The Cognition of Designers in Developing Design Concepts:

The Roles of Experience, Heuristics, and Linguistics

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This paper will review some of the ways in which expert designers differ from novice designers in their approaches to developing design concepts. The specific questions we will look at are: What are some of the cognitive heuristics employed by designers, and how do they affect the problem solving process and creative outcomes? What role does language play in developing design concepts? How can a deeper understanding of the cognitive heuristics employed by designers help to improve design education and inform design professionals who wish to gain a deeper understanding in the area of design thinking?

As a continuation of my paper *Novices and Experts in the Graphic Design Phase of Concept Development* (Ciampa Brewer, 2010), I will explore more deeply some existing research on the differences in cognitive behavior and creative practices of expert and novice designers. Through deeper research and reflection of these studies, I hope to gain a deeper understanding of some of the ways I can improve my personal practice habits. This research will also inform the growing topic for my CCT synthesis, the development of a CCT toolbox for designers.

I. Background

Let us first begin to understand what a design concept is. As Landa and Gonnella (2001) describe it:

A concept or idea is the fundamental underlying thinking behind a [design] piece. Essentially, a concept means that you have a reason for what you are doing in a design. It’s
the framework for all your design decisions. Thinking up a concept is the difficult part of the creative process because it involves problem solving and creative visual thinking. (p.10)

The early phases of the design process include problem definition, research on background information relating to the problem, concept ideation and concept development. Some of the general methods designers use in developing concepts includes brainstorming and sketching, just to name a couple. A brainstorming session might start out by listing descriptive words or phrases for a project, such as “elegant; simple; rock and roll music; modern; dark,” et cetera. A descriptive word could even become the overarching concept for a design. Eventually the ideas, or concepts, are transformed into visual representations. That is a condensed version of the concept development process—there are many factors and considerations that go into creating design concepts, and each designer’s cognitive process may be quite different. Let us now look at some of the differences between novices and experts in their creative processes.

II. Some Differences between Novices and Experts

In *Novices and Experts in the Graphic Design Phase of Concept Development* (Ciampa Brewer, 2010), I drew many connections between my study findings and some existing literature on the differences between experts and novices. This section aims to look at some of these connections more closely.

Understanding the Problem

As mentioned, problem definition is one of the first steps in the design process, so it makes sense that one of the first strategies employed by expert designers seems to be that of problem understanding. As Casakin (2003) suggests, problem understanding is a crucial part of
design problem solving, and while elaborating on their understanding of a problem, experts dedicate a substantially greater effort than novices (p. 5). This observation was evident in my own study findings, as the expert devoted more time to reading the information that was presented to her for the design problem prior to beginning to develop ideas and sketches.

Studies in areas such as physics, mathematics, and history also demonstrate that experts first seek to develop an understanding of problems, and this often involves thinking in terms of core concepts or big ideas (Bransford, Brown, & Cocking, 2000). The ability of experts to “chunk” meaningful patterns of information would help to explain their “superior recall ability.” In an interesting study by Kavalki and Gero, simultaneously occurring cognitive actions were observed and compared in novice and expert designers. They looked at these “cognitive segments” as chunks, and through investigating the concurrent cognitive actions, they found that the expert's cognitive actions were well organized and clearly structured, while the novice's cognitive performance was divided into many groups of concurrent actions (Kavakli and Gero, 2002). In closer detail:

“We can see that many concurrent cognitive actions coexist in the novice's design protocol, while only a small group of cognitive actions occurs in parallel in the expert's. Table 5 indicates that the expert's cognitive activity is based on the coexistence of a limited number of actions (5 at most) for each primary concurrent action code. However, in the novice's protocol secondary concurrent actions range from 7 to 16, which is more than the human short term memory can manage at one time (Miller, 1956). Whereas the expert’s working registers stay in the limits.” (Kavalki & Gero, p. 6).

This is a good example of experts’ use of parallel processing and lack of excess demand on working memory. And because experts are better able to recognize patterns that are not
noticed by novices, as was observed in my own study, this would be another implication of how they are able to see the “big picture” with more ease.

**Analogy and Metaphor as Heuristics**

In general, analogy to a previous case or set of cases serves many purposes in problem solving (Kolodner & Simpson in Kolodner & Reisbeck, 1986). Kolodner (1982) suggests that as an expert is having new experiences, he/she is evaluating and understanding them in terms of previous ones, and in the process, he/she must also be integrating the new experience into his/her memory so that it will be accessible in understanding a later case (p. 2). This implies that the use of analogy in thinking of new design concepts depends on the experiences in memory that the designer has to draw from. A novice would have less experience, both professionally and possibly in life (considering age), to draw analogies from. In my study this semester, the expert designer quickly made some analogies from the information presented to her on mathematical thinking. The word “contort” in the information given to her, she thought of a “Mobius Strip,” and from the word “order” she thought of the “Golden Ratio.” The novice designer thought of more straightforward mathematical concepts such as a pencil and numbers. In terms of experience’s role in memory, we could say that perhaps the novice did not produce very interesting analogies because she was less experienced in life and in designing, so had less ready to draw analogies from. As Casakin (2003) stated: “Difficulties in the spontaneous access and use of analogy were reported to be associated with the level of expertise in several studies.”

Beyond anecdotal examples illustrated in the design literature, recent works have provided empirical evidence of the role of visual analogy in design, and suggest that the use of visual analogy improves the quality of design solutions (Casakin, 2003). In Casakin’s study,
subjects were given a design problem and were provided with a board full of visual displays, which they could consider potential sources for analogy (p. 6). What they observed was that the novice focused on the superficial features of the images on the visual display, while the experienced designer established a structural correspondence between the visual sources and the problem at hand (p. 10-11). Casakin’s statement that experts are likely to concentrate on relevant aspects of a problem while novices tend to represent problems by focusing on irrelevant features (para. p. 4) resonates loudly with Resiberg’s assertion that analogies usually depend on a problem’s “deep structure,” and that the problem’s “surface structure” is largely irrelevant (p. 487). It is also important to consider that experts might use surface features in a different way than novices. Blessing and Ross (1996) claimed that although experts often focus on a problem’s deep structure, they also utilize surface features to access a source problem, and this may be considered a helpful heuristic that can lead to the establishment of a successful analogy (as cited in Casakin, 2003). So, experts seem to have the ability to make deeper connection both on the surface and more deeply below it.

It can be said that more expertise is needed to use metaphors in a better way (Casakin, 2007). Metaphors are a useful heuristic to designers because they can help us take concepts we already know and apply them to new problems. For instance, graphic designers are often hired by clients who are in a field or industry that the designer is entirely unfamiliar with. As Casakin put it, “Basically, metaphors constitute an uncommon juxtaposition of the familiar and the unusual. They induce the discovery of innovative associations that broaden the human capacity for interpretation (Lakoff, 1987, 1993). For that reason, metaphors are seen as valuable aids in problem-solving tasks.” (p. 3). In Casakin’s study (2007) of design students, it was affirmed that novices lacked the necessary analytical skills to reflect in-depth on design situations and
therefore faced some difficulties in using metaphors as a primary analytical tool.

**Creativity and Experience**

How does experience affect creativity in design? First, retrieving concepts from metaphors demands creative thinking. Retrieving a design concept from a metaphor belonging to a remote domain demands from the designer to be practical and flexible for adapting the concept to the design problem at hand (Casakin, 2007). Bransford et al. (2000) consider several key principles of experts’ knowledge, and among them are:

- Experts are able to flexibly retrieve important aspects of their knowledge with little attention effort, but also,
- Experts have varying levels of flexibility in their approach to new situations (p. 31).

Flexibility and fluency are often listed as two of the main ingredients in creativity. Csikszentmihalyi (1996) says of divergent thinking in creativity: “It involves fluency, or the ability to generate a great quantity of ideas; flexibility, or the ability to switch from one perspective to another; and originality in picking unusual associations of ideas.” As Bransford et al. (2000) noted, fluency does not mean that experts always perform a task faster than novices. As experts tend to devote more time to problem understanding, they may actually take longer than novices. But the role of fluency aids in efficiency and ease on working memory, as we saw in the case of Kavakli and Gero’s study (2002). And as Casakin (2007) points out, designers become more fluent as their design process develops, and fluency enables the exploration of design alternatives and increases the chance of developing detailed and aesthetic design solutions (p. 13). With flexibility, an expert can create innovative new concepts by looking through
various perspectives and synthesizing concepts to create new ones.

Yilmaz & Seifert (2009) observed some very specific heuristics employed by expert designers, shown in the table below, which bear a great resemblance to the philosophy behind the creative thinking “SCAMPER” technique (Substitute, Combine, Adapt, Modify, Put to other uses, Eliminate, Rearrange).

Table 2. Design Heuristics identified in the sketch sequence through coder’s observations

<table>
<thead>
<tr>
<th>Functional Heuristics</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1. Adjustability according to different users needs</td>
<td>38</td>
<td>19%</td>
</tr>
<tr>
<td>F2. Applying an existing mechanism in a new way</td>
<td>35</td>
<td>18%</td>
</tr>
<tr>
<td>F3. Changing how the user physically interacts with the system</td>
<td>33</td>
<td>17%</td>
</tr>
<tr>
<td>F4. Using a common element for multiple functions</td>
<td>24</td>
<td>12%</td>
</tr>
<tr>
<td>F5. Simplifying the already existing, standard solution</td>
<td>22</td>
<td>11%</td>
</tr>
<tr>
<td>F6. Putting more than one function on one continuous surface</td>
<td>19</td>
<td>10%</td>
</tr>
<tr>
<td>F7. Adding-on, taking-out, or folding away components when not in use</td>
<td>12</td>
<td>6%</td>
</tr>
<tr>
<td>F8. Applying portability to existing standard solutions</td>
<td>12</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>195</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural Heuristics</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1. Changing the configuration using the same design elements</td>
<td>25</td>
<td>18%</td>
</tr>
<tr>
<td>S2. Merging a variety of components</td>
<td>24</td>
<td>17%</td>
</tr>
<tr>
<td>S3. Changing the direction of the orientation</td>
<td>16</td>
<td>11%</td>
</tr>
<tr>
<td>S4. Repeating the same form multiple times</td>
<td>15</td>
<td>11%</td>
</tr>
<tr>
<td>S5. Hollowing out space within a solid</td>
<td>12</td>
<td>8%</td>
</tr>
<tr>
<td>S6. Nesting one design element within another</td>
<td>12</td>
<td>8%</td>
</tr>
<tr>
<td>S7. Changing the scale of elements</td>
<td>11</td>
<td>8%</td>
</tr>
<tr>
<td>S8. Substituting one for another element</td>
<td>10</td>
<td>7%</td>
</tr>
<tr>
<td>S9. Reversing the repeated forms for various functions</td>
<td>9</td>
<td>6%</td>
</tr>
<tr>
<td>S10. Splitting a form into multiple, smaller elements</td>
<td>8</td>
<td>6%</td>
</tr>
<tr>
<td>S11. Folding forms around a pivot point</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>S12. Flipping the direction of a form across an axis</td>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td>S13. Cutting edges into forms</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>153</td>
<td>100%</td>
</tr>
</tbody>
</table>

Yilmaz & Seifert (2009)
As we established, it has been observed that experts spend more time understanding a problem. Christiaans reported that “The more time a subject spent in defining and understanding the problem, and consequently using their own frame of reference in forming conceptual structures, the better able he/she was to achieve a creative result.” (as cited in Dorst & Cross, 2001). Yet another perspective comes from Dorst and Cross (2001): “It seems that creative design is not a matter of first fixing the problem and then searching for a satisfactory solution concept. Creative design seems more to be a matter of developing and refining together both the formulation of a problem and ideas for a solution, with constant iteration of analysis, synthesis and evaluation processes between the two notional design ‘spaces’—problem space and solution space.” (p. 434). The model of creative design proposed by Maher et al. is based on such a ‘co-evolution’ of the problem space and the solution space in the design process: the problem space and the solution space co-evolve together, with interchange of information between the two spaces (Dorst & Cross, 2001).

As Reisberg (2006) sums it up, the “ingredients” of creativity are available to all of us—or perhaps would be available, if we simply acquired expertise in the relevant domain.

**IV. The Role of Language in Developing Design Concepts**

As mentioned earlier, during the concept development phase a designer can use language to describe developing ideas, in their own mind and to others, about a project. Language is also crucial to designer-client communication when developing a design concept because the designer has to be able to understand a client’s problem, field, and target audience, and in return be able to communicate the developing design ideas when later presenting them to said client. As Dong
(2005) stated, language plays at least two roles in design: First, language serves as representations of ideas and concepts through linguistic behaviors that represent the structure of thought during the design process. Second, language also performs actions and creates states of affairs (p. 35). Dong’s paper demonstrated that the production of knowledge relies on designers’ linguistic behavior to construct a composite concept. (p. 51). “Language use does things: it accomplishes reflection, performs actions and enables designers to project possibilities, forms design concepts, and negotiates the value of design concepts. Thinking about language use in design as a tool means seeing language as a mechanism for performing design practice.” (Dong, p. 36).

When developing a creative design concept, innovation can occur when two ideas are blended together to form a new concept. These ideas would be represented linguistically by words or terms. In an experiment done by Morita et al. (year), subjects were asked to perform two tasks - to interpret novel noun-noun combinations and to create a design based on novel noun-noun combinations. They studied the processes through which a new concept is created by synthesizing two concepts, and found that three types of synthesizing processes are used in design (p. 2):

1. Concept abstraction: transferring the characteristics of an existing concept to a new concept
2. Concept blending: blends two basic concepts at the abstract level and produces a new concept that inherits the abstract features of the two base concepts, but the concrete features of neither
3. Concept integration: combines two basic concepts from the viewpoint of a thematic scene and generates a new concept

The use of language in generating ideas might make an interesting parallel to what
Scardamalia and Bereiter (year) present as “knowledge transforming,” a model of mature writing (versus the immature “knowledge-telling” model). Experts can make use of complex knowledge-processing procedures to transform knowledge that is not so assembled into coherent and effective form (Scardamalia and Bereiter, p. 171). This resonates with the designer’s process of facing an ill-defined problem and transforming and combining their existing knowledge to create new design concepts and design solutions.

Lastly, prior to actually developing new concepts, a designer should first gather pertinent research for the design project. In order to interpret, understand, and be able to apply this researched information, they must be able to understand it linguistically. This could have some interesting implications for improving design education, as discussed further in the next section.

So what role does experience play in regards to language? In regards to the link between knowledge and language, there are many viewpoints from philosophers and psychologists. If language and knowledge are in fact mutually exclusive, then it would make sense that an expert, who has more knowledge of a field, might have a higher level use of language in their thinking, concept development process, and ability to communicate effectively.

V. Conclusion and Possible Implications for Improving Design Practice and Education

Seeing some of the rich ways in which expert designers and experts in general approach concept development and problem solving, I feel that I can now synthesize the knowledge of these skills into my own practice. And as hopeful future design instructor, I can think about these findings in terms of how their use might affect design education.

Reisberg (2006) posits that “analogies are plainly helpful in problem-solving, and so we could provide students with experience in the relevant domains so that they would have a basis
from which to draw analogies.” (p. 489). Similarly, Casakin (2007) proposes as an alternative to existing educational design approaches, the use of metaphor in creative problem solving in the context of the first-year design studio: “These tools are considered as a major aid for helping novice students foster their own concepts and ideas in developing design solutions and for overcoming their lack of knowledge and experience.” (p. 5). The challenge of course would be facilitating the use of metaphors and analogies in these novices without experience. If, as Casakin (2007) stated, more expertise is needed to use metaphors in a better way, then how would this actually help novices who are lacking in that expertise? Perhaps instructors in design programs could lead by example, using metaphors and analogies in their teaching and explaining what they have done when they use them. They could also use more “probing” questions in their facilitation to help students develop analogies of their own. Another very effective strategy for improving design education might be to integrate more experiential learning, as Reisberg (2006) suggested, so that students can have real-world design problems to draw analogies from.

Bransford et al. (2000) offered that the research on expertise suggests the importance of providing students with learning experiences that specifically enhance their abilities to recognize meaningful patterns of information (p. 36), and that curricula should be organized so as to lead students to conceptual understanding (p. 42). In retrospect of my own education, I feel that the system short changes students by rushing through subjects in short, four month long semesters. As Bransford et al. posited, there is often only superficial coverage of facts before moving on to the next topic; there is little time to develop important, organizing ideas (p. 42). If I were developing a design school curriculum, I would be sure to design it so that the concepts learned were deeply woven throughout the courses. Also, through illumination of the cognitive heuristics
of expert designers, it would be greatly beneficial for design educators to lead facilitation of these heuristics in their students.

Understanding the structure of designers’ thinking processes as evidenced through language could illuminate the nature of design (Dong, 2006). The analyses of Dong (2006) illustrated how language serves as a container for transferring knowledge from one designer to another, and suggests that language is essential for the production of knowledge (i.e., concept formation) during group design processes (p. 51). This has strong implications for design agencies as well as experiential learning for design classrooms. Design students should be required to use their verbal voices more as practice during their education by working with interdisciplinary teams.

There is no substitute for experience. It takes time and deliberate practice (Ericsson, 1994) to become an expert. By having this new insight, I can now begin to implement some of the thinking dispositions and heuristics into my own creative practice to deliberately gain that experience, and one day pass these techniques on to other designers and students.

References:


Ciampa Brewer, R. (2010). *Novices and experts in the graphic design phase of concept development*. Unpublished paper, University of Massachusetts, Boston, MA.


