kinds of novelty to understand the design process from the point of view of S-creativity.

4. Observing S-Creativity Types in empirical Data

The concept of S-creativity provided a new point of view toward the understanding of the encoded results produced by DCOCS. Novelty were produced by the process where a new instance was created first time in the perceptual, functional, or conceptual level; This instance had a new index. Regarding the two types of S-creativity, Novelty of design situation referred to the instance depended on instances with new indexes, while Novelty of design situatedness referred to the instance depending on instances with old indexes. In the later case, an old interpretation was replaced by a new interpretation. The interpretation here was in a broad sense; that means all the instance in the design process that based on some other instances.

4.1 DESIGN SITUATION INSTANCES

In this coding scheme there were three different classes of novelty of a design situation; they were new perceptual instances (P), new functional instances (F), and new goal-setting instances (G). All of them appear for the first time in the design process and are based on new instances.

A P-instance of novelty of a design situation is the perceiving of something new from new depictions at the first time, for example, the designer perceived the shape of the new depiction for the first time. In terms of DCOCS, it is illustrated by Pfn in Figure 2.

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Transcript

110 00:40:11 Then, I was still having a tough time, looking in this building. So, I am trying the other kind of method.

D_type		index	baseon	L_type	L_content
Dc	1	new		L1	44

P_type		index	P_content	index	baseon
Pfn	1	new	of the building	new	Dc1

Figure 2 A segment having a P-instance of novelty of design situation

An F-instance of novelty of a design situation is the attaching of a functional reference to new P-instances or new D-instances. For example, the designer attached the functional reference of "building" in the emerged shape he perceived in the sketches, Fnp in Figure 3.

A G-instance of novelty of a design situation is the goal-setting based on initial requirements, explicit design knowledge, or tacit knowledge occurring first time in a design process. Here it was triggered by new F-instances, new P-instances, or new D-instances. For example, the designer set up the goal to place the building by seeing the building and attaching the meaning to the shape, the Type 1.1 goal in Figure 3.

Transcript

2 When I was trying that I was also thinking of what kind of form the building would be. So this is

D_TYPE	INDEX	BASEON	L_TYPE	L_CONTENT
			L1	1

P_TYPE		INDEX	P_CONTENT	INDEX	BASEON
Pof	1	old	siteline	old	L1
Psg	1	new			

F_TYPE	INDEX	F_CONTENT	INDEX	BASEON
Fnp	new	building	new	Psg1

G-TYPE		F_CONTENT	TRIGGER
Type1.1	-1	place to put the building	Psg1, Fnp

Figure 3 A segment having a F-instance of design situation and a G-instance of design situation.

4.2 DESIGN SITUATEDNESS INSTANCES

Similarly, three different classes of novelty of design situatedness are defined. They were unexpected discoveries in the perceptual levels, re-interpretation in the functional levels, and renewed goals in the conceptual levels.

A P-instance of novelty of design situatedness refers to perceiving a new visuo-spatial relationship in existing sketches. For example, the designer perceived the symmetry in the existing depictions, Prp in Figure 4. This instance was called unexpected discoveries in previous literature (Schön and Wiggins, 1992; Goldschmidt, 1994).

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Transcript

5 Then I try to see the symmetry within the site along this line. here is one, here is another.

D_TYPE		INDEX	BASEON	L_TYPE	L_CONTENT
Dsy	1	new	Prp1	L1	1

P_TYPE		INDEX	P_CONTENT	INDEX	BASEON
Prp	1	new	symmtry of the site	old	L1

Figure 4 A segment having a P-instance of design situatedness

An F-instance of novelty of design situatedness refers to the attaching of a new functional reference to old P-instances or D-instances. For example, the designer gave a new meaning of "circulation within the site" to the old spatial relationship in the sketches, Frei in Figure 6. This instance was called re-interpretation in previous literature (Goldschmidt, 1994; Suwa, Gero and Purcell, 2000).

Transcript

28 00:09:06 I was also thinking of circulation within the site, say, you enter here, going to the exit

D_TYPE		INDEX	BASEON	L_TYPE	L_CONTENT
				L1	9
				L2	1

P_TYPE		INDEX	P_CONTENT	INDEX	BASEON
Por	1	old	between the inner access road	old/old	L1/L2

F_TYPE		INDEX	F_CONTENT	INDEX	BASEON
Frei	1	new	circulation within the site	old	Por1

Figure 5 A segment having a F-instance of design situatedness

A G-instance of novelty of design situatedness refers to the goalsetting that was extended from a previous G-instance. For example, the designer added more requirements for the coffee shop, Type1.3 in Figure 6. This G-instance might be caused by broadening or narrowing goals or by solving a problem caused by previous goal-setting.

Transcript

99 00:36:36 And then starting there first. I am trying to design the cafe. This edge is where this line (p: the perimeter line of the site in left front) is extending.

D_TYPE		INDEX	BASEON	L_TYPE	L_CONTENT
Dc	1	new		L1	34

P_TYPE		INDEX	P_CONTENT	INDEX	BASEON
Prn	1	new	alignment: between the cafe and	new/old	L1/Dc1

F_TYPE		INDEX	F_CONTENT	INDEX	BASEON
Fi	1	old	the cafe	new	Dc1

G-TYPE		F_CONTENT	TRIGGER
Type1.3	-1	put the cafe with special	Fi1

Figure 6 A segment having a G-instance of design situatedness

The design situation and situatedness occupied a significant proportion of the design process we measured. More than 65 per cent of the perceptual and conceptual instances were novel. In terms of the comparison between the difference of the novice and the expert, they demonstrated very different

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characteristics in the perceptual and functional levels, but similar characteristics in the conceptual level.

6. Conclusions and Discussions

We have briefly described a method to measure the novelty of the design process from the empirical data,. A model of creativity is created that included the process level. Finally, we propose that the design process consists of situated instances that make designing unpredictable.

6.1 MEASURING THE NOVELTY IN THE DESIGN PROCESS

The dichotomy between the novelties of design situation and design situatedness matches the geneplore model proposed by Finke, Ward, and Smith (1992). This model was proposed as a framework within which to describe basic cognitive processes related to creativity. It consists of two distinct phases: a generative phase constructing pre-inventive structures and an exploratory phase interpreting the pre-inventive structures. In our examples, pre-inventive structures are drawing instances and looking instances, and the exploratory phase is finding visuo-spatial relationships from them.

The novelty of a design situation results from a single generative and exploratory cycle, and the novelty of design situatedness results from repetitions of the geneplore cycle. Finke et al (1992) propose the cycle between the phases of generation and exploration typically occurs when people are engaged in creative thinking. By continuing these cycles, one would gradually focus the emergent structure on particular themes and explore more possibilities.

Given that the novelty of design situation and situatedness contribute equally to the creativity, we could not conclude whether the expert or the novice was more creative since the percentage of novelty was similar. However, the result significantly changes if we emphasize the role of novelty of design situatedness more. This changed emphasis is supported by the notion of lateral transformation (Goel, 1995). The result was that the expert had statistically more novelty of design situatedness than the novice in the perceptual, functional, and conceptual levels. The difference led to the conclusion that this expert was more creative than the novice.

Here, we created a method to measure the degree of novelty in the design process through the percentage of design situatedness in different levels in that process. This measurement could further be used as the indicator of creativity in the design process.

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6.2 THE SYSTEM MODEL OF CREATIVITY

The events we measure here are the behaviors demonstrated by the designers in the design process, instead of the processes themselves. Creativity, however, is the emergent phenomenon established by different components in the design process.

Creativity does not happen solely inside people's minds, and the evaluation of creativity changes when we think about creativity in a social context. Csikszentmihalyi (1996) proposed a system model of three components describing where the creativity exists. This perspective is concordant with the relative creativity that is proposed by Christiaans (1992). Following their descriptions, we propose that creativity is situated related to its context, including personal, field, and domain aspects.

This study introduced another level in the personal area in an attempt to capture the creativity in the design process. We examined the emerged behaviors of a single design process through the notion of novelties of design situation and design situatedness. They created novelty for a person in a design process. The outcome of this design process is an aggregation of all the instances, and the novelty of design situation and situatedness produce an impetus for creativity in the lowest level. One instance of design situation novelty may be new in this design process but old in the designer's life.

Given that we are able to evaluative novelty in the levels of process, person, field, and domain, the new model of creativity should be presented in a four-element square, Figure 7.

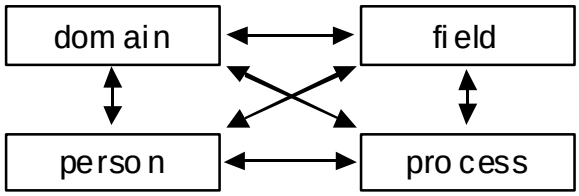

Figure 7 The New model of creativity that take account of the individual design process

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