RELATIONS BETWEEN CREATIVITY AND THINKING TYPES OF DESIGN STUDENTS OBSERVED IN SKETCH DRAWINGS

On the Role of Drawings in Creative Design Process (1)

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Abstract: Designer's drawings could be important clue for understanding the creative thinking process. We prepared several experiments to see how drawings devote to creative design. The subjects were assigned tasks to design paperweights by two different keywords. From observation of drawing process, two different thinking types were recognized. One was who searched as possible as many associations from the given key words, then select one from them. The other was who drew abstracted forms and gradually brush up them to get most fitting image for given key words. Then, the sketches were evaluated, and analyzed on the relations of the thinking types and their drawing ways. The former type sketches were made by cartoon-like single line drawings, and the latter type sketches were made by elaborated and repeated line drawings. Most of good results were seen in the latter type group.

From the results, we became to think that the creative design can be got only when the keyword was once lifted up to high abstracted level concept, which could be fixed after frequent interactions between the concept in mind and drawn images.

keywords: Design, Creativity, Drawing, Experiments, Expression

1. Introduction

The purpose of this research is to make clear the structure of creative thinking process by inferences based on the designer's sketches, and to get clues of method to support thinking process of creative design and method to facilitate creative thinking in design educations. The design thinking process can be represented as the translating process starting from goal descriptions (usually by verbal expression) and ending at the visual images of it. We should make clear that what kind of relations exist between verbal thinking and non-verbal thinking in generating creative ideas.

In this paper we focused on the designer's drawings and drawing processes, for they seemed to be a key issue of creative thinking in design process.

2. Positioning of this research

The position of our research in the field of design could be summarized as follows.

2.1 Researches on the relations of constraints and creativity

Before preparing this research, some other experimental studies had been made by Noguchi[1][2], in which he tried to know how constraints affected creative design thinking. In those experiments, constraint means description of design goal and methods to get the goal (for example materials to be used or method of making the goal object). Those constraints were given as keywords in initial goal description. The initial goal description was served as constraint in which searching space was restricted and prompted thinking. The keywords in the goal description gave a direction of thinking in the searching space.

It seems that designer can make image of target only when the keywords are sufficiently specific to make images of substantial appearance of target objects. The first stage of design thinking can be said as breaking down process from the goal description into several specific keywords. In other words, there is somewhat hierarchical structure of concepts in the keywords by which the designer can use them for generating visual images of design target. This means that designer's thinking process is composed of repeated interpretations between verbal described concepts and image configurations which destine to final image of design target. Our research stands on the basis of this viewpoint.

2.2 Researches on the creative cognition

The essential part of creative thinking is the effort for extricating from the frame of preconceived ideas in the domain of personal conscious world, in which dynamic relations of designer's intention and unexpected finding process is evolved.
Finke, Ward and Smith [3] presented an important research on the mental synthesis of creative configuration of form. They made experiments to verify the role of visual thinking in mental synthesis and creative invention. Their experiments were arranged to start with several given elements of forms to be selected to make combinations of them as a creating object. It gave us very interesting suggestion. However, we assert that essential point of creative thinking is not the newness of selection or combination of given elements but to make original image of target object as a whole and the effort for extricating from the frame of preconceived ideas in the domain of personal conscious world.

2.3 Researches on the designer’s drawings
The designer’s drawings belong to the intermediate domain between verbal description and image configuration. So that, designer’s drawings can be important clue to know the nature of creative thinking. Moreover, in behavior of drawing, the physical actions like moving hands and seeing eyes might be crucial point of knowing design creativity.

Goldschmidt [4] suggested that an architect’s thinking process was sometimes started from doodlings and they gave clue of connecting a concept and a figure. She asserted that this process was no less systematic and logical than any other rational dialectic process.

Purcell and Gero [5] had elaborated study on the confirmation of visual and spatial thinking mode in design process by using a method of cognitive science.

Suwa,Gero and Purcell [6] focused on the occurrence of unexpected discovery in designer’s drawing process. They had an experiment to know it. Based on the results of the experiment, they suggested that the design goal and image configurations were affected each other with bi-directional relations and the unexpected discovery was occurred in the drawing process through mediation of the tacit component of designer’s knowledge.

However, the design experiments of those researches were focused only on the personal behavior of professional designers. We thought that before tracing personal behavior of thinking process, we would need to know the general tendency of creative thinking in the design task.

Upon our stance of above mentioned, we adopted experimental methods using about 80 subjects and analyzed drawings of them to know their tendency of thinking ways.

3. Experiment
The purpose of this experiment was to know how visual image of a new object is created from verbal description (key words).

3.1. Procedure of the experiment
About 80 subjects (first year class students of Chiba University) were assigned a task to design two kinds of paperweights, one of which was to give a sense of relaxation and the other was to give a sense of excitement. This experiment was composed of three steps in the entire process. The first step was made for the purpose of giving training of thinking and drawing to the subjects, because they were still in rudimentary stage in the first year design class.

At first the subjects were assigned two tasks. One was to draw the most favorite plant and the other was to imagine an unknown plant and draw it. After a week from this initial training, the subjects were assigned the second task that was to design a paperweight with which gives a sense of relaxation. After 20 minutes was given for drawing, sketches were gathered and copied for using them to examine subject’s mid term output of thinking process. Then the subjects were instructed to continue drawings. Color pencils were used for drawing this time. After 30 minutes was given for drawing, sketches were gathered and copied again.

After a week from the last task, the subjects were assigned the third task that is to design a paperweight with which gives a sense of excitement. The same process as the second task was took in this task.

3.2. Evaluation of the sketches
Methods of evaluation of resulted sketches were made on the basis of following two ways.

Firstly, two expert design educators evaluated mid term sketches (results at 20 minutes after start) in following evaluating items by 5 steps grading (grade 3 was neutral point) on each.

(1) Whether new form was intended to generate or not?
(2) Whether form of ready-made objects were used or not?
(3) What was drawing skill?
(4) Whether a metaphor was used or not?
(5) Whether intended to make aesthetic form or not?
(6) Whether intended to make funny sense or not?
(7) The number of ideas (normalized score 0 to 5).

The results of averaged grades on the evaluation items were analyzed with using the principal component analysis method. From the result of the analysis, the values of the principal components on each sketch were positioned onto two-dimensional distribution maps (Fig.1 and Fig.2).

From the component loading value of each principal
component, we recognized as axis X (principal component No.1) represented creativity and axis Y (principal component No.2) represented ability of expression (Table 1).

Based on the two-dimensional distribution graphs, the first quadrant area implies creative and good expression ability, the second quadrant area implies not creative but good expression ability, the third quadrant area implies not creative and poor expression ability, the fourth quadrant area implies creative but poor expression ability.

3.3. Examination of thinking process

In next step, we examined on the difference of two kinds of sketches drawn by the same subject, those were rough sketches drawn in first 20 minutes and colored sketches drawn in next 30 minutes in this experiment. Examination was focused on how did the subjects carry their thinking process from start to the end of the experiment.

As the results of the examinations on the sketches by two expert design educators, several groups of thinking types were recognized (Table 2). Those were as follows.

1) Type of subjects who drew sketches in evolving and modifying one sketch to get satisfied one. This was named "evolving type".
2) Type of subjects who drew, at first, as possible many drawings as they could imagine, then selected one of them and refined it. This was named "diverging and select type".
3) Type of subjects who drew only one or two sketches, but elaborated drawing. This was named "Adhering type".

4) Type of subjects who drew only one or two poor drawings. This was named "Poor imagination type".

Typical examples of sketches by those types are shown in Fig.3 and Fig.4.

3.4. Analyzed Results

We looked into the relations between the number of sketches in each quadrant of the principal components spaces and the thinking types mentioned above.

Firstly, we counted the number of samples of each thinking type in each quadrant of the principal components space. Then calculated proportions of each thinking type in each quadrant. The results are shown in Table 3. The result was shown as follows:

1) The evolving type and adhering type were mostly seen in the first quadrant area of both cases ("Relaxation" and "Excitement").
2) The diverging type was scattered over the second, third and fourth quadrant areas but scarce in the first quadrant area in both cases.
3) The adhering type was mostly seen in the first and second quadrant areas in case of "Relaxation", but in case of "Excitement", it was mostly seen in the first fourth quadrant areas.
4) The poor imagination type was mostly seen in the third and fourth quadrant areas but scarce in the first and second quadrant areas in both cases.

From these results we found that:
a) "Evolving type" produced the most numbers of creative drawings, and most of their sketches were abstracted forms with drawings of repeated lines.
b) "Diverging type" produced many idea sketches, and most of their sketches were cartoon-like drawings of well-known objects.
c) The number of ideas was not correlated to high creativity.
d) There was some difficulty to discriminate the "adhering type" and "poor imagination type".

3.5. Confirmation of thinking types by preparatory drawings

As mentioned in section 3.1, we assigned two preparatory tasks to the subjects before main experiment was held, those were to draw most favorite plant and then to imagine and draw an unknown plant. We examined and classified the way of the preparatory drawings of each thinking type (Fig.7 and Table 4). The classification viewpoints were as follows.

(1) Elaborative drawing
(2) Cartoon like drawing
(3) Intermediate (Could not categorized into (1) or (2))

As the results, we found that:
The averaged number of sketches in evolving type and diverging type were apparently larger than the other types. The proportion of elaborated drawings was large in evolving type and adhering type, but was extremely small in poor imaginarion type, and was intermediate in divergent type. The proportion of cartoon-like line drawing was large in divergent type and poor imagination type, but was small in evolving type and adhering type.

As elaborate drawings were mostly seen in evolving type and adhering type, both types were suppose to be similar groups, and also from the number of cartoon-like drawings, divergent type and poor imagination type were supposed to be similar groups.

Those results seemed to support our classification of the thinking types.

4. Discussions for Conclusion of this stage

From the results of above mentioned experiment and analysis, we came to believe as mentioned below.

In creative thinking process in which many capable solutions were included, high-level abstraction in translating from verbal goal description to its visual image was needed for creating good solution. In other words, direct associations (as seen in the cartoon-like sketches of diverging type) were in most case not effective for creative solution.

As we saw in the experiment, even if in the simple design process, goal description was not directly represented its visual image at first. Then, the subjects had to search as possible as many associations and/or metaphors of well-known objects at first stage. This stage of thinking process was seen in the drawings of the "diverging type".

After doing it, they might have to look into common factors in them at high abstracted level of the imaginations or metaphors. This stage of thinking process was seen in drawings of the "evolving type". It was supposed that most of evolving type could include diverging thinking process in them but not explicitly.

As for goal description on the utility (in this case,
Table 2. Process of classifying thinking type groups based on the ways of drawings
(“R” indicates “Relaxation” sketch and “E” indicates “Excitement” sketch)

<table>
<thead>
<tr>
<th>Classification of 1st stage (Number of Sketches in task 1 -&gt; task 2)</th>
<th>Adhering evolve</th>
<th>Divergent and select</th>
<th>Continuously Evolve</th>
<th>Evolved (-&gt;1, narrowing down)</th>
<th>Evolved (&gt;1, more than 2, visible process)</th>
<th>Sudden change (non-visible process)</th>
<th>Fickle (quite different change)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only a few evolved (1-&gt;1)</td>
<td>26</td>
<td>23</td>
<td>13</td>
<td>16</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>A little evolved (1-&gt;2)</td>
<td>21</td>
<td>24</td>
<td>13</td>
<td>16</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Not so evolved (2-&gt;1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not so evolved (2-&gt;2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classification of 2nd stage</td>
<td>Poor imagination type</td>
<td>Adhering type</td>
<td>Divergent type</td>
<td>Evolving type</td>
<td>Poor imagination type</td>
<td></td>
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<td></td>
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<tr>
<td>Sketch A of evolving type</td>
<td></td>
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<td></td>
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<tr>
<td>Sketch B of evolving type</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sketch A of diverging type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sketch B of diverging type</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Sketch A of adhering type</td>
<td></td>
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<tr>
<td>Sketch B of adhering type</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sketch A of poor imagination type</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sketch B of poor imagination type</td>
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</tr>
</tbody>
</table>

Figure 3. Examples of “Relaxation” sketches
(Sketch A indicates the sketch of first 20 minutes and Sketch B indicates the sketches of after A)

Figure 4. Examples of “Excitement” sketches
Evolution type in case of "Relaxation" Paperweight

Diverging type in case of "Relaxation" Paperweight

Adhering type in case of "Relaxation" Paperweight

Poor imagination type in case of "Relaxation" Paperweight

Figure 5. PCA distribution maps of each thinking type in case of "Relaxation" paperweight

Evolution type in case of "Excitement" Paperweight

Diverging type in case of "Excitement" Paperweight

Adhering type in case of "Excitement" Paperweight

Poor imagination type in case of "Excitement" Paperweight

Figure 6. PCA distribution maps of each thinking type in case of "Excitement" paperweight
Table 3. The numbers of samples of each thinking type in each quadrant area  
(the numbers in parenthesis are proportions of each thinking type in each quadrant area)

<table>
<thead>
<tr>
<th>Thinking types</th>
<th>Relaxation</th>
<th>Excitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quad I</td>
<td>Quad II</td>
</tr>
<tr>
<td>Evolving type</td>
<td>6 (0.46)</td>
<td>3 (0.15)</td>
</tr>
<tr>
<td>Diverging type</td>
<td>1 (0.08)</td>
<td>11 (0.55)</td>
</tr>
<tr>
<td>Adhering type</td>
<td>6 (0.46)</td>
<td>5 (0.25)</td>
</tr>
<tr>
<td>Poor imagination type</td>
<td>0 (0)</td>
<td>1 (0.05)</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 4. Relations of thinking types and way of drawings in the preparatory drawings

<table>
<thead>
<tr>
<th>Thinking types</th>
<th>Number of samples</th>
<th>Average number of sketches</th>
<th>Proportion of elaborated sketches</th>
<th>Proportion of cartoon-like sketches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolving type</td>
<td>9</td>
<td>3.4</td>
<td>0.44</td>
<td>0.33</td>
</tr>
<tr>
<td>Divergent type</td>
<td>28</td>
<td>3.5</td>
<td>0.29</td>
<td>0.61</td>
</tr>
<tr>
<td>Adhering type</td>
<td>14</td>
<td>2.2</td>
<td>0.43</td>
<td>0.36</td>
</tr>
<tr>
<td>Poor imagination type</td>
<td>10</td>
<td>2.4</td>
<td>0.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
<td>2.6</td>
<td>0.31</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Figure 7. Examples of preparatory drawings of each thinking type

“paperweight”), it served as loose constraint for the creative thinking process. If the keywords (in this case “give a sense of relaxation”) of goal description were not directly related to the function of utility at first, many well-known things associated from the keywords had to be imagined in no consideration of its function of utility. Then, many associated things and/or events were drawn in this stage of thinking process. It seemed that the divergent thinking type was stayed in this stage and did not go forth.

However, this process was not creative yet. To make it creative, the well-known images of associated things should be once raised to high-level abstracted thinking for form generation. Only when the abstracted form can get properness of function of utility, good solution will be resulted. This would be the reason why the evolving type was able to generate many creative drawings.

Some part of the adhering type could be included in the evolving type, but another part of them might be included in the poor imagination type. We supposed that if most of this type could make explicit their divergent thinking stage, they would make more good results.

The poor imagination type was supposed to be in low activated level of thinking. They seemed to be not interesting in assignment itself, or they had not so rich experiences of imagination world in their lives.
5. Perspective

The problems are as follows.

(1) What causes the difference of thinking types? Was it caused by nature of individuality or by difference of searching spaces with the keywords? We will need to confirm this by another experiment.

(2) What is the abstract image or abstract level thinking, and why creative process needs the abstract level thinking. For approaching this problems, we will need to consider on tacit dimension of human knowledge, which was pointed out by M. Polanyi [7] as an essential part of creative thinking. Suwa, Gero and Purcell [6] pointed out that designer's drawings gave clue of unexpected discoveries and some kinds of tacit knowledge would be concerned with their drawing process. Lakoff [8] mentioned that most of human cognition could be related with functions of human body and physical actions. They might be important clues to understand the tacit knowledge. We will inevitably have to concern with big riddle of human creativity as mentioned above.

Having large perspective of research, however, at the next step, we will need to know how designer struggle in creating new idea as a visual image. For this purpose, we are preparing next experimental studies, and it will be appear in another paper in near future.

References

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