

TRAINING PROGRAMS FOR COGNITIVE COMPONENTS OF CREATIVITY: A PRELIMINARY STUDY

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ABSTRACT

This paper discusses the development of a set of brief exercises to address the cognitive elements of creativity; fluency, flexibility, originality, elaboration and problem sensitivity. To foster the design creativity, an exercise program for the cognitive elements of creativity has been devised and it is composed of five activities including making stories, negation, filling black box, sensitization and diverse classification. Each activity of the exercise program has been devised so that one or two cognitive elements are strongly addressed. In this way, this program could be used in helping students considering their individual needs and contexts. Preliminary experimental results indicate that the proposed creativity cognitive element exercise program could be useful in design creativity education.

Keywords: Creativity Learning Model, Cognitive Components of Creativity, Creativity Thinking Activity Program, Design Creativity

1 INTRODUCTION

It is important to establish a concrete concept of design creativity and to find a distinct cognitive process for design problem solving in education of design creativity. We have conducted research work toward design creativity education so that various underlying cognitive elements and processes of design creativity are identified and then these design creativity elements and processes can be enhanced through training methods reflecting individual learner's cognitive personal characteristics. Visual reasoning capability has been identified as a critical element of design creativity [5], and a design reasoning model obtained from visual reasoning process were devised to investigate the cognitive interaction among elementary steps of visual reasoning [8, 6]. This design reasoning model has been used to study design creativity education and to development of its enhancement program. The study on the design activity was also conducted to identify the critical steps in the design process and to investigate the characteristic patterns of designers based on their personal characteristics [4]. In addition, the studies on design creativity modes have been conducted by investigating the relations among personal creativity modes, perceived creativity and design team interactions [3]. In this paper, the cognitive elements of design creativity will be identified, and the new exercise program for design creativity elements will be proposed. We also developed the conceptual design task to evaluate the design creativity. In addition, the effectiveness of the proposed exercise program will be validated with experiments.

2 COGNITIVE ELEMENTS OF DESIGN CREATIVITY

The cognitive elements of design creativity have been defined based on Treffinger's creative learning model [10]. The Treffinger's creative learning model encompassed the cognitive and affective aspects. The cognitive aspects in Treffinger's creative learning model are fluency, flexibility, originality, elaboration, and cognition and memory. We replaced cognition and memory with problem sensitivity, and identified five cognitive elements of design creativity such as fluency, flexibility, originality, elaboration and problem sensitivity. These five creativity elements coincide with those claimed by Kraft [7], and the definitions of each cognitive elements of creativity are following.

- **Fluency.** Fluency is an ability to make multiple answers to the same given information in a limited time [2] and quantity of meaningful solutions [11].
- **Flexibility.** Flexibility is an adaptability to change instructions, freedom from inertia of thought and spontaneous shift of set [2]. That is the mode changing categories [11].
- **Originality.** Originality is rarity in the population to which the individual belongs; its probability of occurrence is very low [2, 11].
- **Elaboration.** Elaboration is the realization or transformation of an idea, which may become very general or simple or in contrary very fantastic or enriched into details [11].
- **Problem Sensitivity.** Problem Sensitivity is an ability to find problems [11] and to aware needs for change or for new devices or methods [2].

3 DESIGN CREATIVITY COGNITIVE ELEMENT EXERCISE PROGRAM

The exercise program was developed to enhance the above five elements of the creativity. This program includes 'making stories', 'sensitization', 'negation', 'filling black box' and 'diverse classification'.

3.1 Making Stories

The 'making stories' exercise asks the students to produce different stories using three different pictures by changing the order of them. Therefore, this activity aims to improve the flexibility cognitive element. The elaboration element can also be developed through this activity by implying cause and effect of given pictures and specifying them. In addition, the originality can be enhanced through the activity to make unique and novel stories.

3.2 Negation

In the 'negation' exercise, the students are asked to compulsively and purposely negate the given objects. In this activity, the students are supposed to negate a chair and a shopping basket and make new ideas about them. As a result, the fixed views or ideas on the objects can be broken, and the students can find the different and potential aspects of the objects. In this way, this activity can help to make new objects and transform original objects. This program aims to develop flexibility and originality.

3.3 Filling Black Box

The objective of 'filling black box' is to mainly develop fluency by logically addressing the connections between the given input and output concepts as many times as possible within a limited time. This activity can also develop elaboration by explaining the logical relations of input and output concepts. The originality can additionally be enhanced by discovering distinctive connections between given input and output concepts.

3.4 Sensitization

In the ‘sensitization’ exercise, the students are asked to express their feelings on the given physical objects and abstract concepts according to five different senses. In this activity, the problem sensitivity can mainly be developed to dig out potential characteristics of the given objects or concepts. In addition, this activity aims to develop the flexibility by describing concrete feelings on abstract concepts from the view of five senses.

3.5 Diverse Classification

The final activity is the ‘diverse classification’ exercise. In this activity, the students are asked to classify the given objects in several different ways. Therefore, the flexibility can be mainly developed by considering diverse criteria to group the given objects in a different fashion. In addition, this activity aims to develop the problem sensitivity to understand the multiple characteristics of given objects.

4 VALIDATION EXPERIMENTS

4.1 Experimental Design

We grouped the five activities of the creativity cognitive element exercise program into two activity sets: activity set A and activity set B. Activity set A was composed of making stories, negation, and filling black box. It is expected that the activity set A improves the participants’ fluency, originality and elaboration mainly. On the other hand, activity set B contained sensitization and diverse classification, and is expected to mainly enhance the participants’ problem sensitivity and flexibility. Figure 1 represents the map between the creativity cognitive elements and each exercise activity. From the map given in Figure 1, we assumed that fluency, originality or elaboration of those who attended the activity set A will be enhanced and problem sensitivity of those who attended the activity set B will be enhanced. For the confirmation of our assumptions, we conducted the experiments investigating the effectiveness of creativity cognitive element exercise program.

The experiments were carried out according to the following steps. Firstly, we applied pre-test that could measure the abilities of five elements of the creativity to 50 freshmen of the creative engineering design course. Secondly, we classified 50 students into three identical groups. When assigning the students into three identical groups, each group was formed in order for the average scores of five creativity elements of each group to be uniform based on the results of the pre-test. In addition, the distributions of gender and grade were uniform for each group. A number of each group was 17, 16, and 17, respectively. The group 1 performed activity set A, the group 2 performed activity set B, and the group 3 was considered as a control group in which none of such activity

Elements Activities	Fluency	Flexibility	Originality	Elaboration	Problem Sensitivity
Making Stories		High	Low	Medium	
Negation		High	Medium		Low
Filling Black Box	High		Low	Low	
Sensitization		Medium			High
Diverse Classification		High			Medium

Figure 1 Relation map between creativity components and each training program

sets was applied. Thirdly, a week after each group carried out the creativity cognitive element exercise program; all groups had a conceptual design task as a post-test. The post-test is the design task to produce concept designs of a portable reading device.

4.2 Pre Test

The pre-test was applied to identify the identical experimental and control groups. The pre-test was composed constructive perception test and mental synthesis test.

4.2.1 Constructive Perception Test

The constructive perception test was performed according to the method proposed by [9]. The students were asked to generate and write down as many interpretations as possible of ambiguous picture cards. Four minutes were given to each ambiguous picture. In the constructive perception test, fluency and flexibility of the participating students were evaluated. The number of ideas that the students generated in the constructive perception test were counted and used to evaluate their fluency. The more the counts of ideas, the participants obtained the higher the fluency scores. In the case of flexibility, the categories generated by the students were counted and considered to be their flexibility scores. These categories could be counted by grouping several ideas on the basis of their ideational similarity.

4.2.2 Mental Synthesis Test

The students were required to memorize 15 object parts, and then generate a meaningful product with three objects in a given category while closing their eyes for two minutes [1]. Then, they were asked to sketch and describe their product invented in their mind for 6 minutes. The first section was to make a transportation vehicle using cylinder, half-sphere, and cross. The second section was to make furniture using tube, sphere, and ring for two minutes with their eyes closed, and they were asked to sketch what they imagined for two minutes. Then, they had to make a reasonable explanation of it in terms of a weapon category for 4 minutes.

In mental synthesis test, originality, elaboration and problem sensitivity were evaluated by assessing the results from those two sections. The originality of generated ideas was evaluated by mainly considering their novelty. In addition, the degree of transformation of the idea from the given object was taken into a consideration as well as the subject judgment on the goodness of the ideas. The assessment of the elaboration on ideas was two-fold. In the section 1, the detail of the design thinking and its external presentation were considered as the evaluation criterion. On the other hand, in the section 2, the degree of development of ideas and their detail as weapons were heavily weighed. In the case of problem sensitivity evaluation, the degree of the appropriateness and fidelity of the answers of each student to given questions were computed by taking the averages of those two sections.

4.3 Post Test

4.3.1 Conceptual Design Task

The post-test is a conceptual design task to design the portable reading device. In the design task, during first 10 minutes, the students had to produce as many ideas as possible for a portable reading device with five given clues: an accordion, a tape, a hinge, a toilet pump and a steel wire hanger. Then, during next 20 minutes, they were to choose one of the ideas which they generated, and elaborate on it with sketches and detailed descriptions.

Similar to the case of pre-test, the evaluations on the results of post-test were conducted in terms of the five creativity components. Fluency was measured by counting the number of ideas in assignment 1. In the measurement of flexibility, the categories of generated ideas were counted. In addition, the conceptual distance between the generated ideas and given clues was considered. The originality measure was done by considering the novelty of the ideas in comparison with all other generated ideas and their distinctiveness. In the elaboration measurement, the detail of the developed conceptual design given in assignment 2 was evaluated. Besides, the detail of the usage of the conceptual design that was required to be addressed in assignment 2 was heavily weighed. The problem sensitivity could be evaluated by considering how well the students reflected the issues of users or situations in which the portable reading device was used.

4.4 Results and Discussions

The evaluations on each creativity component in the case of the post-test were conducted by two evaluators. The correlations between two evaluators are good enough for evaluation results to be used for further analysis ($r=.944$, $p<.01$ in fluency; $r=.559$, $p<.01$ in flexibility; $r=.608$, $p<.01$ in originality; $r=.602$, $p<.01$ in elaboration; $r=.644$, $p<.01$ in problem sensitivity).

As results of paired t-test, the scores of fluency ($t=-.298$, $p=.050$) and originality ($t=-3.073$, $p<.01$) of post-test are significantly higher than those of pre-test in group 1; however, the differences between pre and post test were not found in group 2 and 3 as you can see in Figure 2. Accordingly, it is believed that the increase in scores of fluency and originality can be attributed to the effectiveness of the *activity set A* of the creativity element exercise program since it aimed to enhance students' fluency, originality and elaboration. However, we could not find the statistically significant results in the case of elaboration, although activity set A also aimed to enhance students' elaboration ability. *Activity set B* was designed to improve the students' flexibility and problem sensitivity, but no such statistically significant results were found. Therefore, it is necessary to revise the activities in the activity set B. It is also possible to revise the pre test. In pre test, we used the constructive perception and mental synthesis test. However, it was not easy to measure problem sensitivity from the mental synthesis test. Therefore, it may be necessary to develop another pre test, which is similar to post test, conceptual design task, to compare the scores between pre and post tests and furthermore to improve the effectiveness of the design creativity element exercise program.

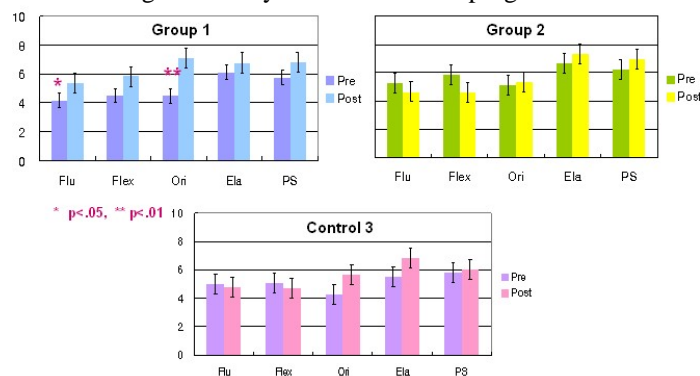


Figure 2 Results of differences between pre and post-tests in each group

5 CONCLUSION

In this study, the cognitive elements of design creativity were identified and a new exercise program for cognitive elements of design creativity was proposed. This program could be used in helping students considering their individual needs and contexts. Five cognitive elements of design creativity were identified: fluency, flexibility, originality, elaboration and problem sensitivity. The proposed exercise program for cognitive elements of design creativity was composed of five different activities such as making stories, negation, filling black box, sensitization and diverse classification. The validation experiments were conducted to investigate the effectiveness of the exercise program for design creativity cognitive elements. The results show that the proposed program was partially effective to enhance the students' design creativity cognitive elements, especially fluency and originality in activity set A. A more rigorous approach is desired to examine what cognitive elements could be effectively addressed in each activity. These research efforts would be helpful for design creativity education by considering individual's needs and contexts.

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