ON THE CHARACTERISTICS OF FUNCTIONAL ELEMENTS FOR INNOVATIVE DESK LAMP CONCEPTUAL DESIGN

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ABSTRACT
The key function of desk lamps is illumination. Usually, the structures are simple and adjustable for desk lamp with some additional functions. In the perspective of product innovative design, designers focus on the structure of lamp and ignore the possibility of other innovative design. The representations and the creative functional elements for desk lamps are also proposed in this study for innovation design. The main creative functional elements are lamp shades, hinges, pipes, and lamp based. The connecting relationship for these main creative functional elements are the assembled type, the composite type, and the integrated type. Finally, 3 creative functional elements and 3 connecting relationship are used in the example, and 3 innovative concepts are obtained.

Keywords: desk lamp design; creative functional elements; graph theory.

TITRE FRANÇAIS DE L’ARTICLE (MAXIMUM DEUX LIGNES)

RÉSUMÉ
Le résumé français est obligatoire. Évidemment, si l’article est rédigé en français, le titre principal et le résumé principal sont en français. Par contre, il ne faut pas traduire le texte « Received…Accession Number 0000 ».

Mots-clés : premier mot-clé; deuxième mot-clé; troisième mot-clé.
INTRODUCTION

The mass production of products using machines became possible after the industrial revolution. This, along with consistent technological advancements, has created a wide variety of products available from which consumers can select. For businesses, one major challenge is to launch innovative products as quickly as possible. Nevertheless, creativity is not something that is always readily available; to create an endless stream of innovative and brilliant ideas for new products is nearly impossible for designers. The greatest challenge for designers is to combine creativity and functionality. However, the speed of launching new products is far quicker than is the speed of generating ideas, which can compromise product innovation. One method of facilitating product design is by adopting product semiotics, with which designers can generate product combinations that satisfy design restrictions and criteria before styling the look of the new product.

Desk lamps are an everyday necessity for many people. The key function of desk lamps is illumination, and the design of these desk lamps does not vary substantially. Although the design of desk lamps is a critical factor influencing consumers’ choices, innovation is typically lacking from it, especially regarding the method of use and of structure. Consequently, the purpose of the present study was to investigate the expression and connection of the semiotic functional elements of desk lamps and to analyze and explore the relations of these functional elements to set up new design criteria for more innovative and creative desk lamps. The objectives of this study were as follows:
1. Explore the expression of product semiotics and the types of connection between the functional elements.
2. Analyze the semiotic structure of desk lamps for determining the design criteria.
3. Design a desk lamp product on the basis of the aforementioned connections of elements and the design criteria of desk lamps.

1 LITERATURE REVIEW

In this section, first product functional elements are discussed, followed by product semantics, and then graph theory.

In consumer psychology, product attributes refer to characteristics explicitly and implicitly detectable by consumers and combinations of product properties. Therefore, each product is a set of product attributes, which include the appearance, brand, functions, and price of a product. The value of these various product attributes varies among consumers [1], and consumers view each product as a collection of several attributes. Each product comprises connotative and denotative attributes; the former refers to the physical and chemical properties as well as the appearance of a product, whereas the latter refer to the sum of the geometric shapes of the connotative attributes.

Product attributes are referred to differently by different researchers; some have referred to product attributes as “product characteristics/features,” others have used the term “product components,” and others still have referred to them as “product elements.” In the present study, “elements” was used to refer to product attributes, and product “functional elements” refers to the objects constituting a product. Each product, regardless of the type, is formed by several functional elements. Each combination of elements can be disassembled then reassembled into a new combination of elements [2].

Semiotics is a branch of human science studying the creation and expression of meaning. It focuses on the processes of transmitting ideas and concepts through words, icons, customs, and everyday experiences. Semiotics covers extensive areas and has been widely applied to many design and art works [3]. Studies of product semantics began in the early 1980s when semantics from semiotics was first introduced to product design [4]. Hsiao indicated that the problems and possibilities encountered by users when using a product are obscured by visual aesthetics [5]. Hsiao also proposed that based on Peirce’s theory of signs, product semantics can be divided into product semantics, product syntax, and product pragmatics and that the cognitive process of signs is based on coding and decoding; the designer is the
encoder, whereas the user is the decoder. Hsiao concluded that because designers, when using elements, must consider the code system that users are familiar with, product design is not merely about employing styling skills.

A graph composed of nodes and edges that connect between two nodes is called a general graph. If only one edge can be drawn between two nodes, it forms a simple graph. Each node is number coded for identification. Each node is identified to highlight its importance. A graph may contain \( n \) parts. If there is a path between any two nodes in the graph, then this graph is connective and is a connective graph [6].

Similarly, isomorphism has various basic principles; for example, to be isomorphic, two graphs must share the same number of nodes, the same number of edges, and the same number of parts. Additionally, if a graph contains a node connected to another three nodes, then the corresponding isomorphic graph should also contain a node connected to three other nodes. Furthermore, isomorphic graphs must have the same number sequence. According to graph theory, to define two graphs as isomorphic, neither the size of nodes nor the length of lines are relevant; rather, the relations between the nodes and lines and how the nodes and lines are linked are what are relevant.

Liu and Wu have proposed the representations for bicycle characteristics using the concept of graph theory, but the process for bicycle design is not mentioned in the study [7]. This paper proposes representations for bicycles. By using symbols representations, bicycles can be represented simple and quickly for innovation design.

2 FUNCTIONAL ELEMENTS AND CONNECTION ANALYSIS

2.1 Collecting Design Cases and Verifying Elements

Desk lamps were chosen to be the sample of the analysis because they are frequently used consumer products. Assorted types of desk lamps exist on the market, and their design is generally focused on their appearance rather than their structure or special functions. Therefore, this study chose to use desk lamps to explore the use of semiotics in product design.

First, the study collected pictures of desk lamps available on the market; 76 samples (desk lamps) met the criteria. The 76 desk lamp samples were numbered in sequence, and the main components of the desk lamps were classified into lamp shades, hinges, pipes, and lamp bases, and each part of each sample was analyzed in detail.

2.2 Denotation by Using Signs of Desk Lamp Functional Elements

The problems and possibilities encountered when using products may be obscured by visual aesthetics. The functional aspect of products is often overshadowed by the appearance of products, for both users and designers. In this section, the appearance of desk lamps was expressed uniformly using signs to eliminate interference from the appearance. One sample was chosen from the collection to exemplify the aforementioned steps.

1. Verify the desk lamp elements and their relations.
2. Assign each lamp element a sign.
3. Connect the signs of each element.

For exemplification, the study used one sample from the collection of samples. First, the elements of the desk lamp sample were identified (Fig. 1(1)) and coded with the corresponding signs (Fig. 1(2)). Next, the types of connection between the elements were classified in detail, and graphs for the different types of connection of each class (Fig. 1(3)) were generated. Fig. 1(4) shows an example of the sign graph of the desk lamp sample: I for lamp shades, L for hinges, P for lamp pipes, and B for lamp bases. Regarding the types of connection, there were the assembled type, the composite type, and the integrated type.
2.3 Desk Lamp Sample Analysis

The elements of the 76 samples were analyzed according to the aforementioned description, and the numbers of elements of the 76 samples were summarized, as shown in Table 1. The analysis determined that most of the desk lamp samples were composed of three elements, and that the second most samples were composed of seven elements (Table 2). Therefore, the design of the majority of desk lamp samples was focused on three elements. In addition, the additional features of the functional elements of the samples were different; the additional features in the illustrated sample were the handle and the magnifying glass.

Table 1. Applying semiotics to the desk lamp samples.

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<table>
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</tbody>
</table>

Commented [AS]: This can probably be omitted.
### Table 2. Number of elements.

<table>
<thead>
<tr>
<th>No. of elements</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of samples</td>
<td>23</td>
<td>11</td>
<td>15</td>
<td>8</td>
<td>18</td>
<td>1</td>
<td>76</td>
</tr>
</tbody>
</table>

#### 2.4 Semiotic System

The key elements of each lamp outlined in 3.3 were labeled with corresponding signs. A summary of the signs is presented in this section. Each element was assigned a specific code. For example, F is the code for additional functions, and additional functions were coded in sequence as F1, F2, F3, and so forth (Table 3).

### Table 3. Desk lamp elements.

<table>
<thead>
<tr>
<th>Element</th>
<th>Sign</th>
<th>Graph Theory Denotation</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamp shade</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamp hinge</td>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamp pipes</td>
<td>P</td>
<td></td>
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</tbody>
</table>
2.5 Types of Connection

In this study, there were three types of connections of desk lamp elements, indicative of the lamp structure: the assembled type, the composite type, and the integrated type. For the assembled type, the operation methods and the functions were simpler than they were for the other two types, and there were no other additional or supplementary functions. For the composite type, the hinge or hinges were used to not only connect the lamp pipes; these hinges provided better stability for using the additional lamp features. For the integrated type of connection, the lamp pipe also acted as a joint, and therefore, no hinge was required to use the desk lamp.

Table 4. Types of connection.

<table>
<thead>
<tr>
<th>Type of connection</th>
<th>Denoted by signs</th>
<th>Denoted by graph theory</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembled</td>
<td>![Image of Assembled]</td>
<td>![Image of Assembled]</td>
<td>![Image of Assembled]</td>
</tr>
<tr>
<td>Composite</td>
<td>![Image of Composite]</td>
<td>![Image of Composite]</td>
<td>![Image of Composite]</td>
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<tr>
<td>Integrated</td>
<td>![Image of Integrated]</td>
<td>![Image of Integrated]</td>
<td>![Image of Integrated]</td>
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</tbody>
</table>

3 DESK LAMP CREATIVE DESIGN PROCEDURE AND EXAMPLES

In accordance with the results outlined in 3.3, a lamp design was completed following the desk lamp creative design procedure and with no more than three elements. The relations among the desk lamp elements were expressed using the graph theory, and design restrictions were established.

3.1 Desk Lamp Design Restrictions

The design restrictions for the three-element desk lamp are summarized as follows:

1. There should be at least one element for the lamp shade (I).
2. There should be at least one element for the lamp base (B).
3. The lamp shade (I) should be connected to only one element.
4. The lamp base (B) should be connected to only one element.
5. Other elements can be a hinge (L), a lamp pipe (P), or an additional function (F).
6. The assembled type of connection should be applied to connect the elements.

3.2 Design Implementation

In this section, the incorporation of desk lamp design restrictions, presented in 4.1, into the actual design is described. The graph theory approach was applied for implementing the design, and the element connections featured in this design case were determined.

1. The number of elements were verified.
2. The designated elements were introduced in sequence.
3. Other elements were introduced in sequence.
The connections were introduced. Again, no more than three elements were used in this desk lamp design. Each element is represented by a dot in Fig. 2.

![Element graph](image)

**Fig. 2.** Element graph.

After drawing the dots, in accordance with the design restrictions, one of the elements was labeled as the lamp shade (I). Fig. 3 was created by labeling the lamp shade element in Fig. 2.

![Labeling the lamp shade element](image)

**Fig. 3.** Labeling the lamp shade element.

After labeling the first element, the next design restriction was implemented: at least one element should be the lamp base. Therefore, one of the remaining two elements was labeled as the lamp base (B). Fig. 4 was created by labeling one of the elements as the lamp shade in Fig. 3.

![Labeling the lamp base](image)

**Fig. 4.** Labeling the lamp base.

After labeling two of the elements, the last element could be a hinge (L), a lamp pipe (P), or an additional function (F). Thus, all three elements were labeled, and three element-labeling graphs were produced. Fig. 5 was created by labeling the lamp base element in Fig. 4.

![Labeling other elements](image)

**Fig. 5.** Labeling other elements

After all element signs were labeled, the other criteria had to be fulfilled. One of the criteria was for the elements to be connected by the assembled type of connection; therefore, the three semiotic elements...
were connected accordingly. For example, the design restrictions mentioned that the lamp shade could not be connected to the lamp base; therefore, this restriction was considered when defining the relation between the lamp shade and the lamp base. Fig. 6 was created by connecting the elements in Fig. 5.

![Fig. 6. Types of connection among elements](image)

The study used three desk lamp elements to design three possible desk lamps. From the three possible designs, the study chose to implement the element relation shown in Fig. 6(b).

3.3 Particularization Design

In this step, Fig. 6(b) is taken as an example for particularization. There is lamp shade, lamp hinge and lamp base in this study. The sketch for the concept is shown in Fig. 7, and the 3D rendering scenario is shown in Fig. 8.

Using time and place have to consider in the design of this desk lamp, and the desk lamp should be adjusted in accordance with the user's own habits. Lamp shade should be rotated, when you open the lamp shade, the lamp could become a desk lamp, otherwise it could become softer when close the lamp shade. The lamp base is set up a small recess of some items may be placed on the lamp base.

![Fig. 7. Types of connection among elements](image)
4 CONCLUSIONS

The functions of the desk lamps on the market are similar. The present study used the graph theory approach to determine the functional elements of desk lamps, create signs for these functional elements by applying semiotics in the process, and then design an innovative desk lamp based on the principles of graph theory. The conclusions of the present study are as follows.

(1) This study created signs for the functional elements of desk lamps and connected these desk lamp elements according to the type of connection.

(2) According to our observation that most desk lamps contained three elements, the following criteria were applied for designing desk lamps. First, there should be at least one element for the lamp shade (I), one element for the lamp base (B), and the remaining element can be either a hinge (L), a lamp pipe (P), or an additional function (F).

(3) The study designed a three-element desk lamp, and three innovative possible designs were obtained. In addition, one of the three designs was chosen for implementation.

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