

Effect of Early and Late of Innovative Design in the Imagination and Creativity

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ABSTRACT

Imagination and creativity are important factors of design performance, but few research exam imagination and creativity on design performance simultaneously. This study attempts to examine imagination and creativity toward design performance in the front and in the final stage of concepts generation. The subjects of the study were 544 students in pairs who were participants of the two design contests. Results showed that imagination and creativity all have positive effects on design performance. Imagination affects the front and creativity affects the final stage of design performance. This study shows that imagination and creativity should be important on design education.

Keywords: Imagination, Creativity, Design Performance, Imagination Test of Concept Combination (ITCC)

INTRODUCTION

As we all know, OECD Creative Economy covers a large share of radical creativity and innovations emerge from new firms, often start-ups, which account for up to 60 per cent of net job creation in many countries [1]. As the author of “Creative Age” concept, Florida [2] emphasized that creativity and innovation is driving the economy to stimulate inclusive growth. Fitzgerald and Wakabayashi [3] indicates Apple iPhone’s birth, it did not invent a mobile, but also provided unpredictable arts and values for business and consumers around the world. Beside the practice focus the implement of designing, the scholar has interested in how factors affect design performance? Some research infers design performances are related to flexible designers’ personality [4], talented expertise [5], and creative thinking [6]. For the convenience of contacting subjects, most researchers apply case study [5], [7]. Therefore, it is hard to

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examine the relationship between individual's variables (imagination and creativity) and design performances.

However, the company embrace creativity generates higher revenue and provides greater stability through design industry. For acquiring better design performance, how we can do for designers? Some scholars suggest select appropriate designers by personality [4], expertise experience [5], and creative thinking [6]. Other emphasized team factors, such as diverse composition [7] and improving communication [8] can raise design performance. The others refer to organizational factors, such as flexible task [4] and division for work [9]. For accomplishing design tasks gather in different industry, design teams are mostly composed of people with diverse professionals [10] and creative imagination [11].

How can arrange different designers based on these diversities of imagination or creativity? This is main research focus in study. According to above incentives from design practices and literatures, we investigated effects of team imagination and creativity on design performances in the different stages of concepts generation.

1 RESEARCH REVIEW

1.1 Imagination

The creation process consists of new ideas, generating concepts, and solving problems. Although imagination is not enough sufficient and precise part of creating process, imagination specializes in the cognitive process within is a lengthy and complicated process [12]. Imagination is bound to creation process, Ward [13] concludes imagination as this process of re-configuring or re-combining concepts which precedes creativity. For new ideas generating and this cognitive process, there is more than ever imagination research publication. But how can evaluate the imagination? Some evaluate it from the past experience to create unreal images. But others exclude the boundaries or past experience to create unreal images even without perceptions or experiences from the past [14]. Heath [15] emphasizes imagination entails copying the psychological object to produce an image without past experience and new images. Horng, Wang, Shyr, Lee and Wang [16] followed the perspective of concept combination of the imagination to develop a test for the imagination. They applied the imagination can be measured by connectivity means linking a variety of experience is to produce new information [17]. From the process, imagination can be defined as the cognitive process of creating and imaging what never happened.

The test of the imagination is in accordance with Horng et al. [16], it followed the perspective of concept combination of the imagination to develop. And they defined concept combination means that the output or interpretation process of creating new concepts is derived via two or more combined known concepts. For example, "jotter" and "computer" will form notebook, and "blind" and "dog" will link to generate guide dogs; so lots of new words or concepts are formed by combining different concepts [12]. Horng et al. [16] also show the link base of two concepts into the interpretation to explain the production process of imagination. It comes from the emergence of new ideas from conceptual combination. To combine two unrelated objects or events, an interpretation process would take place to find meaning for the co-occurrence of objects/events. Three kinds of interpretation were identified by [12] that imagination is defined as individual cognitive ability of creation (show in *Table 1*). For producing more creative ideas, thinking process of consists of the finding, solving problems, and implementing steps of design practices. But in design practices, few design tasks are

so small and can be done by single designer. Therefore, it is necessary to incorporated and implemented by teams. And team members are often composed of diverse background and professional [10]. To achieve design performance, it must be necessary to align team members [8], roles, concepts, and experiences of team members [18]. Among the factors of team performance, researchers stress the combination of members' imagination. Therefore, performance can be defined as the outcome of individual and team imagination.

All in all, according to the theory of concept combination, imagination can affect creative design activities and improve design performance [12], [16], [19]. And it can break through past creativity limits on design performance [20]. Therefore, this study proposes that the combination of imagination or creativity in team can strengthen the relationship between imagination and design performance.

Table 1. Interpretation style and examples

Interpretation Style	Definition	Example	Explain
Conjunction	Describe the relationship between two concepts	“Light”and “White Cloud”into “Bright”	light is light white cloud is light
Property	New concept is composed of one or more concepts	“Stone”and “Dolphin”into “Dolphin Statue”	Dolphin statue is made of stone
Relation	New concept is composed of the two obstacles or the property in common	“the Earth”and “Shell”into “Ocean” “Coke”and “Computer”into “My roommate”	There is ocean in the earth, and there are shells in ocean. My roommate is using computer while dinking coke

Reference: [12], [16]

1.2 Creativity

In the Creativity Economy, the economy is being driven by creativity and innovation. Not only to seek higher revenue and create popular trend, businesses also take individual creativity into human capital [21]. Since creativity being introduced after [22], it has been focused as the major of thinking skill, education, innovation, and even more in R&D field [23], [24]. From thinking skill, the creation process consists of new ideas, generating concepts, solving problems, and implementing [25]. In education, creativity influences new concept generating and can be facilitated for imagination. In innovation, creativity is the source of social and realizing process in the future [25]. According to West's [26] research, the creation process includes idea generation and problem solving. It is benefit to solving problem and creates new concepts in designing, marketing, R&D. Further, Moreau and Engeset [27] stress creativity is more concrete or specific measures of innovation. Even in the practice of designing, Demirkan and Afacan [28] found the linkage of design between education and industry, and emphasize the importance of creativity. Through empirical data from class, it verified the efficiency and factors of creativity.

Many studies have shown individual creativity [23] and designer's team [29] can accumulate individual creativity into their competency. From individual, creativity is considered as a process that intersected by individual domains, fields, and experts [23], and value-creation, imagination, and materialization processes [30]. However, Rhoten, O'Connor and Hackett [31] found the creativity as the creation processes of collaborative creation of original ideas and the practices from diverse domains. Thus,

the study concludes that individual creativity is the base of team competency, and it is emphasized the major factors on design performance.

1.3 Design performance

Design performance is the output of designing and the result of the creative process [32]. And its level can be measured by industry, corporation, and designer field. In design industry, it can be defined as the design effectiveness of each company and its stock market returns [32]. In corporation field, it is defined as the designing expenditure, designers' salaries, design consultants' fees, or equipment investment of financial measures that designers influence through their design choices (material costs, manufacturing equipment). Others defined design performance from designers, like the accomplishment of tasks and solutions of problems. There are two categories of quality and creativity indexes to evaluate design work in design industry [29]. In design team level, characterizing the quality of the design performance by measuring the coherence of the description of related design concepts and events in design documentation is examined [7]. From individual designer, design performance is often gathered from their behavior and studies of design concepts. And it is evaluated by other designing expert and experienced designers. The evaluation criterion is often made of whether the generating process of concept is novice, outstanding or exceptional by interviewing with judges [5].

Most researches emphasize the application and evaluation of design performance, but few researches the factor and its effect on design performance. Some researches notice the effect of creativity and increase its outcomes [6], [33]. The creativity is good to explain the process of thinking, such as inspiration and verification of creative activities [16]. Leahy and Sweller [34] argues that imagination contributes to random knowledge development and is a cognitive process of innovation for handling and adapting to environmental changes. Thus, imagination is more than creative thinking skills and it also has positive effect on performance results [19], [34], [35]. Therefore, the design performance is the outcome of designing that concepts generating, associative thinking and imagination in the creative process of product design. The results of designing while applied imagination to associative thinking, solving problems and then has the impact of improving design performance [32].

2 METHOD

This study investigated effects of team imagination and creativity toward design performances in the different stages of concepts generation. We gathered two-man team's data from two similar creativity contests during two years. The study analyzed whether imagination and creativity cause the difference of design performance in the preliminary and the semi-final stage of the creativity contest.

2.1 Subjects

The subjects are colleague and undergraduate school students who joined a design contest held by Chung Hsing University in Taiwan in 2014 and 2015. Every contest team is consisted of two students which major in design or engineering college. A total of 272 teams (544 persons) attended the preliminary contest of two peoples. The study uses the 272 preliminary teams and the 115 semi-final teams as subjects to examine the empirical relationship of imagination and creativity on design performance in different stages of the creativity contest. The features of contest teams are as follows: 1) School of teammates: 265 teams are same and 7 teams are different. 2) Gender of teammates: 228 teams are same and 44 teams are different.

2.2 Procedure

The design contest consists of three stages (show *Table 2*). Before the preliminary contest, every participant of each team was requested to submit individual's imagination test of concept combination (ITCC) [16] with creativity blueprint of the task in this contest by team. Two judges evaluated and decided which teams can attend the semi-final stage. Then, the contest held a workshop for those teams entering the semi-finals and applied Torrance Test of Creative Thinking (TTCT) to measure creativity of these teams in the workshop. After the workshop, the contest team must be creative their product plans after two weeks.

Table 2. Work flow of the design contest

Stage	Treatments
Preliminary Contest	Every contest team consists of two students which find out their teammate by themselves. Every team had to write down a creativity blueprint associated with all three topics which are cool, playing, and saw. The blueprint was limited to 100 words or an A4-size picture. Every team delivered the blueprint to attend this contest through internet. In addition, every participant of each team was requested to submit individual's ITCC [16] with blueprint.
Semi-final	Teams in the semi-final should participate in a one-day workshop. We measure their creativity in the workshop with ITCC. The workshop has four classes about creativity and imagination, design, saws, and cases. After the workshop, competitors had to create a concrete product plan with the same topic as preliminary contest within two weeks.
Final	The final teams had to report their product plan within 15 minute. In the end, judges have decided their place in the contest.

2.3 Variables

2.3.1 Imagination

The imagination is the relational thinking ability regarding many different concepts mutual associations, and then finding unique relationships [14]. This study adopts the perspective of [12] to define imagination as the front-end mechanism of thinking and the process of concept combination that combines two or more concepts to produce new concepts. Thus, the concept combination is an intrinsic cognitive mechanism. We adopted imagination test of concept combination (ITCC) [16] that asked participants to imaginatively combine two concepts to produce new concepts and record the associative reasons. The scale has 18 questions, and every question has two nouns. The subjects were requested to create a new concept by the two nouns. For example, "cell phone" and "justice" are associated with "police", because the police will take a cell phone to direct people to solve commitments. Because of time constraint, we occupied 9 items of the scale (see Appendix). In the past research, the task is reliable with 9 items. We also average the scores of the teammates as imagination of a team. We averaged the imagination scores of the teammates as imagination of a team and received data from 245 teams in the preliminary stage.

2.3.2 Creativity

The creativity is defined by [36] as involving diffusion thinking skills. The diffusion thinking ability can be surveyed according to the three dimensions: the first dimension is the fluency that the ability to face a problem and come up with a lot of answers or possibilities, generally based on the number of different ideas within a time limit and using unit numbers for measurement; the second dimension is the flexibility that the ability to diversely think in different dimensions or angles, based on the accounting

number of conceptual categories within a limited time for measuring; the last dimension is the originality that the rarity or uniqueness of an idea or concept determined by its statistical infrequency, and the ability to demonstrate the unique insights using the degree of scarcity to measure originality. This study adopts the Torrance Test of Creative Thinking (TTCT) [22] that is based on the theory of diffusion thinking to assess a person's creative thinking ability, by assessing participants' reactions to the above three dimensions, thereby measuring diffusion thinking ability and calculating the total score on behalf of the whole of creativity. The creativity scale consists of the originality, conformity, and efficiency of each photo [22], [35]. The original TTCT test includes 32 streamline in pairs. The subjects were requested to draw a new picture with all or part of these streamline in pairs. Time constraint is limited under five minutes. The study calculated its originality, conformity, efficiency, and summed all in the final, and averaged the creativity scores of the teammates as creativity of a team and received data from 84 teams in the semi-final stage.

2.3.3 Design Performance

The design performance consists of two scores of preliminary and semi-final stages. At preliminary stage, two judges evaluate whether pass into the semi-final stage according to participant's creativity blueprint. The rule of evaluation is whether link all three different concepts of combination [16]. The study examined whether the 272 teams have passed into the semi-final stage (yes or no) to represent their design performance in the preliminary.

At semi-final stage, the seven judges include design and engineer professors from different department and schools. They possessed over 10 years of practical design experience and their scoring was reliable. These judges followed three indicators to assess the design performance and every indicator scoring from 0 to 100. These evaluation indicators are innovation (occupy 60% in total score), subject conceptualization and content clarity (clarity) (occupy 20% in total score) and strategy for competition and creative marketing (competition) (occupy 20% in total score). These indicators are amounted in to the total score. The study averaged the total scores of severe judges as the design performance of a team. Because design performances from total judges may have no significant difference, we examined whether the 115 teams have passed into the final stage (yes or no) to represent their design performance in the semi-final stage. For example, the teams attending the final stage have high design performance. Because design performances from total judges may have no significant difference, and the study combined two design competitions graded by different judges and evaluation standards. We examined whether the 272 teams have passed into the semi-final stage (yes or no) to represent their design performance in the preliminary stage, and examined whether the 115 teams have passed into the final stage (yes or no) to represent their design performance in the semi-final stage. For example, the teams attending the final stage have high design performance.

3 RESULTS AND DISCUSSION

3.1 Correlation analysis

3.1.1 Imagination and design performance of the preliminary contest

This study used the design score of contestants to verify the effects of imagination and creativity on design performance. This study used the Pearson and Point-biserial correlation analysis in order to determine whether there was correlation between study variables (show *Table 3*). First, the study is according to the qualification of the semi-finals as design performance and analyzed the relationship between imagination and

design performance. The analysis showed imagination and design performance have a positive significant correlation ($r = 0.14$, $p < 0.05$). The result presents that contestants have higher imagination leading to higher design performance results in the preliminary contest.

3.1.2 Imagination, creativity and design performance of the semi-final contest

Further, the study according to the qualification of final as design performance and analyzed the relationship between imagination, creativity and design performance. The analysis showed no significant correlation between imagination and design performance ($r = 0.04$, $p > 0.05$), but creativity and the design performance have a positive significant correlation ($r = 0.24$, $p < 0.05$). The result presents that contestants have higher creativity leading to higher design performance.

3.2 T-test and Logistic regression analysis

3.2.1 Imagination and design performance of the preliminary contest

The 245 teams divided into two kind groups of entry semi-final and no entry semi-final, and used T-test to examine whether there is a significant difference between two groups. The results show that two groups has significant difference in imagination ($t = -2.27$, $p < 0.05$), and the imagination of the entry semi-final teams (mean=7.81) is significant higher than the no entry semi-final teams (mean=7.02).

Further, the study adopted the Logistic Regression Analysis (*Table 4*) to explore the influence effect of imagination on design performance. We examined whether the 245 teams have attended the semi-final stage (yes or no) to represent their design performance, and 245 teams divided into entry final-team and no entry final-team. The entry final-team has high performance and the no entry final-team has low performance. In the overall model fit, X^2 is significant ($X^2 = 5.13$, $p < 0.05$) and Hosmer-Lemeshow is not significant (Hosmer-Lemeshow=9.23, $p > 0.05$). These results showed that the overall model fit is good. In addition, the Wald of imagination is 4.99 ($p < 0.05$), presenting that these teams of high imagination have higher design performance and are accepted into the semi-final stage certainly.

Table 3. Descriptive statistics and correlations among variables

	Mean	S.D.	1	2	3	4	5
1. Imagination	7.35	2.70					
2. Creativity	42.75	11.46	-0.04				
3. Fluency	19.25	6.21	0.00	0.94**			
4. Flexibility	11.30	3.02	-0.03	0.81**	0.78**		
5 Originality	12.19	4.27	-0.08	0.75**	0.52**	0.35**	
6.Design Performance	0.30	0.46	0.04	0.24*	0.21+	0.27*	0.170

Note: + $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 4. Logistic regression results

Variables	B	S.E.	Wald	Df	Strength of association
Imagination	0.11	0.05	4.99*	1	Cox-Snell R ² =0.02
Constant term	-1.14	0.39	8.49**	1	Negelkerke R ² =0.03
Overall model fit	$X^2 = 5.13^*$ Hosmer-Lemeshow=9.23n.s.				

Note: + $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; n.s. $p > 0.1$

3.2.2 Imagination, creativity and design performance of the semi-final contest

The 79 teams divided into two kind groups of entry final and no entry final, and used T-test to examine whether there is a significant difference between two groups. The results show that two groups has no significant difference in imagination ($t=-0.36$, $p >0.05$). However, two groups has significant difference in creativity ($t=-2.41$, $p <0.05$), and the creativity of the entry final teams (mean=47.93) is significant higher than the no entry final teams (mean=41.7).

Further, the study adopted the Logistic Regression Analysis (show *Table 5*) to explore the influence effect of imagination and creativity on design performance. We examined whether the 79 teams have attended the final stage (yes or no) to represent their design performance, and the 79 teams divided into entry final-team and no entry final-team. The entry final-team has high performance and the no entry final-team has low performance. In the overall model fit, X^2 is significant ($X^2=4.64$, $p <0.1$) and Hosmer-Lemeshow is not significant (Hosmer-Lemeshow=12.01, $p >0.05$). These results showed that the overall model fit is good. In addition, the Wald of imagination is 0.02 ($p >0.05$), presenting that there is no significant association between imagination and design performance. However, the Wald of creativity is 4.02 ($p <0.05$), presenting that these teams of high creativity have higher design performance and are accepted into the final stage certainly.

Because the preliminary contest is focused on generating the creative conceptions, excellence teams with high imagination were picked into the semi-final stage. These semi-final teams have no significant difference on imagination. The semi-final stage is focused on products of the creative conceptions, and teams with high creativity have better creative ability to get better performance. Therefore, there is no significant association between imagination and design performance of the semi-final stage, but there is significant association between creativity and design performance. Overall, imagination has affects in the front stage and creativity has affects in the final stage of design performance.

Table 5. Logistic regression results

Variables	B	S.E.	Wald	Df	Strength of association
Imagination	0.02	0.12	0.02	1	Cox-Snell R ² =0.06 Nagelkerke R ² =0.09
Creativity	0.05	0.03	4.02*	1	
Constant term	-3.40	1.53	4.92*	1	
Overall model fit	$X^2=4.64+$ Hosmer-Lemeshow=12.01 n.s.				

Note: + $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; n.s. $p > 0.1$

4 DISCUSSION AND CONCLUSION

This study defines imagination in terms of the ability for conceptual combination, and examines the effects of imagination and creativity on design performance through two creativity competitions. The results showed that imagination and creativity have positive effects on design performance. Imagination has affects in the front stage and creativity has affects in the final stage of design performance. Teams with rich imagination member can get more concepts on the front stage and teams with rich creativity member can achieve better design performance in the final stage. The imagination can explain the creative production processes, and creativity can handle

the creative problem-solving activities. In short, creativity and imagination could affect the creative process of design activities.

From associative thinking, the purpose of this study is to separate imagination as a concept independent from creativity, and to explore and verify the impact of the imagination's cognitive mechanisms in order to further understand the sub-cognitive processes behind the details of creativity [37]. This result has similar conclusions like imagination is helpful in learning [15] and formatting concepts [8] of designing. This study also verifies most scholars' belief that imagination belongs more to the front-end thinking mechanism of creativity, and has a potentially influential effect on creative thinking and activities development [38], [39]. Therefore, people with a rich imagination in the creative cogitating stage can also easily associate various special or unique concepts and freely imagine, link and combine concepts to produce new ideas or innovation. In addition, the design performance comes from the implementation effectiveness of each stage of the creative process (creative preparation, incubation, inspiration and verification). Design activities rely on creativity to solve problems and improve design performance [25]. In this study, the results also supported that Creativity increase problem solving [35] and performance of designing [6].

In short, the study contributes to the relational studies in imagination and creativity. It identifies a new role whereby imagination can strengthen traditional creativity research deficiencies in the stage of idea generation and creative incubation, and examine whether the imagination and creativity have explanatory power in design performance. However, despite its strengths, the study has some limitations. First, it relies on data from student samples and two design contests. The results may not be validly extended to other practical field applications. But the study still has some researchable values because this study explores the relationship between imagination, creativity and design performance. Second, the indicators of design performance following the design contest may have some weakness in relation to objective and practical appraisal. Therefore, results of the study should be retested in other large design contests or other practical activities.

The imagination has been important and getting more attention as creativity in the design industry before. The design performance is the output of creative process to solve problem, it not only consists of creativity at the later stages but also imagination at the front stages. This study verifies that imagination and creativity of teams affect the design performance. In accordance with this study, this study suggests that design education should emphasize the training on creativity and imagination of designing in classes or activities.

APPENDIX

Imagination Questionnaire		
No. Question (Two Concepts)	New Concept	Reason
Example: Mobile ↔ Justice	Police Officer	The scene I surface is a police officer holding a mobile to detect in a crime scene
Newspaper ↔ Airport		
Ear ↔ CD		
Disaster ↔ Coffin		
Kitchen ↔ Plate		
Taste ↔ Earthquake		
Ceremony ↔ Desert		
Stage ↔ Trend		
Island ↔ Reason		

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