Design Thinking and Creativity: An Empirical Study on Their Correlation

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Abstract
In the design field, creativity and design thinking are crucial attributes for professional designer. The current study attempts to examine these relationships through an empirical approach. Two studies were reported. In the first study, we found that everyday creativity was correlated with execution, collaboration, reasoning and reflection of design thinking (r .32 - .35). In addition, scholar creativity was related to ideation (r = .24) and reasoning and reflection of design thinking (r = .31). The second study demonstrates that creativity was only related to reasoning and reflection (r = .30). Furthermore, creative personality was related to reasoning and reflection (r = .50), ideation (r = .51), and collaboration (r = .27). Several limitations were found and implications of studies were discussed.
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1. Introduction

Scholars argue that design thinking is an important strategy for an organizational culture of innovation (Sipe, 2020). It is rooted in creative problem-solving (Slater, Dhanasekaran, & Govindarajulu, 2020). Most importantly, it takes customers' needs into consideration, thereby enhancing customer experience through producing better products (Benson & Dresdow, 2014). Moreover, it is a mental exercise that requires convergent thinking, divergent thinking, reflective thinking, and practical reasoning (Benson & Dresdow, 2015).

Creativity has been a frequent topic of discussion in the literature within the design field (Cassim, 2013; Kim & Ryu, 2014). Professional designers are often asked to generate creative ideas and solutions to satisfy market demands. Thus, their creative capabilities have become an important asset. In the business field, Chongwatpol (2020) found that business students could also employ design thinking to expedite the framing of their creations and develop that asset for teaching and learning. Taken together, creativity and design thinking are crucial components of a successful business model. However, empirical studies on the relationship between design thinking and creativity are scarce and most of them follow a qualitative approach (e.g., Wu, Chen, & Chen, 2012; Yang, 2018). Therefore, the current study attempts to examine these relationships through the empirical approach.

2. Design Thinking

The techniques and practice of design thinking stem from a human-centric approach, which involves a collaborative problem-solving and creative thinking abilities (Aflatoony, Wakkary, & Neustaedter, 2018; Chen et al., 2018). This approach helps individuals question the status quo, solve problems, and create appropriate action plans and products. Most importantly, it encourages a variety of solutions to complex problems and evaluating these solutions in a dynamic structure (Girgin, 2021). Design thinking has proved to be beneficial and a number of co-operations and higher education programs have adopted its application (Matthews & Wrigley, 2017). For example, Schumacher and Mayer (2018) argue that management education should value design thinking, as it could facilitate managerial creativity. This, in turn, could allow timely responses to consumer needs, the employment of emerging technological possibilities, and utilization of different business models. In a quasi-experimental field study over a four-month period, Kurtmollaiev et al. (2018) found that the intervention of design thinking training had a positive effect on participants' initiative and recognition of opportunities, their transformative capabilities, team innovation output, and team operational capability. Another study (Farrar, 2020) also showed that integrating design thinking into biomedical instrumentation projects could boost students' perception of learning. Through an online instructional technology platform, Novak and Mulvey (2020) found that, students preferred using design thinking rather than their creative thinking proper.

A number of scholars have proposed different design thinking models (Coleman, 2016; Tschimmel, 2012). Taken as a whole, the design thinking process requires four elements: (a) empathy, allowing designers to see the world from multiple perspectives; (b) optimism, the ambition to create a better product and overcoming a challenge; (c) experimentalism, constantly asking questions and rethinking and reworking ideas; and (d) collaboration, team members seeking mutual input and information. Concerning individuals' personality, Tsai

(2019) found that design thinking correlated with personality (e.g., extraversion, conscientiousness, and openness). These findings echo the preceding discussion of the four elements of design thinking.

3. Creativity

To survive in today's complex society, creative thinking is crucial for generating innovative and practical solutions for human needs (Wojciehowski & Ernst, 2018). Creativity is defined as the sensitivity that recognizes and solves problems and it consists of two important characteristics: novelty and utility (Ulger, 2018). For this reason, developing creative thinking skills should be an imperative in students' formation. To this end, teachers have become a critical influence in helping students to develop their creative minds (Cenberci, 2018). Therefore, creative thinking skills should be applied at the highest level to achieve permanent learning (Brodin, 2016).

Creative thinking includes divergent thinking, which consists of four core components: fluency, flexibility, novelty, and elaboration (Klieger & Sherman, 2015). It is, by nature, an activity of recognizing problems, then solving them. From that perspective, Nuha, Waluya, and Junaedi (2018) believe that creative thinking is critical in the modern era, and that it can be promoted through efforts such as training students to solve their own problems. Studies have attempted to identify the key processes that people must employ to produce creative solutions. Mumford et al. (1991) identifies eight core phases of creative problem solving, including problem definition, information gathering, concept/case selection, conceptual combination, idea generation, idea evaluation, implementation planning, and adaptive execution. Moreover, in order to generate these solutions successfully, high-quality, original, and practical ideas should be considered as well as the application of vast knowledge or expertise. It is true that every domain may require a different knowledge base, but similar problem-solving processes can be identified in most domains of endeavor (Mumford & McIntosh, 2017).

4. Study 1

4.1 Purpose of the Study

The first study examined the relationship between design thinking and creativity among Chinese design undergraduates. We asked two research questions: concerning our participants, what is the relationship between design thinking and their creativity? Do gender and age play roles in design thinking and creativity? The current study is the first to examine these two variables from an empirical perspective. In so doing, we hope to obtain a better understanding of the design thinking and creativity of design students.

4.2 Methods

4.2.1 Participants

We used convenience sampling to recruit 92 third-year Chinese fashion design college students in Taiwan, among them, nine (9.8%) were male and 83 (90.2%) were female. The average age was 20.36 (SD = 1).

4.2.2 Measurements

To capture individuals' design thinking, we used the Tsai Design Thinking Scale (TDTS: Tsai, 2018). The TDTS has 16 items with a 5-point Likert-scale. The TDTS measures four components of design thinking: reasoning and reflection, indicating individuals' ability to observe, gather, and reflect upon necessary data and problems; ideation, referring to generating possible ideas and solutions; collaboration, suggesting people enjoying teamwork; and execution, involving prototyping, testing, and determining feasible solutions. Tsai (2018) reported the reliability and validity of TDTS.

We also used the Kaufman Domains of Creativity Scale (K-DOCS: Kaufman, 2012). It assumes a domain-specific perspective on creativity. The K-DOCS includes 50 items and produces five factors (through exploratory factor analysis) of self-assessed creative behaviors: self/everyday, scholarly, performance (encompassing writing and music), mechanical/scientific, and artistic. Kaufman (2012) reported coefficient alphas (from 0.83 to 0.87) and the coefficients of congruence of the K-DOCS were generally strong.

4.3 Results

4.3.1 Correlational Analysis

Table 1 shows the means, standard deviations, and intercorrelations among the five variables (everyday, scholar, performance, scientific, and artistic creativity) of creativity and the four variables (reasoning and reflection, ideation, collaboration, and execution) of design thinking. We investigated the relationship between the nine variables using the Pearson product-moment correlation coefficient. In terms of the relationship between design thinking and creativity, execution positively and significantly correlated to everyday creativity (r = 0.32). Collaboration also positively and significantly correlated to everyday creativity (r = 0.33). Ideation positively and significantly correlated to scholar creativity (r = 0.24). Reasoning and reflection had a positive and significant ($p < 0.01$) correlation with everyday creativity (r = 0.35) and scholar creativity (r = 0.31). With regard to creativity, everyday creativity positively and significantly correlated to scholar creativity (r = 0.54) and artistic creativity (r = 0.37). Performance creativity had a positive and significant correlation with scholar creativity (*r* = 0.50), scientific creativity (*r* = 0.58), and artistic creativity (*r* = 0.27). Scientific creativity positively and significantly correlated to scholar creativity (*r* = 0.41). Scholar creativity positively and significantly correlated to artistic creativity (*r* = 0.52). With regard to design thinking, reasoning and reflection positively and significantly correlated to ideation (*r* = 0.31), collaboration (*r* = 0.31), and execution (*r* = 0.31). Finally, collaboration positively and significantly correlated to execution (*r* = 0.40).

4.3.2 Group Differences

To understand any possible differences in design thinking and creativity between the genders, we used an independent-sample t-test to compare the mean scores of the eight measures. Table 2 shows no such significant differences among most variables; however, we recorded significant differences in scientific creativity, t (90) = 2.47, p = 0.004, male students (M = 3.32, SD = 1.05), and female students (M = 2.43, SD = 0.83).

We performed a two-way between-groups multivariate analysis of variance (MANOVA) to investigate gender and age differences in nine dependent variables, and treated gender and age as independent variables. In terms of gender, Table 3 shows a statistically significant difference between men and women in the combined dependent variables, F (9, 76) = 2.84, p = 0.006 , Wilks's Lambda = 0.75, partial eta squared = 0.25. In terms of age, we found no statistically significant effect on the combined dependent variables, F (9, 76) = 0.95 , p = 0.57 , Wilks's Lambda = 0.59, partial eta squared = 0.10. Regarding the interaction between gender and age, we detected no statistically significant difference in the combined dependent variables, F (9, 76) = 1.85 , p = 0.07, Wilks's Lambda = 0.82, partial eta squared = 0.18.

Because we were conducting this series of analyses, we ran the risk of an inflated Type 1 error. In order to minimize the Type 1 error across multiple tests, we implemented a Bonferroni adjustment by dividing 0.05 by 9 (which equals .006 after rounding) as our cut-off. When we considered the results for the dependent variables separately (ANOVA), we detected no difference in gender and age that reached statistical significance using a Bonferroni adjusted alpha level of 0.006.

4.4 Discussion

The first research question concerned the possible connection between creativty and design thinking among Chinese undergraduates. According to zero-order correlation, we found that everyday creativity correlated to execution, collaboration, reasoning and reflection of design thinking (*r* = 0.32 - 0.35). In addition, scholar creativity related to ideation (*r* = 0.24) and reasoning and reflection of design thinking (*r* = 0.31). However, performance, scientific, and artistic creativity did not correlate with design thinking among our participants. Our participants were fashion design students, thus the lack of detected relationship between artistic creativity and design thinking was an unexpected result. Therefore, it is prudent to employ other measures to fully understand the relationship between creativity and design thinking.

The second aim of this study was to examine the possible effects of gender and age on creativity and design thinking. The independent sample t-test showed that male students had higher scores for scientific creativity (M = 3.32) than their female counterparts (M = 2.43). However, as our sample comprised nine male (9.8%) students and 83 (90.2%) female students, the explanation of these results should be interpreted with caution. In light of this vast majority of female fashion design students, future studies should investigate other participants from different majors, to increase representativeness. Additionally, based on a two-way MANOVA, we found that gender had some effect on creativity and design thinking. However, upon further examination, the one-way ANOVA showed that gender and age did not play a significant role in creativity and design thinking.

5. Study 2

5.1 Purpose of the Study

In the preceding study, the relationship between creativity and design thinking remained unclear. As a result, in the second study we used creative personality, another measure to understand this relationship. Because most participants in our first study were female, the significant gender imbalance may have compromised the results. Thus, in the second study we recruited students from different departments in order to obtain a better ratio between the two genders. The major goal of the second study was to examine the relationships among design thinking, creativity, and creative personality. We asked two research questions: what is the relationship between design thinking, creativity, and the creative personality of our participants? Do gender and educational levels play a role in creativity and design thinking?

5.2 Methods

5.2.1 Participants

We used convenience sampling to recruit 67 Chinese digital media design college students in Taiwan, of which 40 (59.7%) were male and 27 (40.3%) were female. There were 21(31.3%) first-year students, 32(47.8%) second-year students, 11(16.4%) third-year students, and three (4.5%) fourth-year students. The average age was 24.43 (SD = 9.34) years.

5.2.2 Measurements

We used the same TDTS measure to evaluate participants' design thinking profiles. We used the short version of the Creative Behavior Inventory (CBI; Dollinger, 2003) to assess individual creative performance. Based on Hocevar (1979), Dollinger's short version discarded high-level items and retained those related to commonplace creative behaviors. The CBI contains 28 creative-activity items, all answered using a four-point ordinal response scale: A = "never did this", B = "did this once or twice", C = "did this 3-5 times" and D = "did this more than 5 times". Dollinger (2003) reported Cronbach's α for the CBI to be 0.89. Silvia, Wigert, Reiter-Palmon, and Kaufman (2012) conducted an exploratory factor analysis and found that a one-factor model reasonably described the data.

We used the CPS (Gough, 1976) to evaluate creative personality. Consisting of 30 items, it asked individuals to place a check mark next to each adjective that best described them. Of these, 18 were positive-weighting items (i.e. indicators of a creative person), and 12 were negative-weighting items (indicators of a non-creative person). According to Gough's scoring protocol, each selection of one of the 18 positive items scored one point, and each selection of one of the 12 negative items subtracted one point. Thus, the theoretical range of scores ranged from -12 to +18. For the purposes of the current study, we slightly modified the check-mark response format to a Yes/No format. We then summed the scores to form the CPS index. Several studies have found that CPS is a reliable and valid measure of creative potential (Oldham & Cummings, 1996; Sheldon, 1995).

5.3 Results

5.3.1 Correlational Analysis

Table 4 shows the means, standard deviations, and intercorrelations between the two variables (CBI and CPS) related to creativity and the four variables (reasoning and reflection, ideation, collaboration, and execution) of design thinking. We investigated the relationship between the six variables using the Pearson product-moment correlation coefficient. The results show that CBI correlated with reasoning and reflection ($r = 0.30$), and CPS correlated with reasoning and reflection ($r = 0.51$), ideation ($r = 0.50$), and collaboration ($r = 0.27$).

5.3.2 Group Differences

We used an independent sample t-test to compare the mean scores of the six measures. Table 5 shows no significant differences between males and females among most variables. However, reasoning and reflection were significant, t (65) = 2.12, $p = 0.04$, male students ($M = 4.15$, $SD = 0.58$), and female students ($M = 3.83$, $SD = 0.65$); and creativity as measured by the CBI was also significant, t (65) = -3.39, $p = 0.002$, male students ($M = 32.85$, $SD = 3.89$), and female students ($M = 38.04$, $SD = 7.27$).

We conducted a one-way between-groups analysis of variance to explore the impact of educational level on the six variables. Table 6 shows a statistically significant difference at the $p < 0.05$ in the CBI, F (3, 66) = 3.51, $p = 0.02$. The effect size calculated using the eta squared was 0.14, which is a large effect. Post-hoc comparisons using the Turkey HSD test indicated that the mean score for third-year students ($M = 38.55$, $SD = 5.70$) was significantly different from that of first-year students ($M = 32$, $SD = 3.94$).

We performed a two-way between-groups multivariate analysis of variance (MANOVA) to investigate gender and educational level differences in six dependent variables, treating gender and educational level as independent variables. In terms of gender, Table 7 shows no statistically significant difference between men and women on the combined dependent variables, F (6, 54) = 1.58, $p = 0.17$, Wilks's Lambda = 0.85, partial eta squared = 0.15. In terms of educational level, we detected no statistically significant effect on the combined dependent variables, F (6, 54) = 1.64, $p = 0.06$, Wilks's Lambda = 0.61, partial eta squared = 0.15. Regarding the interaction between gender and educational level, we found no statistically significant difference in the combined dependent variables, F *(6, 54)* = 1.46, $p = 0.11$, Wilks's Lambda = 0.64, partial eta squared = 0.14.

Because we were conducting a series of analyses, we ran the risk of an inflated Type 1 error. In order to minimize the Type 1 error across multiple tests, we implemented a Bonferroni adjustment by dividing 0.05 by 6 (which equals 0.008 after rounding) as our cut-off. When we considered the results for the dependent variables separately (ANOVA), there was a difference in CBI on the educational level to reach statistical significance using a Bonferroni-adjusted alpha level of 0.008, F (1, 67) = 4.8, $p = 0.005$, partial eta squared = 0.20.

5.4 Discussion

According to the zero-order correlation, we found that creative personality was not related to creativity; however, in terms of design thinking, creativity was only related to reasoning and reflection ($r = 0.30$). Furthermore, creative personality was related to reasoning and reflection ($r = 0.50$), ideation ($r = 0.51$), and collaboration ($r = 0.27$). Unexpectedly, we detected no relationship between creativity and creative personality in the current study. Another unexpected result was that only reasoning and reflection of design thinking were related to creativity. A possible explanation is that we had used CBI as an indicator of creativity in this study; however, creativity is commonly viewed as multifaceted (Hennessey & Amabile, 2010). Although we could find a one-factor-model CBI in the literature (Silvia et al., 2012), it may not be sufficient to capture different components of creativity, such as generating and evaluating creative ideas. Therefore, when we used the CBI as an indicator of creativity and the TDTS as an indicator of design thinking to examine these relationships, the results of the current study were not conclusive.

Another focus of the second study was to examine the effects of gender and educational level on creativity, design thinking, and creative personality. We found that male students had higher scores for reasoning and reflection than their female counterparts. Conversely, female students had a higher creativity score than their male counterparts. In terms of educational level, third-year students had higher creativity scores compared to first-year students. We further examined the interaction of gender and educational level on these relationships; we could not detect any statistically significant difference.

6. General Discussion

Taken together, the main goal of these two studies was to investigate the possible relationship between creativity and design thinking. The results suggest that creativity does relate to design thinking. More specifically, we found empirical evidence of a positive correlation between some variables of design thinking and creativity; among them, reasoning and reflection seem important for everyday and scholar creativity. These findings have important implications for design educators in the support of creativity. Educators should teach not only how to generate creative ideas but how to think and critically evaluate these ideas. Additionally, in the first study, we found that collaboration and execution were important to creativity.

In terms of gender, we found that in the first study male students had higher scores for scientific creativity than female students. However, in the second study, female students had a higher creativity score than their counterparts. Therefore, the possible effects of gender on creativity remain unclear. With regard to design thinking, our findings suggest that design thinking shows no bias according to gender, though in the second study, we found that male students had higher scores of reasoning and reflection than female students. We recommend further research to obtain a clearer understanding of this issue.

In short, the current research direction is promising, and there is need for more empirical studies to understand the relationship between creativity and design thinking more comprehensively. These have become the standard thinking models for students' toolboxes. Design educators should thus maximize their teaching resources and practices to help students develop the required skill sets in their future design markets.

7. Limitations and Implications

We noted a number of limitations. First, cross-sectional design formed the basis of the methodology of the current study, which might limit the interpretation of our findings. Second, convenience and homogeneous samples might have influenced the results of the current study; thus, further research requires more ethnic diversity. Finally, the current study employed self-report measures, which may not have properly captures individuals' design thinking and creative performance. Using other approaches of measurement could be more promising.

Barring the evident considerations for the limitations of this study, the results of the current study provide useful insights into the relationship between design thinking and creativity. Our research findings are significant for the education of design professionals. Design educators eagerly promote both design thinking and creativity in their classrooms to help their students produce high-quality projects. In our study, we found that execution, collaboration, reasoning, and reflection were important for everyday creativity. Creativity, ideation, reasoning, and reflection were also prime factors for scholars. In other words, educators could utilize group settings to facilitate design students with the aim to complete design projects. Most importantly, after completing projects, teachers could ask students to reflect on their design intentions through writing journals or group discussions.

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Table 1. Zero-order correlations, means, and standard deviations for study variables

Variable	1	2	3	4	5	6	7	8	9
1.Everyday creativity	--								
2.Scholar creativity	0.54**	--							
3.Performance creativity	0.15	0.50**	--						
4.Scientific creativity	0.20	0.41**	0.58**	--					
5.Artistic creativity	0.37**	0.52**	0.27**	0.14	--				
6.Execution	0.32**	0.09	-0.07	-0.06	0.10	--			
7.Collaboration	0.33**	0.11	0.08	0.10	0.03	0.38**	--		
8.Ideation	0.17	0.24**	0.16	0.09	0.18	-0.05	0.11	--	
9.Reasoning/Reflection	0.35**	0.31**	0.03	0.05	0.18	0.31**	0.31**	0.31**	--
M	3.67	3.38	2.78	2.51	4.00	3.56	3.50	3.59	3.81
SD	0.56	0.62	0.70	0.89	0.63	0.75	0.60	0.61	0.56

* $p < 0.05$.
** $p < 0.01$.

Table 2. Gender differences for study variables

	Male		Female			
Variable	*M*	*SD*	*M*	*SD*	*t*(90)	*p*
Everyday creativity	3.78	0.80	3.66	0.53	0.62	0.54
Scholar creativity	3.47	1.02	3.37	0.57	0.48	0.63
Performance creativity	2.84	0.92	2.78	0.68	0.25	0.80
Scientific creativity	3.32	1.05	2.43	0.83	2.47	0.004
Artistic creativity	3.85	0.76	4.02	0.61	-0.77	0.44
Execution	3.52	0.73	3.57	0.76	-0.18	0.86
Collaboration	3.61	0.61	3.49	0.60	0.57	0.57
Ideation	3.85	0.67	3.56	0.60	1.36	0.18
Reasoning/Reflection	3.74	0.60	3.81	0.56	-0.39	0.70

Table 3. Multivariate and univariate analyses of variance for study variables

		ANOVA *F* (1, 91)								
Variable	MANOVA *F*(9, 76)	C1	C2	C3	C4	C5	D1	D2	D3	D4
Gender (G)	2.84	2.30	1.61	0.67	5.89	0.33	5.34	5.20	4.54	0.04
Age (A)	0.95	1.04	0.77	0.88	1.23	1.47	1.12	0.77	1.00	0.10
G x A	1.86	1.88	2.31	0.56	1.35	0.02	6.53	5.20	2.55	0.39

Note. Multivariate *F* rations are Wilks's Lambda statistic. C1 = Everyday creativity; C2 = Scholar creativity; C3 = Performance creativity; C4 = Scientific creativity, C5 = Artistic creativity; D1 = Execution; D2 = Collaboration; D3 = Ideation; D4 = Reasoning/reflection.

Table 4. Zero-Order Correlations, Means, and Standard Deviations for Study Variables

Variable	1	2	3	4	5	6
1. Reasoning/Reflection	--					
2. Ideation	0.67**	--				
3. Collaboration	0.50**	0.32**	--			
4. Execution	-0.02	0.16	-0.15	--		
5. CBI	0.30*	0.17	0.07	-0.03	--	
6. CPS	0.51**	0.50**	0.27*	0.07	0.01	--
M	4.02	3.52	3.86	2.98	34.94	8.67
SD	0.63	0.78	0.69	0.62	6.03	4.30

* $p < 0.05$.
** $p < 0.01$.

Table 5. Gender differences for study variables

	Male		Female			
Variable	*M*	*SD*	*M*	*SD*	*t*(65)	*p*
Reasoning/Reflection	4.15	0.58	3.83	0.65	2.12	0.04
Ideation	3.68	0.75	3.30	0.79	1.98	0.05
Collaboration	3.94	0.66	3.74	0.64	1.20	0.23
Execution	3.01	0.68	2.93	0.53	0.53	0.60
CBI	32.85	3.89	38.04	7.27	-3.39	.002
CPS	9.15	3.97	7.96	4.74	1.11	0.27

Table 6. ANOVA results

Variable	*SS*	*df*	*MS*	*F*	*p*
Reasoning/Reflection	1.53	3	0.51	1.32	0.28
Ideation	0.95	3	0.32	0.51	0.68
Collaboration	2.26	3	0.75	1.80	0.16
Execution	0.51	3	0.17	0.43	0.73
CBI	343.49	3	114.50	3.51	0.02
CPS	76.12	3	25.37	1.40	0.25

Table 7. Multivariate and univariate analyses of variance for study variables

		ANOVA *F* (1, 67)					
Variable	MANOVA *F*(6, 54)	D1	D2	D3	D4	C1	C2
Gender (G)	1.58	0.23	0.91	1.46	0.20	4.54	0.20
Education (E)	1.64	1.18	0.37	1.8	0.16	4.8	1.4
G x E	1.46	1.56	0.46	1.85	1.99	0.84	2.63

Note. Multivariate *F* rations are Wilks's Lambda statistic. D1 = Reasoning/reflection; D2 = Ideation; D3 = Collaboration; D4 = Execution. C1 = CBI; C2 = CPS.