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Design for Graphical Manual Created by Computer Tools in the DIY Products: Exploring the Effects About Color and Other Elements of Design

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Abstract — **The purpose of our paper is to explore the effectiveness for the comprehension about the structure of DIY products with colors on the surfaces of parts in a graphical manual drawn by computer tool. In additions, we want to find up a good representation of a manual for the DIY users to better understand and easy to assemble a product. Many manuals of DIY merchandises are owing to ambiguous graphics, the buyers take much time to assemble parts together correctly during the process of work. Our research designs one empirical study to evaluate the effectiveness and visual comprehension about the graphical expression of the manual of product. After the experiment, we analyze these data through statistic techniques of ANOVA & Chi Square. Our experimental results show that there will be good perceptibility to understand the process and positions of assembly works when they have colors and apply other design elements on the manuals. The validation of empirical information could be translated into other products that need to be expressed by computer graphics in manuals.**

Keywords-DIY；Features；Assembly；Manual

I. INTRODUCTION

The graphic manual is a very simple and important element for the unified visual style to DIY products. It is a set of graphic elements and instructions, according to which the identity has to be put together in adequate position. Good design of manuals should help the user understand the structure of goods easily and their arrangement must be correspond to the principle of perceptible information which is one of the seven principles of universal design [1]. Many experts and scholars in the area of universal design have developed a set of brief principles that designers could apply when developing products and environments [2]. The seven principles contain equitable use,flexibility in use,simple and intuitive use,percepyible information,tolerance for error,low physical effort and size and space for approach. Designers use the principles to guide the design process. The principles provide a methodology that systematically evaluates new or existing designs and help both designers and consumers in educating about the features of more usable products and environments [3]. Consequence,these principles can help designers to apply them to encourage users understand the process of assembling parts easily, and facilitate to assemble parts into product as soon as possible. Furthermore, successful universal design is typically accomplished by means of gaining a better understanding of real-user needs [4]. So, we design some different kinds of manuals to experiment in a pilot study.

For the purpose of exploding the more inclusive design to a manual, we added a set of design elements which are color , instructions, show position, and graphical forms. In these factors,color is mainly applied and arranged by means of harmonious rule for pleasing people [5]. Here, we neglect to discuss the acceptability and perceptibility of colour differences which include colour attributes itself [6]. Various styles of drawing that include assembly, exploding drawing and detail drawing are used to promote the visual effect. Because computer graphics can not only offer to generate, explode, and display graphic image, but assist to scale, modify and colour surfaces, we made the graphical manual with the tool of 3D CAD package for communication and visualization [7].

The manual may also include a lot of other graphic elements that are positions of parts, directions of watch, colours, assembly instructions and various styles of displays which include sectional drawings and different scales of drawing [8]. However, it examines whether there is significant differences exist while the ways of matches of parts and styles of displays have been changed.Finally, this empirical study described in this paper explore the degree of understanding the assembled process of DIY products as a methodology to derive a set of principles that can be used to design graphical manual of DIY products. Besides, we hope to seek the best expressive way that can help product makers to cost down and promote the communication and visualization of manual of DIY products.

II. METHOD

A. Participants

There are two groups of participants committed to the empirical studies. A total of 100 students responded to the survey, One is thirty-one students of the Department of Crafts and Design from Taiwan University of Art (7 males and 24 females), and the other is sixty-nine students of the Department of mechanical Engineering from Hwa Hsia Institute of Technology (67 males and 2 females).

B. Styles of Display

The empirical study has four graphical manuals presented for different patterns of DIY products, and they are separately expressed by four various types of displays. Every product in the manual mainly consists of three parts that are assembly drawings, a set of parts and flow charts. Four types of displays are introduced in the following descriptions: The first one (abbreviated as CI) is exhibited with colors in all graphics including assembly drawings, parts and flow charts. Except for colors, all parts are located in the same direction as assembly and some instructions are described beside the detail graphics in the flow charts (see Figs 1.).

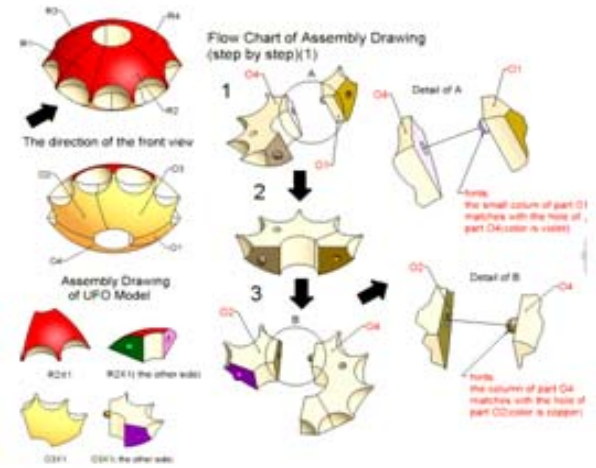

Figure 1. Colors on the assembly, parts & instructions on the flow chart (CI)

The second one (abbreviated as CNI) is displayed the same style as the first one but parts are not put in the same directions as assembly location. In the flow chart, there is no instruction beside the graphics or detailed drawings (see Fig. 2). The third one (abbreviated as NC) has not colors on the surfaces of objects including the flow chart of assembly drawing (see Figs. 3). The fourth one (abbreviated as NCI) has not colors on all parts and assembly drawing, and no instruction beside the detail graphics in the flow chart (see Fig. 4).

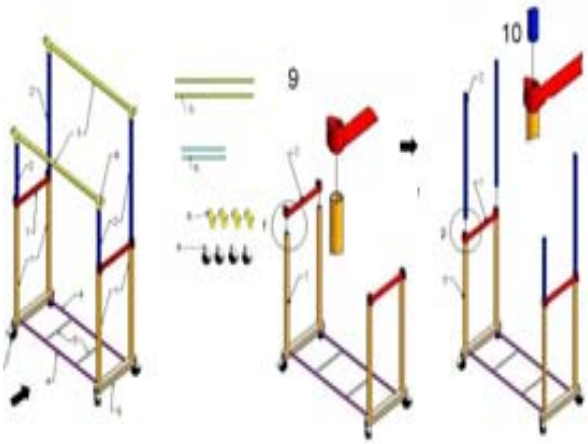

Figure 2. Colors on the assembly, parts & no instructions on the flow chart (CNI)

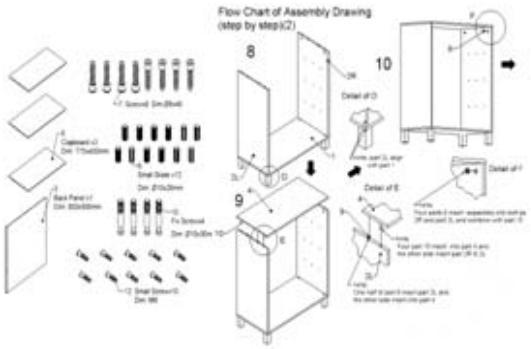

Figure 3. No color on the assembly, parts & flow chart (NC)

To avoid the non-expected effects caused by other factors to the goal of this study, all the representations of objects in this test are drawn by the tool of Computer-Aided Drafting and ignored in lighting and texture.

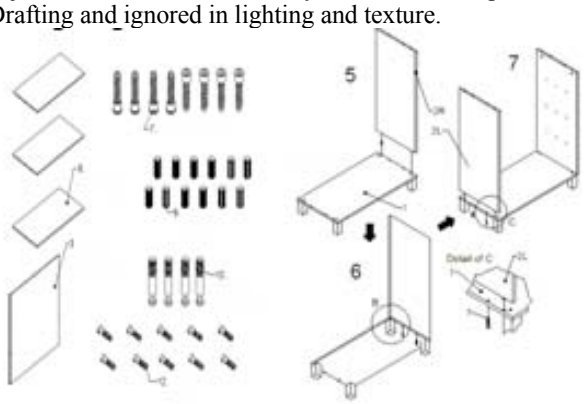

Figure 4. No Colors on the assembly, parts & no instructions on the flow chart (NCI)

C. Contents of the empirical study

In order to explore the comprehensions of the consumers to the different products including simple and complicated

constructions, we demanded participants to look through the manual from the first page to the last one. Every manual has the same contents and arrangement except colors, instructions and the direction of parts to be displayed.

The contents of the manual in the empirical study contain three daily commodities constructed by three different combined ways (see Fig. 5), which are displayed in the manual in sequence. According to the forms of combination between parts, these patterns of assembly respectively are divided into (1) match of hole and shaft, (2) match of screw and (3) match of puzzle. The contents of the empirical study include two parts. One is the descriptions of graphical manuals including assembly drawings, parts and flow chart of assembly. The other is test book that includes two parts: (1) the directions of parts in assembly, total items amount to 12 questions (each product has 4 questions) (2) which part should be put in the right position in the assembly drawing (see Fig. 6), total items amount to 28 questions (Clothes Rack has 6 questions, Bookcase has 15 questions, UFO model has 7 questions). The final question asks the participants to select their best option from the four displays. To avoid the non-expected effectiveness caused by different methods of drawing tools, all the 2D & 3D graphics in the manual and test book were created by the Autodesk Inventor Professional 2010.

In addition to the expression of graphics, arrowheads and a series of numbers are added to the steps of assembly process. To emphasize the differences between design elements, it is obviously shown by the appearances of elements according to different occasions. Nevertheless, it is a fact that graphic is a very simple and effective tool to communicate with users. With a view to avoiding confusion by the users of DIY products, colors in adjacent surfaces should be different and opposite as much as possible. If graphics make the users confused in the process of assembly, it has to be added a detailed drawing to illustrate for assistance near the place of match. Regarding to parts, we will mark them with names and numbers that will help users to find the right component matched in the correct place easily. If necessary, we will draw a sectional view to reveal the relative positions between parts of the products and indicate the structure of assembly. Leaders are used here to point out what the parts are belonging to and where they are, arrowheads should always terminate on a line such as the edge of a hole; dots should within the outline of the part.

Figure 5. Three types of DIY products in the manual

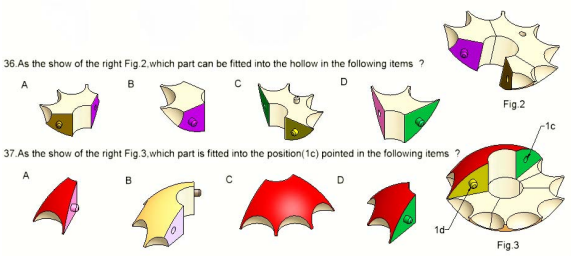

Figure 6. Tests of match in selecting the correct part

D. *Procedure of empirical study*

With the purpose of corresponding to the sequence of empirical process, there were two steps taken placed in this study sequentially for the following DIY products: Clothes Rack, Bookcase and UFO model. First, all the 100 participants were divided into four groups. Every group (25 participants) were randomly arranged to look through one of the four displays in the manuals of the three products. Secondly, they went to the next step to select the correct answers from the test book of the empirical study in a certainly time and then handed up to count time as soon as the questionnaire was finished. After carefully analyzing, there is no significant differences existed about the factor of spent time, and it was about thirty-three minutes for finishing the empirical studies.

III. RESULTS

An analysis of variance (ANOVA) was performed here to investigate whether there were significant differences existed within the understanding of the manuals for the three DIY products constructed with various types of surfaces by the four types of displays in the empirical study.

A. *Result of the empirical study*

The result of the empirical study was conducted by the participants after calculating all collected data. As shown in Table Ⅰ, the first kind of expression (abbreviated as CI, M=31.52) is perceived as more distinct than those of NC (M=25.8) and NCI (M=26.48). Furthermore, if we separately analyze the perceptibility of the three DIY products exhibited by four various displays. Table Ⅱ shows that the effectiveness are various in the different product presented. There are three outcomes to be obtained as followed.

- About the product of Clothes Rack, the comprehension about assembly related to both position and match are not significant difference no matter what types of displays.
- About the product of Bookcase, both the first type of expression (CI, M=14.76) and the second (CNI, M=14.44) are exhibited more explicit than that of the third type of expression (NC, M=11.16).
- About the product of UFO model, the first type of expression (CI, M=8.72) is the best demonstration, and it is clearer than the third type of expression (NC, M=6.48) and that of the fourth (NCI, M=6.72).

Further analysis, if we make the statistic analysis of ANOVA on the position & direction to each product, it shows that there is no significant differences existed in the four kinds of display about Clothes Rack and Bookcase. On the contrary, there is significant differences (p**<0.01) existed in the product of UFO model, and the first type of expression (CI, M=3.6) is more comprehensive than the second type of expression (NC, M=2.56) and that of the forth type (NCI, M=2.84). When we analyze the condition of match for the three products separately, there is no significant differences existed for the four kinds of display about the products of Clothes Rack. But, there are significant differences (p**<0.01) existed in the products of Bookcase and UFO model. It shows that both the first type of display (CI) and the second one (CNI), which are the products of Bookcase and UFO model, are clearer to modify good perceptibility than that of the third (NC).

In the last question of this test book, we asked participants to select which type of display was the best representation during the process of study. It shows that the display of (1) CI (75%) was the most selected in the four displays. Through the statistic analysis of Chi-square, there is an obvious finding that the display of CI was the optimal answer in all displays including (2) CNI, (3) NC, (4) NCI and (5) others.

TABLE I. DESCRIPTIVE STATISTICS & ANALYSIS OF VARIANCE FOR COMPREHENSION TO ALL THE THREE PRODUCTS OF DIY ABOUT THE FOUR TYPES OF DISPLAY

Types of Display	M	SD	N	F	Scheffe' Comparison
(1) CI	31.52	5.32	25	4.892**	1>3 1>4
(2) CNI	29.20	5.23	25		
(3) NC	25.80	6.14	25		
(4) NCI	26.48	6.93	25		

P**< 0.01

TABLE II. ANALYSIS OF VARIANCE OF COMPREHENSION ABOUT THREE PRODUCTS OF DIY IN THE FOUR TYPES OF DISPLAY

Types of products	F	Scheffe' Comparison
Clothes Rack	1.247	No Significant Difference
Bookcase	5.777**	1>3, 2>3
UFO model	6.241**	1>3,1>4

P**<0.01

B. Responses of the interview

During the operation of empirical study, we interviewed participants to capture their perceptions and impressions, and we summarized the responses of participants. Besides color and instruction, there are some factors that would affect the understanding of manual designed by computer as followed: (1) Apply the explosive drawing in the manual in order to clarify the relationship between parts. Especially it can indicate the fit position between two connected parts. If necessary, the animation can be used to show the assembly process step by step. On the contrary, it can also show the condition of exploding (2) Sectional drawing of parts is frequently used to appear the condition of assembly and the direction of arrangement while they are combined (see Fig. 7). (3) For the purpose of increasing attention and avoiding complication in the process of assembly, only those parts which should be colored on their surfaces. (4) Orthographical views can be used in the manual design for the exhibition of all parts (see Fig. 8). Besides, most participants always mentioned that different colors on the surfaces of parts will bring about various effects when they were matched together. Therefore, even though we ignored the attributes of colors here, it will be a very important factor when we decide to use colors on the surfaces of parts in the manual. So, in relation to colors and tone, it ought to make a deep discussion as well as classification in the further research.

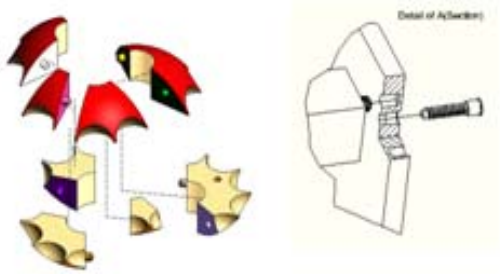

Figure 7. Explosive drawing & Sectional part

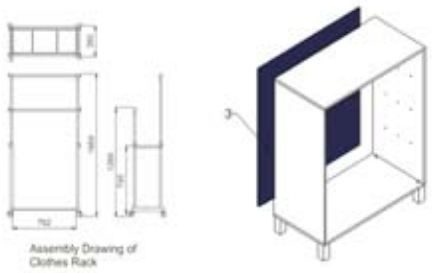

Figure 8. Orthographical views & Color only by the assigned part

IV. CONCLUSION

The purpose of the survey in this research is to understand the differences of perceptibility to the DIY products manual which is displayed by colors and other design elements. Applying the principles of universal design is to ensure this product manual to be used effectively by the widest range of user groups. We do not make a further distinction here about the feeling of various colors themselves. In general, we obtain the facts that colors painted on surfaces of parts can really promote the comprehension of the DIY products. By the way, no all kinds of products can correspond to the rule, which depends

on the styles of shape or the types of DIY products. As usual, when we color parts in a manual of DIY products with the complicated shapes, there would have a good effectiveness of display.

The results and participants' implications derived from the research findings show the following conclusions:

- The design of product manuals should more use the factor of color in order to enhance the effectiveness of revealing the process of assembly. Besides, arrowheads, leaders, letters and numbers can also help users to understand the relative position among parts of products.
- For products with simple matching way like hole to shaft, it is not necessary to use colors as well as instructions to display. It is recommended that the structure of single line is good for the DIY product manuals.
- DIY Products with irregular shapes of surfaces and sophisticated structures should be represented with the best expression by colors on parts, instructions in flow chart and parts shown in the same direction as assembly.
- Explosive drawing, sectional graphics, orthographical views and photos should be broadly applied in adequate places in the manual design of DIY products.

In this study, we try to establish a framework for concise and understandable manual of DIY product based on existing experimental study. In general, it is distinctly indicated that computer tools are useful for design of graphical manual and the style of displays with colors and instructions in manual are used in complicated DIY product such as UFO model. Nevertheless, if we want to make a manual for the clothes rack, colors and instructions are not necessary for use.

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