INVESTIGATING THE DEVELOPMENT OF IMAGINATIVE AND CREATIVE CAPACITY IN PRODUCT DESIGN

K. Chen

Department of Industrial Design, National United University, Miao-Li, Taiwan

Abstract: This research was conducted through a literature review, case studies, and interviews with experts on award-winning works in international design competitions. Through qualitative analysis of these design projects, we identified several paths leading from imaginative constructs to conceptual development in the design process: thematic relationships, intersecting attributes, the transfer of attributes, inherited attributes, causal relationships, analogical relationships, multi-level inclusive relationships, and the interpretation of contrasting meaning. Lastly, statistical analysis was used to determine the weight of each conceptual development mode in the design process. Results show that the most significant mode of conceptual development in the overall design process is causal relationships, followed in decreasing order by multi-level inclusive relationships, thematic relationships, the transfer of attributes, analogical relationships, inherited attributes, intersecting attributes, and lastly, the transfer of attributes. It is hoped that the results of this study will serve as a useful reference in design education, particularly with regard to the development of imaginative and creative capacity.

Keywords: design imagination, creative analysis, case study, conceptual development, design process

1. Introduction

1.1. Background

Humans have an inherent tendency to explore the world through sensory perception. An enormously talented Renaissance painter, scientist, and engineer, Leonardo Da Vinci is widely considered to be one of the most enduring geniuses of imagination in human history. Da Vinci spoke about a common disregard for human senses, indicating that the average person looks without seeing, listens without hearing, touches without feeling, eats without tasting, acts without awareness, and speaks without thinking. He felt that humans suffered from a general lack of imagination and realization of sensory perception. Picasso was a tremendously influential contemporary artist, Shakespeare one the greatest literary giants, Philippe Stark an Italian genius of design, and Einstein one of the most pivotal scientists in human history. These great men all had one thing in common: extraordinary sensory ability and imagination.

1.2. Objective

The aim of this study was to explore the potential mechanisms through which creative and imaginative capacity in the field of design is developed. The results could enhance our understanding of how to strengthen imaginative and creative power in design, and create products with greater aesthetic and sensory value.

The research was conducted through case studies of award-winning works in international design competitions. We discuss the concept development process and reconstruct the mechanisms through which imaginative design took form. Our purpose was to understand what creative and imaginative elements these prizewinning works showed, and how the imaginative capacity was developed during the design process.

2. Literature Review

2.1. Imagination

Wiktionary defines imagination as "the image-making power of the mind; the act of creating or reproducing ideally an object not previously perceived". This type of mental activity is not bound by any form of rules or regulations, nor limited by existing models of thought. To compare imagination and association: Association is linking one object, person, or idea to another; there is a clear thread of logic. Imagination, on the other hand, need not follow these trails of logic. Children are usually seen as being rich in imagination, because their thought processes have not been fully developed, and thus they have less mental rules or limitations compared to adults.

Designers or artists also require extensive imaginative capacity, as their work is of a creative nature. Imagination allows them to transcend existing boundaries and produce new artistic functions or conceptions. Gaston Bachelard indicated that imagination is "the ability to distort images generated through perception; most of all it's the ability to free ourselves from the first images." Through imagination, we can activate the meaning behind the characterization of reality, e.g. (Kaplan, 1972). Maria Montessori defined imagination as a force behind the discovery of truth. She indicated that, far from being a passive entity, the human brain is an eternally burning flame that can ignite independent, creative imagination, (e.g., Standing, 1957). Albert Einstein considered imagination to be more important than knowledge.

2.2. Creativity

While imagination is not limited by existing models of thought, creativity is a step toward further development based on existing concepts. Creative work requires knowledge in related domains (such as some simple guidelines for thought) and a capacity for pattern recognition and deconstruction, e.g. (Khlar & Simon, 1999). Studying the creative process from the angle of pattern recognition raises the question of how humans derive new solutions from existing conditions, knowledge, experience, and familiar concepts. Seen from this point of view, creativity can be considered a process of analogical thought leading to a solution, (e.g., Gentner, 1983, 1988; Holyoak & Thagard, 1995). An analogy is a reasoning process that, based on similarities among concepts, connects specific elements from one concept to another, enabling this concept to produce a new meaning or solution.

A metaphor is a special analogical form, often seen as an important medium of scientific discovery, (e.g., Brown, 2003; Lakoff & Johnson, 1990). Brown (2003) has indicated that the process of scientific discovery often occurs by connecting particular elements of an existing problem concept to another problematic concept, and then using the knowledge or solution from the first concept to solve the second .Therefore, Sternberg (1996) emphasized that apart from the insight, fluency, flexibility, uniqueness, and continuous effort, creativity also requires the following three abilities ; Synthetic ability: The ability to produce creations from existing knowledge and skills. Analytic ability: The ability to analyse contexts and evaluate ideas. Practical ability: The ability to translate theory into practice.

Imagination is the mother of creativity, and creativity involves practice and implementation. Although there are few studies on how to assess imaginative capacity, a number of scholars have expressed opinions on their assessment of creativity. Guilford was the first to research measurement of

creativity, using the Divergent Thinking Test published in 1950. This included an "Unusual Uses Test" (Guilford, et. al., 1958), which was followed by the Structure of Intelligence (SOI) test (Guilford, 1967). After reviewing literature on the criteria for creative products, Besemer & Treffinger (1981) proposed the Creative Product Analysis Matrix (CPAM), a three-dimensional model for judging creativity in products. Based on CPAM, Besemer & O'Quin (1981) had developed the Creative Product Semantic Scale (CPSS). This scale uses three dimensions (Novelty, Resolution, Elaboration and Synthesis) and fourteen indicators (surprising, original, and convertible, logical, suitable, useful, valuable, expressive, complex, ingenious, attractive, organized, and elegant) to assess product creativity. Using the results of empirical studies, Besemer & O'Quin (1986) modified and produced a new version of the CPSS. The original 14 indicators were amended to 11. The indicators "convertible" and "attractive" were combined into the single indicator "surprising"; "suitable" and "relevant" were combined into the indicator "logical", and the indicator "expressive" was renamed "understandable". The results of reliability and validity analysis confirmed that these 11 indicators are a valid, reliable tool for assessing the value of creative products. The author feels that the greatest difference between imagination and creativity is that imagination allows considerable room for dreams and hitherto unexplored dimensions, while creativity is more result-oriented and tends to adopt known approaches to solving problems. An individual with a strong imagination will also be highly creative; however, a creative individual may not necessarily have a unique or rich imagination.

2.3 Concept formation and creative design

Gaston Bachelard categorized imagination into two types: formal imagination and material imagination. While the former focuses on the appearance of forms and reacts to the external senses, the latter penetrates into and expresses internal feelings. It is only through material imagination that one can understand and materialize the immanent, (e.g., Kaplan , 1972). To facilitate the continuance of imagination, we must penetrate and discover its roots. Freud (posited that dreams are the fulfilment of wishes and compensate for the insufficiencies of desire. He wrote that, aided by the imaginative mechanism of dreams, imagination transcends the boundaries of reality and satisfies the aspirations and expectations of the self. Joseph Addison posited that literature is an environment in which the pleasures of the imagination are created.

With regard to concept formation in imagination, scholars have found that the production of a new concept of combined concepts is influenced by several factors, such as the similarity between concepts, the physical classification of concepts, whether there are shared attributes between concepts, and the sequence of combined concepts. Greater similarity between concepts implies a greater likelihood of shared attributes among combined concepts. However, corresponding attributes indicate a lower probability of producing a new concept, (e.g., Wisniewski, 1996; Ward et.al. 1997). In other words, greater similarity in concepts can produce an outcome lacking imaginative quality.

Ulrich & Eppinger (2008) once described the design as a series of steps transforming a set of inputs into an output. Product development is a process of conceptualization, design, and commercialization. Many of the steps involved in this process are of an intelligent or organizational –rather than substantive-nature. Ulrich divided the process of product development into six stages: planning, concept development, system-level design, detail design, testing and refinement, and production ramp-up. Research on creativity from the angle of cognitive processes can generally be divided into three categories: stage theory, remote association theory, and divergent thinking. Stage theory divides the process of creativity into four phases. Remote association theory sets creative thinking as a process by which objects are connected or associated to meet specific needs or achieve specific objectives. The third theory sees creativity as an ability produced by divergent thinking. These three theoretical viewpoints are further explained below:

Wallas (1926) divided the creative process into four phases: preparation, incubation, insight, and verification.

(1) **Analysis and preparation**: The task of the individual in this stage is to carefully analyse the problem, explore its dimensions, and accumulate and systematically organize problem-related knowledge and skills, with the aim of solving the problem

(2) **Incubation**: If a solution to the problem is not derived in the previous stage, the creative process enters the incubation phase. In this phase, the problem is internalized into the unconscious mind; the individual no longer devotes conscious thought to the problem. Although nothing appears to be happening externally, the individual's thoughts are still working in the subconscious or preconscious, unlimited by logical, conscious thought. The initial constructs for unexpected and extraordinary results may begin to take shape in this phase.

(3) **Inspiration**: In a moment of insight, the creative solution bursts from preconscious processing into conscious awareness. In this phase, after long- or short-term incubation, the individual has begun the initial formation of the creative outcome.

(4) **Verification**: In this stage, the individual verifies the value of the idea according to internal and external criteria, and further elaborates and modifies the idea.

With regard to divergent thinking, Guilford (1988) proposed the principle of the "structure of intelligence" (SOI). He indicated that divergent thinking and creativity are related concepts. Rather than aiming for a single solution to a problem, divergent thinking involves creatively generating multiple answers and solutions to a problem. As seen from this point of view, creativity comprises the following four characteristics: fluency, flexibility, originality, and elaboration. Fluency is the capacity to respond rapidly to stimulus (problems). Apart from the ability to generate a large number of meaningful, relevant ideas and associations in response to a problem, this characteristic also includes fluency in expression. Flexibility means being able to think flexibly about problems and change the direction of thought when needed. The problem and its solutions are approached from many different sides rather than being limited to a single angle or viewpoint. If failure or difficulty is encountered during the problem-solving process, flexibility refers to the ability to re-think other feasible methods. Originality refers to the ability to generate unique, statistically rare ideas. Elaboration refers to two capabilities: One is the ability to execute a plan to completion, while the other is the ability to refine solutions with further details and ideas.

In the remote association theory, Mednick (1962) defined creativity as "the forming of associative elements into new combinations which either meet specified requirements or are in some way useful. The more mutually remote the elements of the new combination, the more creative the process or solution." From the viewpoint of cognitive structure, there is a fixed hierarchy of individual associations. The intensity or gradient of the associative hierarchy is negatively correlated with the total number of associative elements produced. While individuals with a steeper gradient react faster to stimuli and have more intense associations, they produce fewer associative elements. Conversely, individuals with a shallower gradient have relatively fewer associations and respond more slowly to stimuli, but can produce a greater number of creative associations. Mednick believed that individuals with a flat hierarchy (slope) are more inclined toward remote associations and more capable of creative thinking. Conceptual combination refers to joining or juxtaposing two or more existing concepts to produce a contextually suitable new concept, (e.g., Davidson, 1995; Ward, Smith & Vaid, 1997). Therefore, the process of design can be generally categorized into four continually repeated stages: data collection, incubation, creation, and verification/modification. The design also involves many new and imaginative concepts. Rather than being limited to the development of a single product, it is a process that leaves a great deal of room for imagination. Designers must consider the design of the overall system rather than confining themselves to localized parts. With its engaging and active elements, design can attract public participation; promote social consensus, and lead to harmonious decision-making. Design is imaginative in nature, capable of stimulating the development of creativity.

The author feels that imagination is a potential capacity in each individual- one that can be developed and trained through superior design concepts, forming an imaginative power that combines both artistic and scientific qualities. Extending beyond the realm of product development, design is an effective path to the creation and realization of aesthetics in life.

3. Case Studies

This study applied case-oriented inference methods, (Maher & Pu, 1997). We collected information on IF and Red Dot award-winning works (2008: 77 IF award-winning pieces and 62 Red Dot award-winning pieces/ 2009: 50 IF award-winning pieces and 56 Red Dot award-winning pieces) and interviewed experts on 20 selected works. From the interview results, we identified the development paths of design imagination. The interview content is briefly described below:

- How was the theme for this work established?
- How are the design concepts shown in this project?
- What prerequisite knowledge is required to undertake this design project?
- What difficulties were encountered during the design process? How were these resolved?
- What type of personnel was involved in this design project? What are their backgrounds? What were their individual tasks?
- What were the results of this design project? What was its contribution as far as solving a problem or expressing innovation? How were its innovative or contributing elements produced?

3.1. Case study: Toy chest

Toy Guardian was awarded the 2010 IDEA bronze medal. Generally speaking, it is not an easy task to make children put away their toys. Based on the saying, "To make children obey, use their imagination", Toy Guardian was designed as a toy chest in the form of an animal. Through the vivid imagination of children, putting toys into Toy Guardian is transformed into "feeding the animal". This design aimed to motivate children to put away their toys on their own initiative.

Equipped with wheels, Toy Guardian can be "ridden" by children, enhancing its animated features (see Fig. 1). We reconstructed and analysed conceptual development and design procedures in this case, as shown in Fig.2. Experts were interviewed to discuss the thought patterns behind the creative design process. Through path analysis, we investigated conceptual formation and inter-concept relationships in this design project. These relationships are briefly described below:

Thematic relationship: Following conceptual combination, a new concept was produced from the potential relationships between various existing concepts. For example, the concepts of "animal" and "pet" were combined with "toy" and "animation". The resulting concept was to transform the act of putting away toys into an activity of "feeding the pet".

Intersecting attributes: This means that the new concept is interpreted through the shared attributes of different concepts. The intersecting parts of the various concepts are used to give meaning to the new concept. For example, "feet" was combined with "movement" to produce "wheels" ("Wheel" is the new concept generated through the shared attributes of "feet" and "movement").

Transfer of attributes: During conceptual combination, a new concept is generated by transferring certain attributes from one concept to another. For example, "toy" was combined with "pet" to produce "toy pet". The concept of animation (life) was combined with "toy chest" to produce a toy chest in animated form.

Inherited attributes: This refers to inherited attributes at different levels within the conceptual combination. An example is the relationships among "animation-master-pet": Humans are animate beings and act as masters to pets, which are also living creatures.

Causal relationship: A causal relationship is established to join two different concepts; for example, "eat" was combined with "movement" to generate the concept of "animation" (only an animate being can move and eat; thus, an interactive causal relationship was established between all three concepts)

Analogical relationship: The final new concept is an analogy of the relationship between two existing concepts. For example, "feeding [a] pet" was used as an analogy of "putting away toys" (new concept: putting away toys while feeding a pet)

Multilevel inclusive relationship: A single concept is used to join two concepts into a multi-level set. For example, the concept "putting away toys" was used to combine "eat" and "movement" (putting away toys involves concepts of both "tidying" and "movement"; thus, "eat" and "movement" were combined to interpret the new concept)
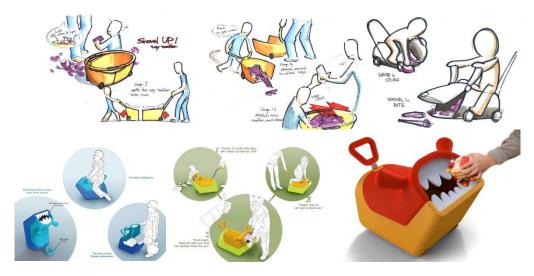

Figure 1. IF Concept award-Toy Guardian (provided by Lu Zong Yu)

4. Results and Discussion

Diagrams of the thought patterns behind each design project were produced from interviews with experts. The creative process, according to our knowledge, can be roughly divided into four stages: Data collection/literature review, incubation, creation, and verification. The first phase mainly involves establishing the design theme, applying existing technology, observing and solving problems, and collecting relevant data. Incubation is mainly a subconscious phase (incorporating the personal experience of the designer and unconscious thought). In this stage, the designer also seeks to conceptualize the problem and search further for potential solutions. In the creation phase, the designer visualizes the potential concepts or ideas in the context, culture, and surroundings of the user (considering materials, form, and processing).

In the verification stage, a prototype is produced and tested to determine the feasibility of the idea. The concept is then modified and fine-tuned to produce the final design outcome. From the path diagrams, we analysed the formation and development of the creative process. We identified seven different models of conceptual development: thematic relationship, causal relationship, analogical relationship, multi-level inclusive relationship, intersecting attributes, the transfer of attributes, and inherited attributes. Future research will further development for the creation of models and understanding of patterns concepts for creative effects connected to each other. At the same time to further explore the impact of development of product design and creativity in the conceptual combination mode.
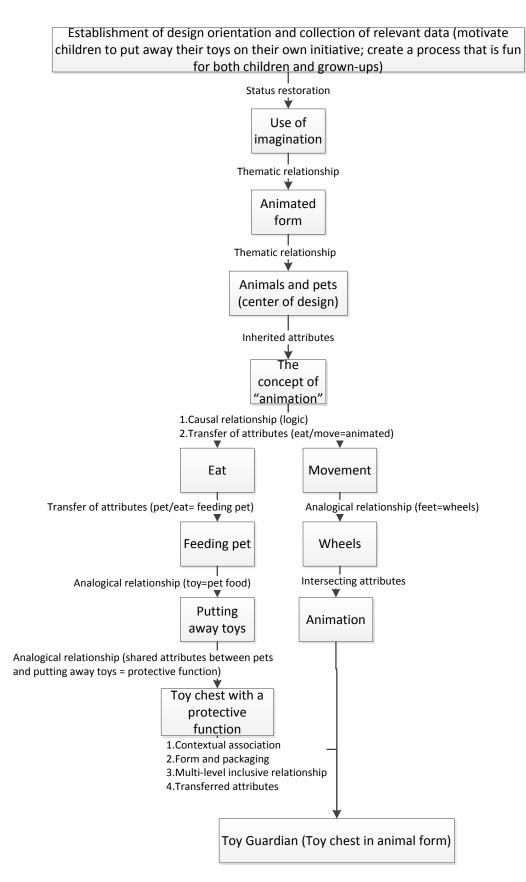
Figure 2: Path analysis of design imagination behind Toy Guardian

References

Addison, J., A most gratifying delusion, [cited 2010 April 28]; Available from http://www.mnstate.edu/gracyk/courses/web%20publishing/addison419.htm

Albert Einstein, ＜Imagination＞, [cited 2011 May 28]; Available from http://www.quotationspage.com/quotes/Albert_Einstein/

Besemer, S. P. & O'Quin, K. (1986). Analyzing of creative products: Refinement and test of judging instrument. Journal of Creative Behavior, 20(2), 115-126.

Besemer, S. P. & Treffinger, D. H. (1981). Analysis of creative products: Review and synthesis. Journal of Creative Behavior, 15(3), 158-178.

Brown, T. L. (2003). Making truth: Metaphor in science. Chicago: University of Illinois Press.

Davidson, J. (1995). The suddenness of insight. In R.J. Sternberg & J. Davidson (Eds), The nature of insight. Cambridge, Mass.: MIT Press. (pp. 125-155).

Freud, F., Translated by A.A. Brill, 1911, The Interpretation of Dreams, [cited 2011 December 14]; Available

From   http://books.google.com.tw/books?id=3kiY47lpI3AC&printsec=frontcover&hl=zh-TW&source=gbs_ge_summary_r&cad=0#

Gentner, D. (1983). Structure-mapping: A theoretical framework for analogy. Cognitive Science, 7, 155-170.

Gentner, D. (1988). Metaphors as structure mapping: A theoretical framework for analogy. Child Development, 59, 47-59.

Guilford, J. P. (1967). The nature of human intelligence, New York: McGraw Hill.

Guilford, J. P. (1988). Some changes in the structure-of-intellect model. Educational & Psychological Measurement, 48, 1-4.

Guilford, J. P., Merrifield, P. R., Wilson, R. C. (1958). Unusual Uses test. Orange, CA: Sheridan Psychological Services.

Holyoak, K. J., & Thagard, P. (1995). Mental leaps: Analogy in creative thought. Cambridge, MA: MIT Press

http://www.mnstate.edu/gracyk/courses/web%20publishing/addison419.htm

Kaplan, E. K. (1972). Gaston Bachelard's Philosophy of Imagination: An Introduction. Philosophy and Phenomenological Research, Vol. 33, No. 1, 1-24,Published by: International Phenomenological Society , Stable URL: http://www.jstor.org/stable/2106717

Klahr, D. & Simon, H. A. (1999). Studies of scientific discovery: Complementary approaches and convergent findings. Psychological Bulletin. 125, 524-543.

Lakoff, G. & Johnson, M. (1990). Metaphors we live by. Chicago: Chicago.

Lawrence Erlbaum Associates, NJ.

Maher, M.M, & Pu, P. (1997). Issues and applications of Case-Based Reasoning in Design.

Mednick, S. A. (1962). The associative basis of the creative process. Psychological Review, 69, 220-232.

Smith & J. Vaid (Eds), Creative thought: An investigation of conceptual structures and processes. Washington, DC: American Psychological Association (pp. 83-110).

Standing, E. M. (1957). Maria Montessori: Her Life and Work. New York: Plume. pp.263–280.

Sternberg, R. J. & Lubart, T. I. (1996, Jul). Investing in creativity. American Psychologist, Vol 51(7), 677-688. doi: 10.1037/0003-066X.51.7.677

Ulrich , K. T. & Eppinger, S. D. (2008). Product Design and Development, Mc Graw-Hill Education, pp.13-15.

Wallas, G. (1926). The art of thought. New York: Harcourt Brace Jovanovich

Ward, S.M. Smith & J. Vaid (Eds), Creative thought: An investigation of conceptual structures and processes. Washington, DC: American Psychological Association. pp. 1-27.

Ward, T. B., Smith, S. M., & Vaid, J. (1997). Conceptual structures and processes in creative thought. In T.B.

Wiki, ＜Imagination＞, [cited 2009 April 28]; Available from http://zh.wikipedia.org/w/index.php?title=%E6%83%B3%E5%83%8F%E5%8A%9B&variant=zh-tw

Wisniewski, E. J. (1996). Construal and similarity in conceptual combination. Journal of Memory & Language, 35, 434-453.