FORMATION OF CREATIVE THINKING BY ANALOGICAL PERFORMANCE IN CREATIVE WORKS

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Abstract

Analogical technique is assumed as a tool for assisting in creative problem-solving. The researchers instructed the students to perform their creative works through the creative curriculum and instruction with analogical technique. The researchers analyzed the work designers' thinking process of awareness, observation, strategy and reflection from the work design with creative conception by the students. The researchers found that the process of awareness and o bservation benefited the critical imagination of analogy, and the process of strategy and reflection benefited the design of background and conception. The findings and suggestions acquired in this research will be provided to the teaching in university as references with the creative design and monitoring learning in thinking performance.

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1. Introduction

The invisible imagination of design and the cultivation to the ability of problem-solving are embedded in creativity. Creativity is an indispensable ability to determine the success in the future (Gardner, 2007). It is important to increase the creativity in design and potentials for innovations which could be transformed into commercial purposes (Mumford & Gustafson, 1988; Thompson & Lordan, 1999). West and Sacramento (2012) emphasized creativity as essential for survive of organizations. Creativity has become core business for those who seek the development of employees' ability and capacity (McWilliam & Dawson, 2008). In Australian curriculum, creativity is synonymous to innovation and invention, and it appears to play a central role in education in the UK (Burnard & White, 2008). Since 1990s, the countries including Australia, Singapore, Thailand, the United States, and Taiwan have been actively promoting the idea of creativity and taking steps to launch the programs, and to enhance national soft power, hard power and global competitiveness (Shen, 2010).

Creativity in more natural settings displays the same pattern of structured imagination (Cruz & Smedt, 2010). Analogical method is a type of logical method, which deduces the possibilities of the identical or similar properties in other areas on the basis of two certain items or two categories of items in certain property or associations. Analogy is applied through the broader meanings such as resembling, consistency, similarity. Analogy is objectively based on the relationships among the items or events regarding the attributes. It contains the commonality and similarity. Among the items or events, the commonality and similarity in analogy involves the diversities. The similarities in the analogy comprise the ones in terms of information, attributes, relationships, systems and structures and so on.

Analogical method provides us with a new way to try seeking for situations rather than just to wait for the occasions of intuition. Therefore, analogical method can enlighten people on a series of obvious, hackneyed or departing from nature thoughts. Gomes, Seco, Pereira, and Paiva (2006) stated that analogy is an important reasoning process in creative design. It enables the generation of new design artifacts using ideas from semantically distant domain. Crilly (2010) claimed design and other difficult problem solving are punctuated by moments of discovery. These are the moments when something new and important is suddenly "seen.'' In summary, as Middleton (2005) meant that designing, inventing, and the related activity of design and techno logy learning are: complex activities requiring higher-order think; where that higher-order thinking is facilitated not primarily by abstract thought but by visual mental imagery and the manipulation of concrete materials; in situations and contexts that are meaningful to the designer. Problems are solved sometimes by means of logical analysis (i.e. repetition of inductive and deductive reasoning). To obtain a creative

solution, an assumption has to suddenly strike the mind of the person searching. Analogical technique is possible to encourage people to be more creative and to approach tasks with creative outcomes in mind. The idea of teaching someone to be creative can strike people as an impossible task. Analogical technique is that one recognizes some similarities between the problem situation and brainstorming. It is popular to use the four kinds of analogy technique, including direct analogy, personal analogy, imaginary analogy, symbolic analogy (Altshuller, 2000; Shen, 2010).

Preparing college students for a knowledge-based economy is a challenge that requires curriculum design that puts more emphasis on learning skills than on content to be taught (Or-Bach, 2013). The main purposes of this study are to explore: the college students' outcomes of creative learning by employing analogical creativity skills; the thinking steps of creative works by employing NM creative skills; the analysis of the holistic processing of creative thinking on the works with applied analogy of creative skills.

2. Analogical Imagining Method and Assessment

2.1. Analogical Technique

Analogical technique is a tool to provide assistance in problem solving in terms of creativity. In the process of creative questioning and brainstorming, using analogical method may enable people to step out of the limitation of framework in thinking. Through analogical resembling, the pairing of any two relative questions or categories can generate new creativities. Analogy can assist people to understand the unknown items or events via the known ones and acts as the bridge between the image and logic model. Analogies are commonly used by students, teachers, and text books to make these connections, particularly where abstract concepts or ideas are involved. Regardless of type, analogies share common features, such as the familiar concept or idea (analogy), the new concept or idea (target), elements of similarity between the analog and target (links, features, or attributes), and the mapping of similarities between the target and analogy (Glynn, 1995; Seipelt-Thiemann, 2012).

Analogical technique also enables people to kindle similar images based on the key words of problem-solving, and to cause the related ideas of problem-solving by imagination. Direct Analogy (DA), that is directly to compare two objects, ideas or concepts and to have the original theme of the situation switch into the other one to generate a novel concept. Personal Analogy (PA) that is to have individuals become part of the question which have not solved yet or the image which are to be explored, and to have individual consciousness projected onto a particular object or idea. Imaginary or Fanatic Analogy (IFA) that is to

think, as far as possible, by unusual ideas, or possibly to imagine questions by farfetched way, for example, through the extraordinary imagination of sound, image, action, meaning to create a variety of creativities. Symbolic Analogy (SA) that is to use the characteristics of two conflicts, to have the unrelated phrases or words combined, and to obtain new ideas and the key of observation through the contradictions with streamline compression, lacking of coordination (Altshuller, 2000; Shen, 2010; Shen, 2012). Analogical reasoning is a widely used problem solving method. It consists in the transference of knowledge among different domains. This transference is based on similarities between past problems and the new problem. The transference knowledge is then used to generate solutions for the new problem. (Gomes, Seco, Pereira, & Paiva, 2006). Thus, viewing and manipulating objects that had some meaningful relationship to the to -be-invented object was seen as important to the process of generate solutions.

Masakazu Nakayama, a Japanese inventor, created the NM Method, a method to find out the solutions based on the two essentially similar properties of items or categories in thinking process. This method also enables people to kindle similar images based on the key words of problem-solving, and to cause the related ideas of problem-solving by images. Therefore, the thinking way of NM Method comparatively tends to analogical thinking such as situational analogy, phenomena analogy, and personal analogy driving from the observational analogy of natural phenomena (Shen, 2010). Nakamura (2003) pointed there are five steps as the following: (1) KW (Key Word): define the function or the main feature of the required technical system in a short clause including a verb. (2) QA (Question Analogy): look for an event that meets with the KEY WORD defined in the first step among natural phenomena or man-made systems. (3) QB (Question Background): clarify the principle and/or the mechanism that work(s) in the background of the analogous phenomenon found in the second step. (4) QC (Question Conception): idea generation from the principle and the mechanism of QB. (5) ABD (Abduction): combine ideas and brush up the concept (Shen, 2012).

2.2. Creative Thinking Assessment

The study of creativity is a fascinating area with many different approaches (Runco, 1999). The four broad categories into which creativity studies can be classified are person, product, press, and process (Runco, 2004). Creative thinking assessment is full of diverse ideologies. The assessment for creative products is still a lack of precious and effective criterion (Sternberg, 1999). Gangadharbatla (2010) concluded researchers' ideas and pointed about in the product approach of the emphasis is on outcomes. The creative process has

received attention from both psychologists and other researchers in recent years. Some researchers subscribed to the notion of creative process being a mental process and devoted attention to understanding this process using human subjects. The issue of how to assess creative thinking and products has been discussed in academic area. How to provide more relevant research and to establish concrete and practical criterion is still needed to be completed.

As Cropley and Cropley (2010) pointed it is obvious that a creative product involves bringing something new into existence. Without variation from what already exists there would be no creative products. They tried to recognize and foster creativity in technological design education. They proposed that criterion of creativity are included relevance and effectiveness, novelty, elegance, genesis in order to match different kinds of solutions, e.g. routine, original, elegant and innovative. There are properties of the solutions like as: 1. Solution displays knowledge of exist facts and principles. 2. Solution draws attention to problems in what already exists. 3. Solution adds to existing knowledge. 4. Solution develops new knowledge. 5. Solution strikes observers as beautiful (external elegance). 6. Solution is well worked out and hangs together (internal elegance). 7. Ideas in the solution go beyond the immediate situation.

Doppelt (2009) assessed 57 authentic projects and developed assessing creative thinking in design-based learning. He advocated that the criteria for creative thinking assessment in creative works are as follows: 1. Awareness- pupils' awareness that thinking is a skill that can be developed; that the pupil can prepare his or her mind to reason about smoothing, to inquire, and to listen to other people opinions. 2. Observation- the observation of consequences of action and choice; consider other people view; comparing alternatives. 3. Strategy- the use of thinking tools; organizing one's thinking as a sequence of steps; define goals. 4. Reflection- a systematic use of thinking tools; awareness of reflective thinking; evaluation of one's own thinking; designing thinking tasks and methods to implement these tasks. In this study, the researchers adopted Doppelt's ideas as analyzed basis.

3. Research Method

3.1. Works Selection

There were two classes of the course, Creativity and Thinking, taught by the researchers in the University, and there were 96 pieces of works completed by the students in accordance with: (1) description for creation titles (2) process of idea creativity: to describe the purpose of creation, the associated status of products and the motivation for the creativity (3) application of analogical thinking: the procedure of creative planning, work maps, work

characteristics, usage (4) design contribution: for example, the objects of consumption, markets, products, the expected contribution to the research and development opportunity, and feasibility analysis (5) index for patent and related products (Shen, 2010). The students completed their presentations and submitted the assignments in accordance with the criteria. The researchers scored and provided the students with the comments on their works in accordance with the use of analogical methods in their presentations and the use of creativity in terms of the modifications, original creativity, sophisticated design. The final selections of the best two works were chosen to be the subjects of the exploration in the creative thinking.

3.2. Procedure of Work Analysis

After the best two works were chosen, firstly, the creators of the works were invited to fill up the meta-learning form, including the statement of motivation for creativity, self-evaluation in terms of the tacit knowledge of applying analogical methods. Secondly, the interviews to the creators of the works were completed by the researchers in terms of the motivation for creativity, the process of thinking and the purpose of the creativity. Finally, the researchers analyzed the works based on the four aspects of process, awareness, observation, strategy and reflection. According to Doppelt's arguments, in the procedure analysis of awareness, the keys were including the students having mental preparation to listen to other people's opinions. In the procedure analysis of observation, keys were including the students taking meditation on other works and thinking of the substitute alternatives, making creative actions of analogical methods based on the results of observations. In the procedure analysis of strategy, the keys were including the students using analogical methods to organize the thoughts to conduct the horizontal and continuous thinking as creative steps. In the procedure analysis of reflection, the keys were reflection the students employing the systematic usage of analogical thinking, self-thinking with reflection as creative steps, assessment with the thinking design to complete the tasks with methods and products.

4. Results and Discussion

The best two works were chosen as analyzed examples which named piggy banks (Figure 1) and umbrella (Figure 2).

4.1. Creative Product 1: Piggy Banks

The creators made three types of piggy banks. The first product was also entitled as "mood piggy bank' (Figure 1a). The mood piggy bank liked as person mood, if the person

has happy mood, open mind and good fortune and then the piggy bank will have much more money, because he/she will toss much more money into the mood piggy bank. It uses direct analogical creation on the inspiration of mood piggy bank. Like as A is mood piggy bank and B is person mood, if we compare the two objects will generate new ideas C (more money) and D (happy mood). The second product, the budget saving piggy bank (Figure 1b) was personified as whom specializing in counting money. If we have fifty dollars and want to spend forty on shopping, how much money we can put into the budget saving piggy? The system of budget saving piggy bank will help and tell us the exact money we need to put them in. The third product t was to use symbolizing to generate the ideas of secret piggy bank (Figure 1c). If we would like to listen to a secret, we need to pay money into the ATM machine. When we give enough money into the machine and push the red button, it would tell us a secret from the mouth.

The processes of NM method are as following:

1.KW- Piggy Banks/ mood / budget / secret

2.QA- Piggy Banks/ the right to control the deposit and withdrawal of money; good idea if the Piggy Banks could talk about secrets

3.QB- Piggy Banks could reject the deposit of money, calculate the amount of deposits, could tell the master's secrets

4.QC- Piggy Banks could join the Russian roulette, be computing systems, be a refund machine, be recording and be the broadcasting system.

1(a) Mood Piggy Bank   1(b) Budget Saving Piggy Bank   1(c) Secret Piggy Bank

Figure 1.   Piggy banks- three types of piggy banks

4.1.1. Analysis of Creative Thinking Process of Piggy Banks

The creator see types of piggy banks by using analogical creative methods and direct analogical creation. This product was also entitled as "mood piggy bank," to be personified as "budget saving piggy bank," symbolizing as "secret piggy bank." The analysis of creative thinking process of piggy banks is as following, Table 1.

Table 1. Creative thinking process of piggy banks

Piggy Banks	Design Performance	Thinking Creativity
Awareness	1. Developing the relationship between the voice and image of the analogy of ATM as inference to piggy banks. 2. Developing the function of the piggy banks, vocal parts and modeling	1. One observed the procedure of ATM voice hints and deposition, accurate coin recognition, and cumulative capacity. 2. One observed the aims of saving money are to earn a living; the thefts usually wearing sunglasses; rich people always speak more loudly.
Observation	1. The development of the piggy banks having the operation interaction, display on screen.	1. An observation of coins putting into the deposit machine via the coin control access button by the user. 2. An observation that how wonderful that would be if people can withdraw money without depositing them. 3. An observation of the emotional. expression from the withdrawal user
Strategy	1. The direct analogy, personal analogy and symbolic analogy were applied to create ideas. 2. NM analogy was used to create images.	1. Free association: Piggy Banks/ money/ items/ emotions/ feelings/ secret/ size/ amount/ bank/ travel/ cloud. 2. Analogical concept: Piggy Banks/ mood/ secrets/ price. 3. Analogical focus: Piggy Banks in mood/ telling secrets/ price.
Reflection	1. Tending to the psychological reactions, emotions, computing and secret as a design objects 2. The designer will be tending to spread towards free associations and analogical thinking regarding piggy banks in cloud system based on mother and child (siblings) piggy banks.	1. Free association: from the human beings behavior of reflection, thinking performance and the correlation of money. 2. Analogical thinking: based on gather refining thinking.

4.2. Creative Product 2: Umbrellas

The creators made three types of umbrella (Figure 2) by using analogical creative methods and direct analogical creation. This product was also entitled as "folded skirt umbrella" (Figure 2.a) to be personified as "dress changing umbrella" (Figure 2b) symbolizing as "lizard umbrella." (Figure 2c) The process of sensing the umbrella indicated the shortcomings as issues as a basis for analogical thinking. The analogical design of umbrella was focusing on the ideas of human beings toward the functions, structure, and imitation design of the umbrellas.
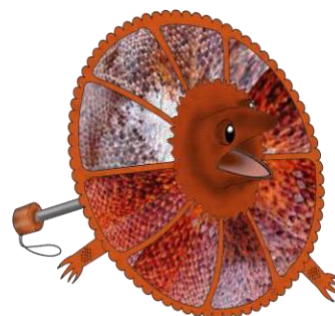
The processes of NM method are as following:

1) KW-umbrella / Folded Skirt Dress Changing/ lizards

2) QA- umbrella acting as human beings to be fashionable and with a stylish and personalized cover of umbrella; freely to hang stuff and the umbrella over being opened; umbrella could store animals

3) QB- umbrellas are easy to be dressed; umbrella stand to be used for sunny racks to dry the skirts; to open meaning to open the mouth and to fold meaning shutting up like a lantern

2(a) Folded Skirt Umbrella   2(b) Dress Changing Umbrella   2(c) Lizard Umbrella

Figure 2.   Diverse Changes of Umbrella

4.2.1. Analysis of Creative Thinking Process of Umbrellas

The umbrellas tended to be horizontal and various thinking and the designer will be conduct the meta-free associations and re-design based on the features. From the awareness to reflection, it appears analogical design ideas of creative thinking of umbrella.

Table 2. Creative thinking process of umbrellas

Umbrella	Design Performance	Thinking Creativity
Awareness	1. To develop the varieties of the folding design on umbrellas, to replace the cover of the umbrellas by changing clothes and moods as human beings doing; to integrate the feelings of human beings or animals into the design concepts. 2. To develop the cover of umbrellas to storage, change as dynamic design	1. Observed that the covers of umbrellas are smooth with cloth; the bracket and controller can be reserved 2. Observed that the cover of umbrellas are too monotonous; umbrellas can be dry or wet to be opened as animals
Observation	1. To develop the variability of the umbrella cover, umbrella stand and the foldable umbrella.	1. The observation of an umbrella stand as the drying rack to hang up the clothes 2. The observation of an umbrella cover as the office workers to wear changeable beautiful clothes 3. The observation of a foldable umbrella as the seeable design of pets in the cage
Strategy	1. The direct analogy, personal analogy and symbolic analogy were applied to create ideas. 2. NM analogy was used to create images.	1. Free association: umbrella / rain/ wet/ clothes/ the sun/ dried/ store/comforts/ patterns/ animals/ running and jumping/catch/grasp/ cloud/fly away/ leaves 2. Analogical concept: umbrella / clothes / dried/ animals 3. Analogical focus: variations of umbrella covers; clothesline umbrella; animal umbrella
Reflection	1. The umbrella, umbrella stand and umbrella storage as design objects. 2. The designer will be conduct the meta-free associations and re- design based on the features.	1. A free association: the reflections from the external and extension of umbrella in terms of the interests and functions of umbrella. 2. Analogical thinking: tending to horizontal and various thinking.

5. Conclusions

The Piggy Banks and Umbrellas were selected as the outstanding ranking in the analogical creativity competition. All of the pieces of works are from the designers based on the concert interaction within the obtained experiences on their daily life bases and going further to create the extending concepts in design by creative thinking. In the awareness, observation, strategy and reflection of creative thinking process, from the manipulation of the ATM table screen, and the interaction among human beings and the umbrella cover, stand and topping to be as the basis for analogical imagination and application. Students

know how to use analogy technique should be easily to create divergent and convergent ideas on works' design even from functions, structures, shapes, and colors and so on.

To sum up the conclusions, this research shows as follows: in the phrases of awareness and observation, the designers were motivated and assisted to conduct the analogical meditation with key elements; in the phrases of strategy and reflection, the designers were motivated and assisted to conduct the background and connectional design. Based on the findings, the researchers argue that students are motivated to conduct the creative meditation via the creative design phrases, awareness, observation, strategy and reflection, on the basis of their daily information encountered and experiences of interaction if the instructions employ the analogical methods in the creative design in the curriculum and instruction.

Acknowledgements

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