PROBLEM FRAMING IN MULTIPLE SETTINGS

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Abstract. In order to improve pedagogical effectiveness, this study aims at gaining an insight on architectural students’ problem framing activities using digital versus paper media. The role of problem framing in design process and its contribution to design learning has been variously studied. Laboratory experiments were conducted to investigate the role of problem framing under three settings namely online co-located, online remote and paper-based co-located. Students were asked to spend 40 minutes in solving a wicked design problem collaboratively. The results show that in the online remote setting the activities of problem framing are significantly different compared to those in the other two co-located settings. We find more density of framing activities happened in the online remote setting than in the other two settings. We also find there is no significant difference of problem framing between online co-located and paper-based co-located settings. Through this study we suggest that multiple design tools need to be considered to support design learning and teaching.

1. Introduction

Design problems have been categorized as well-defined, ill-defined or wicked, reflecting the extent to which their solutions are immediately apparent (Rowe, 1987:165). Design processes have been explored extensively and described according to features of these different categories of design problems (Asimow, 1962, Simon, 1996, Schön, 1984). Common in these studies we find the activity of problem definition being applied to transform ill-defined or wicked design problems into well-defined. In particular, Schön’s cyclical design process, which he describes as a “reflective conversation with the material of the situation”, has been extensively used in research into design education and design activities.
(Oxman, 2002). Schön has referred to the act of problem definition as “problem framing”, the term we will use in this paper. He postulated that the activity of framing was central to a successful process of design and hence is a key activity in design.

Paper-based sketching helps designers engage in the design process, in significant part so that designers can frame problems effectively (Goldschmidt, 1991, Schön and Wiggins, 1992). Digital based design tools have gained prominence in design processes but have typically been used in discrete problem solving processes or in presentation of work. Although some architects suggest that the potential of digital representation challenges convention representation fundamentally, without which designers will not exceed the paradigm of Renaissance world view (Eisenman, 1996), others conjecture that digital tools inhibit communication between the designer’s mind and hand, interrupting the design “conversation” (Corona-Martinez and Quantrill, 2003). Designers, therefore, are often reluctant to use digital tools to ‘aid’ them in this creative and cyclical design process. This attitude has also influenced the teaching of design and hence use of digital tools in architectural education beyond simply use as skill building tools.

The assumption that digital tools interrupt the design conversation is not supported by earlier research. Previous studies have shown that digital tools can afford high level communication including ‘frame’ and ‘reflecting’, which contributes to successful design and design learning (Kvan et al., 2003, Kvan, 2002). The question examined in this research, therefore, is whether the use of digital tools inhibits the “conversation” by reducing problem framing activities specifically.

This research was carried out by observing pairs of postgraduate students in solving the same problem under different conditions. Teamwork process-based protocol analysis was utilized to compare the design activities of postgraduate students using different design tools in different design settings. A coding scheme was developed from Schön’s model of design process in order to encode the design behavior. The design task, which has been used in previous studies (Kvan, 2002), requires these students to spend 40 minutes in solving a real world, wicked design problem. Three settings were set up: online co-located, online remote and paper-based co-located. In this paper we apply the coding scheme to isolate the activities of framing, and report the results and discuss the differences.

2. Background

While well defined problems are solved by relatively straightforward processes, the solution of ill defined or wicked problems is central aspect of research in creative design (Schön, 1985, Cuff, 1991). Thus, the activities in
solving such problems is a valuable focus of effort in the domain of design research (Simon, 1996, Rowe, 1987, Mitchell, 1994, Buchanan, 1995, Schön, 1985).

Rowe (1987) notes that there are two kinds of knowledge: “procedural knowledge” and “substantive knowledge”, observing that they are intertwined and related during designing. In his description of Simon’s “know how”, he distinguishes such design activities as “purposefully planning”, while Schön’s “know that” is the design activities of “engagedly conveying”.

Mitchell (1994:209) describes design as a form of functional interpretation. In his view, the duty of an architect is to bring order to the world. Thus, “a design problem exists when you want something but cannot immediately see how to get it: intellectual effort is to find a solution ... the task is to manipulate the design world to produce such a state and to demonstrate that this state satisfies the predicates of the formulation” (Mitchell, 1994:64). Here we can see that Mitchell’s approach is a design activity that is “planned” to satisfy the functional requirements and the form of compositions by utilizing design rules such as types and vocabularies.

Simon (1996) describes the procedure of ‘manipulation’ or ‘planning’ as a heuristic search in which the size of the problem spaces is reduced through decomposing design problem into several sub-problems. Simon suggests that such a search could be automated using artificial intelligence, with systems that are “not only ... capable of discovering new concepts but also they can plan sequences of experiments, postulate reaction paths for complex chemical reaction, induce rules for interpreting data from mass spectrogram analysis, and enlarge the state space of a system to accommodate variables that are not directly observable” (Simon, 1996:107). In such an expandable search process, the problem is redefined and reconceptualised.

Buchanan (1995) considers that design consists of both the manipulation of exiting objects but also the “inventive science ... which has not subject matter aside from what the designer conceives it to be”. This step of conception belongs in the act of framing, where the designer creates an understanding where none exists. Two important facets therefore are involved in solving wicked problems: first is to conceive a new problem: ‘a working hypothesis’, second is to the knowledge of planning cross-disciplines to relate the new thing.

2.1. PROBLEM FRAMING

The design theories discussed above do not define the activity of problem framing explicitly yet all imply such an activity. In all, the act of designing is predicated upon a ‘problem’ being identified. Thus, 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. This activity has been identified as redefinition, re-conceptualization or re-hypothesized. Schön (1983) identifies the concept of problem framing more clearly.

As [inquirers] frame the problem of the situation, they determine the features to which they will attend, the order they will attempt to impose on the situation, the directions in which they will try to change it. In this process, they identify both the ends to be sought and the means to be employed. (Schön, 1983:165)

He develops this idea further, describing a cyclical design process involves three key elements, namely “framing”, “moving”, and “reflecting” (Schön, 1984). In this description, “framing” is located at the first part of this cycle, while “moving”, an exploratory activity, depends on this “framing”. “Reflecting”, which is that the designer allows the situation to talk back, permits a new way to see things, causing a new design cycle to be initiated going through “reframing”, “removing”, and “reflecting”. This model has been adopted by others in studies of design education and design media (Oxman, 2002) and serves well as a basis for the research reported here.

2.2. FRAMING, FIXATION AND LEARNING

Problem framing not only is an essential element in the design process, but plays an important role in design learning as well (Dewey, 1933, Argyris, 1993, Smith, 2001). Schön has categorized design as a reflective conversation (Schön, 1983). Dewey (1933:106-114) points out five essential functions of reflective activity: suggestion; intellectualization; hypothesis; reasoning; testing the hypothesis by action. Although his concept of reflection has made a unique impact on education and influenced next generations (Schön, 1992), his description of the five activities are problematic. The first phrase, suggestion activity, tends to lead people to have possible solution (pre-conception) directly in their minds. Although he suggests that the sequence of the five phrases is not fixed, he did not clearly define that reflection engages an interactive or dialectical process, therefore the sequence of these activities is ambiguous.

Building upon Dewey’s theory, Schön (1992) seems to solve this problem, and develops the cyclic design process of design. This design process is also a learning process (See Smith, 2001 for more details). Through this process architectural students re-represent design problems by looking at these problems in different ways, therefore prevent them being stuck on early design solutions, thus enhancing their design learning (Sachs, 1999, Kvan, 2002, Purcell et al., 1993). Sachs (1999) claims that the most
common method for “getting unstuck” is to seek help and try to see the design in a new way. Kvan (2002) suggests that the re-representations of design concepts and solutions has the potential to support students design learning.

Argyris (1993:3) provides three reasons to identify organizational learning. The first reason is to learn is to close the gap between our stored knowledge and the knowledge required to act effectively in a given setting. The second is a continual need to monitor our intention and implements that become an iterative process required learning as well. The third is the necessity to codify these effective actions to make them explicit.

Learning occurs when we detect and correct error. Error is any mismatch between what we intend an action to produce and what actually happens when we implement that action. It is a mismatch between intentions and results. Learning also occurs when we produce a match between intentions and results for the first time. (Argyris, 1993:3)

He describes two models of the organizational learning, single-loop learning and double-loop learning. Single-loop learning is the model adopted by many professionals to defend themselves routinely, which prevents them from continuously learning and change, while the double-loop learning is the model that could help professionals enhances their competences. The main difference of both learning models is located at the first part that is governing variables to bridge the knowledge gap.

The governing variables are identified by Argyris as master programs. Since these master programs are a set of values which actors choose to guide their intended consequences, they are similar with the concepts of problem framing. Thus, in the field of learning theories the activities of problem framing has the potential to enhance students’ design competence.

2.3. CONTRIBUTION OF MEDIA TO PROBLEM FRAMING

Designers use a variety of media in design activities such as sketching, drawing, and modeling to generate ideas, explore problems and identify solutions (Corona-Martinez and Quantrill, 2003). The relationship between the medium and the activity has been explored in a number of studies.

Schön and Wiggins (1992) suggest “reflective conversation with materials” as “an interaction of designing and discovery” as a potential of sketching, which could assist designers to find surprised or unintended results. This interaction can be found in Goldschmidt’s dialectics of sketching. She explores the reasoning of sketching used by designers and finds a dialectical pattern of design activities when designers engage in designing, such as “see as” and “see that”. She notes that “sketching is thinking” and continues to observe that “the search cycle ends when the
designer is ready to attempt a ‘hardline’ drawing” (Goldschmidt, 1991:130). Although Goldschmidt wrote before computer tools were widely used in design activities, if could be inferred from this statement that she supports the notion searching, hence designing, ends when hard lines are used, as is the case on the computer screen.

Paper based design tools have been dominant in studio teaching since the formalization of design learning in the Ecole des Beaux Arts. Indeed, the advent of the use of paper in designing has been noted as the moment at which design became an intellectual activity (Wigley, 2001). For many designers, the medium is inextricably bound into the activity of designing, with designers largely using paper to frame design problems (Robbins, 1994). Compared to digital design tools, paper seems to afford more predictability, therefore afford more communication (Sellen and Harper, 2002). Others suggest digital design tools inhibit communication between mind and hand because of the precision demanded by the system, hence interrupting the conversation of design and disrupting ‘framing’ activities (Corona-Martinez and Quantrill, 2003, Lawson, 1994). Corona-Martinez and Quantrill (2003:176) observe that the computer is not a drawing instrument like a pencil but engages the designer in a different relationship with the act of drawing, changing the act with “an intermediate system of drawing according to our indications provided by the pressure on the button of mouse, which in turn responds to the feedback from our sight of what appears on a screen ... something new has invaded the apparently intangible craftsmanship of drawing”.

3. Laboratory experiments

In this study we carried out laboratory experiments to compare the designers’ activities in paper-based and digital-based studio settings, and predict the design activities of subjects are different in those settings. In order to make these settings comparable, in this research we choose Microsoft Net-meeting including whiteboard and chat line as digital design tools and paper-based design tools.

3.1. PROTOCOL ANALYSIS

Protocol analysis was first used by Eastman as a means to study design cognition (Eastman, 1968). Since then protocol analysis has mainly been divided into two types such as process-oriented approach and content-oriented approach (Dorst and Dijkhuis, 1995). Content-oriented approach focuses on information contents of what designers think (Suwa and Tversky, 1996, Kavakli and Gero, 2001). Process-oriented approach looks into the
procedure of designing, and is mainly used in verbal protocol analysis. Compared to content-oriented approach, scholars can isolate different design behaviors that they want to concern by using process-oriented approach. Being aware of the weakness of concurrent protocol analysis (Lloyd et al., 1995), teamwork based protocol analysis has been developed (Dorst, 1995). Through communicating design issues with each other, subjects could easily verbalize their design thinking. Thus, the method of teamwork based protocol analysis was adopted in this study.

3.2. EXPERIMENT DESIGN

The experiment has been used in previous studies to examine the efficiency of design learning in different computer supported collaborative settings (Kvan et al., 1997). This time we adopted one online remote studio setting from the previous studies and developed other two settings. They are the online co-locate and paper based co-locate. Both settings were recorded by digital-cameras set up to capture the verbal and visual data (Table 1.).

<table>
<thead>
<tr>
<th></th>
<th>Paper based co-located</th>
<th>Online remote</th>
<th>Online co-located</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design tools</td>
<td>Paper; pencils; rulers; etc.</td>
<td>Hardware: two computers with keyboard and mouse; Software: Microsoft Netmeeting</td>
<td>Hardware: two computers with keyboard and mouse; Software: Microsoft Netmeeting</td>
</tr>
<tr>
<td>Communication</td>
<td>Face to Face</td>
<td>Chat line</td>
<td>Face to Face</td>
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In the paper-based co-located setting, subjects worked collaboratively on a shared drawing table sitting face-to-face by using paper-based design tools. In the online remote setting, subjects are located remote from one another and communicate by chat line while drawing on a shared white board. While in the online co-locate setting, subjects drew on a shared white board while communicating face-to-face (Figure 1.).
The task is 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. During the 40 minutes’ design exercises, subjects were asked to think about design issues of landscape, playground, car park, and sitting area, etc. while accommodating appropriately sloped pathways. This task is a simple open-ended, “real-world” wicked problem, which has been used in previous study (Kvan et al., 1997). Figure 2 shows an example of a final result in which the initial problem condition can also be observed.
Eighteen pairs of postgraduate students joined in this research project. The subjects have been taught architectural design for more than three years in the same educational settings, therefore they are able to deal with this simple wicked problem by using shared design knowledge domain, and can finish the design task within the given time.

3.3. CODING SCHEME

We adopted Schön’s design process consisting of “framing”, “moving”, and “reflecting” as coding scheme, and developed this by adding some details into it. ‘Framing’ refers to identify a new design problem or idea, interpret further from design brief; and introduce totally new design ideas or realize totally new design information that has not mentioned before; ‘moving’ refers to produce a tentative solution of this idea or problem; and ‘reflecting’ refers to evaluate this solution, that is to “allow the situation to back talk to him (designer)”, leading to reframe, retest and re-evaluate (Table 2.). The verbal protocol data were encoded according to this coding scheme.

<table>
<thead>
<tr>
<th>Coding category</th>
<th>Definition</th>
<th>Examples</th>
</tr>
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<tbody>
<tr>
<td>Framing</td>
<td>Identify a new design problem; Interpret further from design brief;</td>
<td>‘We have to provide a sense of arrival at each site access point.’</td>
</tr>
<tr>
<td>Moving</td>
<td>Proposed explanation of problem solving, a tentative solution.</td>
<td>“Maybe some here can put the playground”</td>
</tr>
<tr>
<td>Reflecting</td>
<td>Evaluate or judge the explanation in ‘moving’.</td>
<td>“I think it is ok. Just represent the design”</td>
</tr>
</tbody>
</table>

4. Results

We counted the number of these design activities in terms of this “framing-moving-reflecting” model and calculate the percentage of those activities (Table 3.). We found that the percentage of “framing” in online remote setting is 43.8% is higher than that in paper (32.5%) and online (35.2%) co-located settings. This finding correlates with findings in previous studies that
low-band width (chat line) affords more design exploration than high-band width (e.g. face to face) (Kvan et al., 1997).

![Figure 3. The percentage of the three design activities across the three settings](image)

ANOVA test was applied to examine whether there were significant differences among these settings (Table 4.). The results of significant test of “framing” in the three settings show that the average distribution of “framing” is significant difference when comparing online remote to online co-located setting (F (1,14) = 42.83, p<0.001), and comparing paper based co-located to online remote settings (F (1,14) = 26.4, p<0.001), however no significant difference is found when comparing online co-located to paper based co-located setting (F (1,14) = 0.22, p = 0.64).

<table>
<thead>
<tr>
<th></th>
<th>Online remote vs. Online co-located</th>
<th>Online co-located vs. Paper co-located</th>
<th>Paper co-located vs. Online remote</th>
</tr>
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<tbody>
<tr>
<td>F(Framing)</td>
<td>42.83</td>
<td>0.22</td>
<td>26.4</td>
</tr>
<tr>
<td>p</td>
<td>&lt;0.001</td>
<td>0.64</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>F(Moving)</td>
<td>197.7</td>
<td>17.7</td>
<td>257.4</td>
</tr>
<tr>
<td>p</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>F(Reflecting)</td>
<td>77.45902</td>
<td>3.48726</td>
<td>97.05918</td>
</tr>
<tr>
<td>p</td>
<td>&lt;0.001</td>
<td>0.0829</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

These results therefore present that no significant difference of “problem framing” is found in both co-located settings (paper vs. digital), whereas significant differences of “problem framing” exist when comparing the
remote setting to two co-located settings, with more proportion of framing activities in the remote setting.

5. Discussion

Problem framing is correlated to learning. If the use of chat line increases the proportion of framing activities, what are the implications of these results for design learning? Do digital design tools benefit designers beyond automation of repetitive tasks?

Importantly, this experiment demonstrates that using digital design tools do not interrupt design process, suggesting that the preconception of digital tools interrupting the design conversation is unfounded, at least in so far as the conversation is measured as a framing process. The results also suggest that the media has some influence on the activity of problem framing.

This and earlier studies together suggest that tools that facilitate multiple representations such as diagrams, text, and models can enhance students’ design learning in a number of ways (Kvan et al., 1999, Kvan et al., 2000). It would appear from this study that digital tools belong in the category of tools which contribute to the process of design and should not be relegated to a role of supporting ‘hardlining’ and presentation after design thinking is completed. The positive effect observed here in the non-co-located setting continues to surprise the researchers as it is counter-intuitive and is not supported by the lore of designing, deserving further consideration.

That modes of representation affect designing has been examined elsewhere and several indications are that digital design opens up new and positive possibilities. Kvan, Wong et al. (2003) identified the value of engaging in multiple representations during design learning and concluded that structural activities with multiple representations including text, diagram, and model support better learning. Perhaps the increased framing observed here is a contributor to the challenge of using digital tools to fundamentally change methods of design.

Some caveats deserve mention. In these experiments, the activities of “framing”, “moving” and “reflecting” took place in a context that may be somewhat different to that of daily practice. In the remote setting, subjects used a chat-line to communicate their design ideas and whiteboard to share their on-the-spot explorations (Schön, 1985), thus the activities of “framing”, “moving”, and “reflecting” therefore are differentiated by medium. The design process appears to be more structured in this experimental context than that more commonly encountered in the messy settings of design practice.

Even with such caveats, we may draw some initial conclusions or identify opportunities for further research. Earlier studies have noted that chat line
conditions are characterized by the introduction of more new ideas and that less fixation is observed. This may be correlated to the higher frequency of framing in the chat line condition noted in this experiment.

Co-located environments are popular in design education and practice, especially where practices are separated by several time zones; such conditions or work need appropriate tools to support designing in these settings. The implications of these findings should not be interpreted only in the design of digital tools but considered also in non-digital contexts. We may also consider the processes undertaken in design activities in co-located settings. It could be that traditional studio tasks need to be redefined to include non-co-located activities in order to promote particular problem framing opportunities or that we need to find ways of realizing benefits in co-located digital work, for example by working through chat media. We need also to investigate whether the difference in problem framing activity correlates to learning. It is possible, for example, that the increased problem framing scaffolds design learning. To do that, we need to examine why more framing occurred in distal activities in these experimental conditions.

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