Frames, Knowledge and Media

An investigative Study of Frame Systems within Computer and Paper Supported Collaborative Design Process

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Can media foster better performance of problem framing? Problem framing contributes to successful design learning. Minsky classified this activity into four types of frames. In collaborative design, media as external representation assist designers to converse their ideas with others and themselves. This paper explores the effects of rich and lean media on the context of frame systems within computer supported and paper supported collaborative design environments. Through conducting laboratory experiment we find that different media indeed can influence the distribution of frames along the whole design sessions. To investigate this phenomenon some possible reasons related to theory are explored, shedding light on our future study on design education.

Keywords: Collaborative design; design media; design cognition; design knowledge; frame systems

Introduction

Designing is the process of problem solving, in which design problems are classified into well-defined, ill-defined and wicked (1987:40). Architectural design is not a solo work but requiring of designers to discuss and communicate ideas with others (Cuff, 1991). During collaborative design, communication is essential for designers to re-conceive ill-defined or wicked problems in order to solve them. Through communication, designers bring their knowledge and experience to bear on those problems. Designers communicate with others and themselves through external representations presented in a variety of media. We can classify communication media in terms of their capacity to support knowledge communication into two categories, namely rich and lean media (Kock, 1998). Face-to-face communication, for example is the richest form because there are extremely short communication cycles that can include verbal and non-verbal representation; email systems and chat-lines are examples of lean media that better support long-term cycles (Shah et al., 1998). Media richness theory contends that rich media can better support knowledge communication and reduce equivocality (Daft et al., 1987). Recent studies, however, have found that lean media can engage people in more
high-level design communication and better group outcomes (Kvan et al., 1997, Kock, 1998). The question remains then whether rich or lean media are better for design framing.

This paper describes laboratory experiments engaged to investigate the effects of media on the framing process. We adopted Minsky’s (1977) frame systems as a coding schema to compare problem framing across three designed settings, namely online remote, online co-located, and paper based co-located setting. Online remote setting employs lean media for communication while the on-line co-located setting and paper based co-located setting adopt richer communication media.

**Frame systems: dual-cognition and dual-knowledge**

We have reviewed elsewhere (Kvan and Gao, 2004) related literature of problem framing to provide a clear framework for understanding design activities. The process illuminates how designers use their knowledge to introduce ideas that are “new” and “original”, an essential and initial aspect of Schön’s (1983) design process of “framing, moving and reflecting”. We have noted that in each of the formulations of the design process, a significant and necessary step occurs when a problem is changed from one that is vague, unsolvable or wicked into one that can be addressed with appropriate design knowledge or processes.

Minsky’s frame-systems classifies problem framing into four types, “syntactic frames”; “semantic frames”; “thematic frames” and “narrative frames” (Minsky, 1977). Following our model of high- and low-level design communication, we suggest that these four types of frames can be designated low-and high-level framing.

…high-level design communication encompassed strategic and significant decisions; low-level design communication, such as the color of a line or placement of a detailed item (such as a bench); task-oriented exchanges, such as reading instructions; and interface-oriented exchanges such as “speak up please” (Kvan et al., 1997:403).

Using this definition of problem framing and frame systems, we can attribute high-level design communication to high-level frames; task oriented exchanges and low-level design communication to low-level frames. We observe that syntactic and semantic frames, as stimulus actions, arise mainly from the perception and action loop. These frames are not supportive of planning and abstract reasoning, therefore belonging to low-level frames. Thematic and narrative frames are evocative, engaging deep structures of memory, thus considered high-level frames.

**Dual-cognition and dual-knowledge**

Norman (1993:23) has distinguished between experiential and reflective cognition. Experiential cognition is “reactive, automatic thought, driven by the patterns of information arriving at our senses, but depend upon a large reservoir of experience”. Reflective cognition is slow, requiring people to “store temporary results, to make inferences from stored knowledge, and to follow chains of reasoning backward and forward”. This is a mode for conceptualization, for planning and reconsideration, from which new ideas appear. Using the distinction of low and high level frames drawn above, we see a correspondence to Norman’s models of experiential and reflective cognition.

Framing and knowledge are intertwined; framing can only occur if the designer has a knowledge context in which to devise frames. The choice of frames can act as triggers to particular chunks of knowledge; by reframing, new chunks can be accessed (Gao and Kvan, 2004). Comprehensive reviews of the literature about the relation between frame and knowledge have been explored recently; therefore we will not reiterate all of the detail here.

We can further define design knowledge into strategic and tactical knowledge. Strategic knowledge as meta-knowledge is “a set of principles and sound evidence; it provides an ordered basis handling
new development and situation. Tactics, on the other hand, are akin to techniques and rules that do not necessarily transfer from a familiar scenario to a new or unexpected one” (Kvan and Candy, 2000:430). We might then profile significant design activity as strategic knowledge, applied in reflective cognition, using high level frames.

**Media as external representations in supporting design communication**

Cognitive work relies upon representations of thought in different media.

„The media with which we store and transmit information are key components to knowledge work and are continually developed. The media include ourselves as cognitive critters, computers of various sorts, and paper documents of various sorts“ (Sellen and Harper, 2001).

Different environments not only trigger designers to frame problems in different ways, therefore influencing the operation of problem construction. Norman (1993) points out the power of external representations in contributing to different types of cognition. Appropriate representations can initiate mental imagery to help understand a problem situation and facilitate creative thinking about the solutions (MacEachren, 1995). Mental imagery can be understood as high-level visions relying on the previous stored information about the properties of objects and events (Kosslyn, 1994:53), thus it consists of interactions between short-term memory and the long-term memory facilitated by external representations. The choice of media provide for different types of external representations for communication (Mumford et al., 1994). In collaborative work, these external representations come to the fore and assume greater importance.

Several studies have been carried out to investigate the effects of computer collaborative tools on design communication. Kvan et al. (1997) found that designers engage in more high level communication when using textual communication tool (lean media) compare to using video conferencing tools (rich media). Gabriel and Maher (1999) conducted three sets of experiments adopting different types of communication, namely face-to-face communication (rich media), computer-mediated using video conferencing (rich media), and computer-mediated using chat-line (lean media). They too found that design communication was significantly different among those three settings and, in particular, that lean media of text better supported design collaboration. Neither these nor other studies have identified the ways in which the media supported problem exploration and definition, noting only that problem spaces were more widely searched in lean media.

**Textual and verbal communication**

Text, as reflective representation, supports high level communication. Lawson and Loke (1997) observe that text plays a key role during design process for interpreting design ideas. Norman (1993:246-247) notes that writing permits ideas to be permanently recorded on the paper and allow people to read, thus prolonging the time for reflection. Olson (1994:241) examined the potential of writing to the development of meta-idea and points out that writing frees cognition from memory, allowing a new form of conversation. Text, therefore, engages intellectual activity, initiates mental process and facilitates a creative attitude (Plocke, 1996). Spoken words lack critical affordance, they are low-speed, and low-capacity communication. The information carried by spoken words is only available in the duration of sound itself (Norman, 1993:108). Compared to voice, therefore, text can facilitate more mental imagery, prolong the duration of reflection, and enable more reflective cognition. By these means, a designer may be able to engage in more effective reflection using text than spoken words.

**Paper and digital based sketching—non-verbal representation**

Paper-based sketching is considered an essential design thinking tool (Robbins, 1994). Goldschmidt
has suggested that „sketching is thinking“ and observes that „the search cycle ends when the designer is ready to attempt a ‘harder-lined’ drawing“ (Goldschmidt, 1991:130). Schön and Wiggins (1992) have called this a „reflective conversation with materials“ that enables „an interaction of designing and discovery“; through sketching designers can find surprising or unintended results.

In co-located environments, paper is thought to better facilitate design communication than digital tools in that it dissolves the boundary between participants and more immediately connects designers to sketching (Sellen and Harper, 2001). Network tools, however, free people from limitation of co-located environments and are thus increasingly used to support collaborative communication. As digital tools become familiar, we find people working together online in co-located and geographically distributed settings. Unlike paper-based drawings, digital sketching (e.g. Whiteboard) can be used in both distal and collocated collaborative environments.

**Laboratory experiments**

Three settings were set up to simulate three design environments, namely an online remote setting, an online collocated setting and a paper-based co-located setting. The three settings offer a range of environments for design communication, from lean to rich. The rich media environment of the paper-based collocated setting simulates traditional design studio setting (Schön, 1985, Cuff, 1991) where design. In our online co-located setting, also a rich media environment, designers discussed face-to-face and used a shared online digital sketching tool (whiteboard) for nonverbal communication. The online remote setting established a lean environment in which designers sat in different locations and used online chat-line and shared whiteboard to communicate each other. Table 1 shows the description of the three settings in detail.

We paired thirty-six postgraduate students together to spend forty minutes in solving a wicked design problem in one of the three different designed environments. The design problem required the students to provide access up a steeply sloping urban park from a bus stop on the lower road to the entrance of hospital on the upper road while allowing a parking area to be accessed from a side road midway up the slope. It is a simple open-ended, „real-world“ wicked problem and has been used in previous studies (Kvan et al., 1997). The subjects have been taught architectural design for more than three years in the same educational setting. Previous experiments had demonstrated that the students are able to deal with this simple wicked problem using their shared design knowledge domain within the given time.

**Coding schema**

Our earlier study (Gao and Kvan, 2004) isolated framing activities by using Schön’s design process (framing-moving-reflecting) and found that significant difference of framing activities exists between

<table>
<thead>
<tr>
<th>Design environments</th>
<th>Design instruments</th>
<th>Media adopted in design communication</th>
<th>Attributes of design media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper-based collocated</td>
<td>Paper; pencils; rulers; etc.</td>
<td>Verbal communication</td>
<td>Rich media</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paper based sketch</td>
<td></td>
</tr>
<tr>
<td>Online collocated</td>
<td>Hardware: two computers with keyboard and mouse;</td>
<td>Verbal communication</td>
<td>Rich media</td>
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<td></td>
<td>Software: Microsoft Net-meeting</td>
<td>2D digital based sketch (Whiteboards)</td>
<td></td>
</tr>
<tr>
<td>Online remote</td>
<td>Hardware: two computers with keyboard and mouse;</td>
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<td>Lean media</td>
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*Table 1*

*The description of the three design environments*
remote and both co-located settings. In this paper we have applied Minsky’s frame systems as a coding schema to the data gathered in the earlier study in order to identify high and low level framing communications during the design sessions. Table 2 presents the detail description of the four frames.

Results

Using the schema described above, we coded the protocols and identified the nature of design framing activity in five-minute intervals for the duration of the design exercise. A summary of results is presented in Figure 1.

Paper based co-located setting (Rich media)
In the first fifteen minutes subjects mainly discussed basic design issues, engaging primarily with low-level frames. During the middle portion of the design session, subjects began to engage in more high-level frames after negotiating. Of particular interest to us is that during the last part of design session, the proportion of both levels of frames appears to decline.

Online co-located setting (Rich media)
Low-level frames are more dominant than high-level frame along the whole design session in this setting, decreasing throughout the design session with no increase in high level framing later. These results suggest that only using digital graphic tools appears to be not appropriate in design collaboration.

Remote setting (Lean media)
In remote setting, low-level frames appear more dominant than high-level frames during the first ten minutes. The proportion of high-level frames dominated during the last thirty minutes, unlike in the other two settings at that phase of the exercise. This setting fostered subjects to communicate each other by using chat line, thus they had to adapt their behaviors to writing down their ideas and meanwhile reading their partners’ instead of spoken words. Textual supported communication (lean media) therefore does not diminish framing activities but, instead, facilitates designers in producing more higher-level frames. It appears that the range of the digital tools in distal collaboration encouraged students to engage in a greater the proportion of high-level frames during last portion of the design session. This finding therefore shows the advantage of distal collaboration supported by chat lines and 2D digital sketching if compared to face-to-face paper based sketching.

Comparative results across three settings
Figure 2 shows the comparative distribution of the low and high-level frames across the three settings. The difference of low-level frames across the three settings is not significant. The proportions of low-level frames of the three settings reduce dramatically when the design continues. Low-level frames correlate to experiential cognition driven by tactic knowledge. When designing becomes more specific low level frames are appearing to be recessive, thus tactic knowledge is gradually not demanding.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Low level frames</td>
<td>Syntactic Frames: Mainly verb and noun structures. Prepositional and word-order indicator conventions.</td>
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<td></td>
<td>Semantic Frames: Action-centered meanings of words. Qualifiers and relations concerning participants, instruments, trajectories and strategies, goals, consequences and side effects.</td>
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<tr>
<td>High level frames</td>
<td>Thematic Frames: Scenarios concerned with topics, activities, portraits, setting. Outstanding problems and strategies commonly connected with topic.</td>
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<tr>
<td></td>
<td>Narrative Frames: Skeleton forms for typical stories, explanations and arguments. Conventions about foci, protagonists, plot forms, development etc., designed to help a listener construct a new, instanitated thematic Frame in his own mind.</td>
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Table 2
The description of coding schema
High-level frames contribute to good design results, requiring reflective cognition driven by strategic knowledge. The distributions of high-level frames across the three settings however are significantly different, indicating that these high-level activities are more dependent on media or tools adopted than low-level activities. These and earlier results suggest we need to examine the cognitive support of those digital environments to develop contexts more suitable for designing and leaning (Kvan et al., 1997, Kvan and Candy, 2000).

**Conclusions**

The above results suggest chat-line communication supported by text with digital sketching can foster people to have more reflective cognition and high quality of design performance compared to adopting face-to-face media (rich media), such as voice and paper or digital based sketching in this case. In remote setting reflective representations, textual supported communication, support reflective thoughts; thus more high-level frames occur. This finding corresponds to previous studies (Kvan et al., 1997). By using chat-line, subjects not only use text to communicate each other through writing and reading, but also have the opportunity to read the previous design communication stored by chat-line, thus might foster reflective cognition or deliberation, the long term action and avoid fixation of design ideas.

Problem framing plays a key role in design cognition and creative thinking, contributing to enhance students’ design learning performance. High-level frames correlate with deep understanding of the design problem, contributing to achieve high-level learning (Minsky, 1977). The study indicates lean media seems to better support designers to engage
high-level framing compared to adopt rich media; without isolating the correlation to framing as we have done here, previous studies also have reached similar conclusions, noting that lean media such as synchronous chat-line communication (Kvan et al., 1997), semi-synchronous web board conference systems (Kvan and Candy, 2000), asynchronous e-mail systems (Kock, 1998), and immersive worlds (Schnabel, 2003) can help designers.

**Future work**

The reason we studied the development of high-level frames is that they are meaningful in examining design education and pedagogy, as set forth in Kvan and Candy’s (2000) strategic knowledge and Plocke’s (1996) second way of teaching design. The pattern of high-level frames among our three experimental settings suggests the possibility for structuring a sequence of design activities employing appropriate media to help designers engage more high-level framing activities. A case study will be conducted to test this hypothesis.

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