An Analytic Study on Constructional Relationship of Intrapersonal Factors Fostering Innovation Competency: From Taiwanese Students' Perspectives

Wei-Ting Hsiao [1], Ming-Chang Wu [2], Chang-Franw Lee [2], Wen-Lung Chang [3*]

[1] National Yunlin University of Science and Technology/Overseas Chinese University, TAIWAN
[2] National Yunlin University of Science and Technology, TAIWAN
[3] National Academy for Educational Research, TAIWAN

ABSTRACT

The objective of this study was to determine the relationship among some intrapersonal factors including individual professional competency, interdisplinary ability, social skills, and team cohesion. Results showed that each of these factors could influence the innovation competency of students enrolled in design programs. To scrutinize effects of these factors on innovation competency, this study examined their correlations with innovation competency and their internal structure in order to comprehensively understand influential processes and paths for innovation competency enhancement in design education. The validated questionnaire was delivered to 296 students enrolled in design programs of universities in Taiwan. SPSS 18.0 and AMOS statistics were used to analyze collected data. To address research questions of this study, t-test, one-way analysis of variance (ANOVA), Pearson correlation analysis, Confirmatory Factor Analysis (CFA), and Structural Equation Modeling (SEM) were performed. The following crucial conclusions were reached: (1) Students enrolled in design programs generally possessed high levels of professional competency, interdisplinary ability, social skills capability, team cohesion, thinking style, and innovation competency; (2) There were significant and positive relationships among these factors. This implies that these intrapersonal factors are highly relied on each other because they co-exist and interact with each other. Thus, any change in one factor would create chain effects; and (3) These highly correlated intrapersonal factors can be developed in real environment through understanding their interactive, hierarchical, and consecutive processes rather than through focusing on effects of a single factor. These conclusions could provide several suggestions for professionals, managers, and, more importantly, school educators in relevant fields. Two suggestions are provided for future high quality and comprehensive research to further understand and improve strategies needed for design education.

Keywords: innovation competency, interdisplinary ability, professional competency, social skills capability, team cohesion

BACKGROUND

With internationalization, Taiwan faces fierce global competition and challenges. The development of various industries has struggled. Accelerating the overall economic transformation and upgrading industries have become top priorities. In this context, cultivating design talents with more innovation competency will aid Taiwan's industrial internationalization (Wu, Chang & Chen, 2012). What is worthy of concern is whether innovation competency is a personal trait, a natural tendency, or a kind of capacity that can be cultivated and taught. After

Contribution of this paper to the literature

- This paper illustrates the importance of social skills, interdisplinary ability, and team cohesion to youngsters' innovation competencies which were conventionally believed being enhanced by professional competencies. In addition, this study approved the successional interaction effects of these factors overwhelm the single-factor effects in the realistic world while people's innovation is inspired. That is, the cultivation of youngsters' innovation ability needs systematic contribution of contextual factors, including both personal and environmental elements, rather than any single reform.

years of systematic research in academic circles, scholars no longer regard innovation competency as an inspired passage. Instead, scholars emphasize effects of skill cultivation and social environmental factors, making innovation competency something that can be affected, taught, and changed in nature (Craft, Jeffrey & Leibling, 2001; Jeffrey & Craft, 2004). With this in mind, previous studies have explored the effect of interaction between an individual and his environment on innovation competency (Amabile, Conti, Lazenby & Herron, 1996; Bandura, 2001) and determined influencing factors at individual level such as personality traits (Chen, 2005), ability requirements (Kerr & Gagliardi, 2003), or achievement motivation (Basadur & Hausdorf, 1996). An analysis of these issues will help us understand the nature of innovation competency and its internal structure as well as hierarchical effects of mutual influences among various factors.

Research Purpose

The purpose of this study was to explore characteristics of innovation competency of students enrolled in design programs and understand the internal structure of innovation competency and mutual influences among various factors by analyzing performance characteristics of each dimension.

Research Questions

Based on our analysis and discussion, we have the following research questions:

(1) What are characteristics of innovation competency of students enrolled in design programs?
(2) What characteristics can be inferred from correlations among four factors of innovation competency?
(3) What are characteristics of the internal structure among these four factors of innovation competency?

LITERATURE REVIEW

Capacity Needs in the Design Industry

Manpower and knowledge in the design industry, like those in many industries, have to be stably upgraded and transformed. Although professional skills taught in design programs of universities/colleges in Taiwan are diversified and specialized, most of them are only focused on specialized areas of design. Beside design expertise, design services also need operational professionals in related areas such as finance, planning, marketing, and so on to handle, manage, and maintain a company's needs. Past studies have found that design professionals should have conceptual, technical, communication, integration, and adaptation ability with background knowledge and professional attitude (Stark, Lowther, & Hagerty, 1986). Based on this, it is evident that quality facets of designers discussed in past studies are diversified. Considerable importance has been attached to conditions under which design professionals can achieve high success (Lu & Lu, 2012). However, these studies did not expound on which abilities are constructive factors of innovation competency. Therefore, the present study will focus on constructive factors underpinning the innovation competency of students enrolled in design programs and explore how professional competency of students enrolled in design programs can influence their innovation competency and thus improve the efficiency and correlation through factors of interdisplinary ability, social skills, and team cohesion.

Definition and Connotation of Innovation Competency

Definition of innovation competency

What is innovation? Economics master Joseph A. Schumpeter has defined innovation as "developing things that have been invented into activities socially acceptable and of commercial value". Management master Peter Drucker (1998) has also argued that "innovation is the new ability empowering resources and creating wealth. Increasing the value of original resources is exactly innovation." Robins (2001) has argued that innovation

competency is a kind of change and a new thinking that can improve products, processes, or services. Janssen (2003) has believed that innovation competency is the overall innovation behavior related to creativity and innovation. It is exhibited by members of an organization in the workplace. It is also a complex behavior with three different behavioral tasks, namely creative formation, creative promotion, and creative realization. Wen and Chen (2008) have thought that innovation competency is a means that allows an organization to enhance its competitiveness. It is also a course through which employees attempt to put creative ideas generated from brainstorming into practice based on interests of individuals and the organization. Integrating perspectives of these scholars, this study defines innovation competency considering the following aspects. The meaning of innovation is a high-value thinking belief that help people generate positive and optimistic beliefs. The goal of innovation is to improve and enhance the quality of an organization. The process of innovation is a process of transforming abstract and new ideas into concrete and feasible actions. In other words, any new idea, method, or product that can be proposed or made can be called an "innovation". Innovation competency explored in this study targets an individual's behavior change ability caused by combined effects of personal traits, cognitive ability, and social environment.

Connotation of innovation competency

The concept of innovation was first proposed by Schumpeter in the 1930s. It originated from the Latin word "Novus". Its original meaning refers to introducing something or a new concept (Robins, 2001). According to Robbins (2001), connotation of innovation is "the process of adopting new ideas and transforming them into useful products, services, or technologies." Therefore, innovation means that individuals or organizations adopt new ideas and implement them. Scott and Burce (1994) have put forward three dimensions of personal innovation behavior, namely generation of innovative ideas, promotion of innovative ideas, and realization of innovative ideas.

Dimensions of innovation competency adopted in this study follow those developed by Scott and Burce (1994). The measuring instrument used in this study was slightly adapted from the scale revised by Janssen (2003) and developed further by Tian and Lu (2005) for "innovative behavior" in the workplace. The instrument contained a total number of 10 questions distributed across three dimensions: 3 questions for idea generation, 3 questions for idea promotion, and 4 questions for idea realization. Cronbach's α coefficient of this scale was found to be 0.91.

Relationships among Innovation Competency, Professional Competency, Interdisplinary Ability, Social Skills Capability, and Team Cohesion

Innovation competency is mainly the result of an interaction between professional proficiency and the good use of creative skill in a specific field (Amabile et al., 1996). Specifically, innovation competency is influenced by professional knowledge in the field (Hung, Chen, & Yeh, 2006). Therefore, innovation is based on deep professional knowledge and technical ability (Chen & Huang, 2006).

In the past, innovation had long been seen as being developed only within an individual. However, now it is generally understood that interdisplinary access to external knowledge is needed in order to achieve the goal of innovation (Calantone & Stanko, 2007). That is, an individual's interdisplinary practice can enhance innovation competency (Hagel & Brown, 2005). From the perspective of enterprise, companies should make good use of employees or supervisors with good personality traits, encourage them to carry out interdisplinary learning, and cultivate them into good tools for enterprise innovation. Today, this is a very important management issue (Fagerberg, Mowery & Nelson, 2005; Kimble, Grenier & Goglio-Primard, 2010). Past studies (Kodama, 2007, 2009; Teigland & Wasko, 2003) have found that interdisplinary teams can integrate multiple skills, knowledge, and experience, making the team's capability more influential than the individual's capacity. They can even avoid the group myth issue regarding group decisions being easily formed in a team with homogeneous members. The argument that diversified and heterogeneous interdisplinary behaviors resulting from different occupations and different industries and innovations brought by interdisplinary knowledge flow can enhance organizational capabilities has received considerable support from studies by various scholars (Kimble et al., 2010).

When an individual is operating in a team-working environment, interpersonal skills become more important (Cohen, 1995). This ability can also be called social skills, including social interaction, cooperation, persuasion, negotiation, guidance, and helping others (Morgeson, Reider & Campionk, 2005). If individuals have better communication, listening, and interactive skills, then the organization will be able to increase possibilities available for adding new knowledge and obtaining new ideas through social interaction to share team experiences and knowledge (Hulsheger, Anderson & Salgado, 2009). Thus, enhancing social skills is the key to accumulation of intellectual capital nowadays (Hsiao & Lai, 2010).

From the preceding section, it can be asserted that innovation competency is influenced by professional competency, interdisplinary capability, social skills or capability, and individuals' mentality toward team cohesion in an organization. In particular, when facing an environment full of uncertainty in corporate practice, team
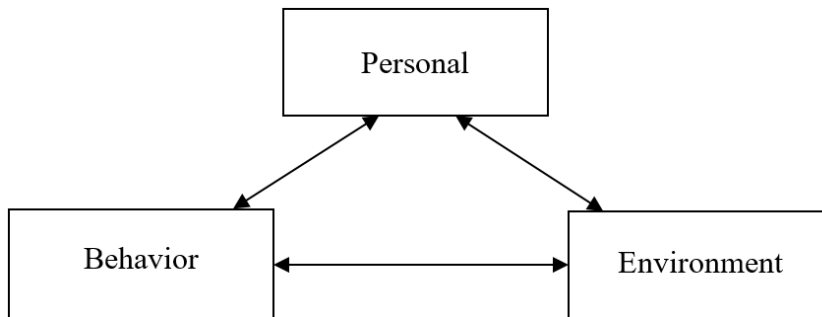
Figure 1. Model of triadical reciprocality (Bandura, 1997)

cohesion is needed to integrate talents from various professional fields and cope with this complex environment full of variables (Cefis & Marsili, 2006).

Comprehensive Reflection of Literature Analysis

Importance of design talents

The fact that Taiwan's industrial scale coupled with high global business competition is very different from other developed countries means that enterprises that can understand consumers' needs and connect with them through excellent R&Ds and innovations will be able to protect themselves and further their interests (Ay & Sung, 2010). Because design can affect the ultimate mentality of consumers, under the current situation where Taiwan's industries urgently need transformation, innovation has become a new magical weapon for business survival while designers or creative individuals have frequently become targets of enterprises that seek to take advantage of their talents.

Innovation competency is the main connotation of design talent cultivation

Based on a survey conducted by Professor Wang (2014) of National Taiwan Normal University commissioned by the Ministry of Education, it is evident that a great disparity exists in employment opportunities afforded to students enrolled in design programs. Those who are good are very good and those who are poor are very poor. This is greatly related to advantages and disadvantages that accrue from an individual's innovation competency (Wang, Chang, & Chiang, 2014). This also highlights that innovation competency courses or related courses developed for students in university design programs will be a critical factor for cultivating design talents with more innovation competency in Taiwan and enhancing national competitiveness (Wu et al., 2012).

Factors enhancing benefits of innovation competency

Early research in the field of creative ideas have placed a lot of emphasis on creativity or the creator's own traits (professional competency, personality traits, etc.) by forcing out and extracting creative ideas through personal traits. Later research studies have attempted to explore the kind of external environment helpful (or unhelpful) for generating creative ideas. That is, a social interaction point of view underlies various investigations (Amabile, 1988, 1996). Previous researches have regarded creative idea as the product of social interaction (Woodman et al., 1993), focusing on the interaction among various variables, including organizational characteristics, social factors, and individual traits. Thus, innovation was regardes as an activity developed only within an individual or organization in the past. However, now it is generally understood that the goal of innovation can only be achieved through team cohesion (Chesbrough & Crowther, 2006).

Social cognition theory (Bandura, 2001) argues that human behaviors and beliefs are often results of continuous interactive influences among personal, behavioral, and environmental factors (**Figure 1**). From this, it can be asserted that the development and playing out of an individual's ability are not affected by a single factor. They often continuously evolve and develop in the interaction process of several possible factors. In the process of interaction and exchange, benefits of individual factors may change, transform, or even disappear (Bandura, 1989).

This study therefore takes the view of reciprocal determinism as it plays out in the social learning theory of Albert Bandura (2001) and the view of social interaction as it plays out in the creativity theory of Amabile et al. (1996) to further explore how professional competency and innovation competency of design students are cultivated through intrapersonal factors such as their interdisplinary ability, social skills, and team cohesion. In
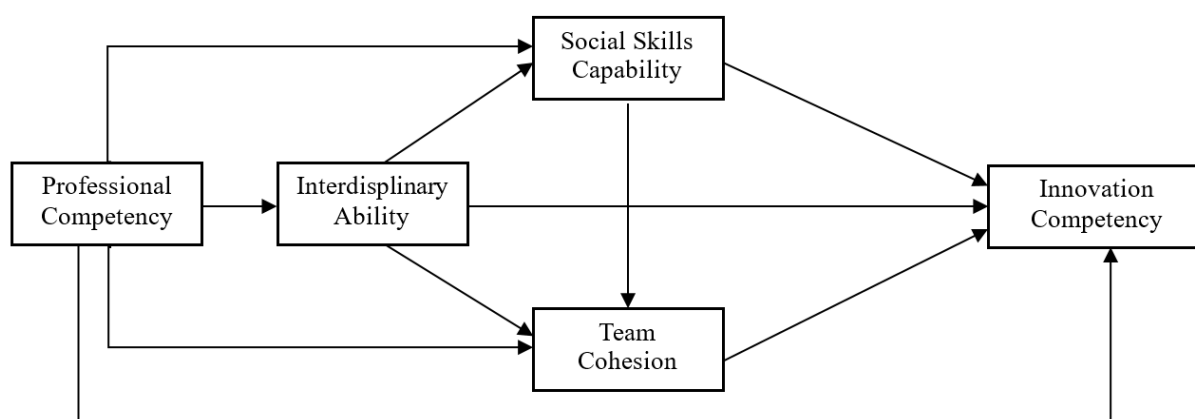
Figure 2. Research framework

Table 1. Basic data summary of formal questionnaire sample (N = 296)

Basic Data of Subjects	Number of Subjects (N)	Percentage (%)
University Enrolled		
Public University	192	64.9%
Private University	104	35.1%
Gender		
Male	91	30.7%
Female	205	69.3%
Program		
Space Design	14	4.7%
Product Design	97	32.8%
Visual Communication	116	39.2%
Integrated Design	63	21.3%
Other	6	2.0%
Total	296	100%

addition, this study pays attention to correlational structure among these five constructs and uses it to conduct an in-depth analysis of interactive influences and structural relationships among them.

RESEARCH METHOD

Research Framework

The purpose of this study was to explore characteristics of innovation competency of students enrolled in design programs and analyze internal structural relationships among these constituent factors (**Figure 2**).

Research Objects

This study was conducted with purposive sampling. Students enrolled in design programs of five universities/colleges located in northern, middle, and southern Taiwan in 2016 academic year were sampled. With respect to research instrument, a total of 400 questionnaires were distributed and 324 valid questionnaires were collected. The total number of valid questionnaires was 296 after excluding questionnaires with incomplete information. Thus, the recovery rate was 81% and the usability rate was 74%. These students categorized by gender and program were basically consistent with proportions enrolled in higher education institutions of Taiwan. Female students dominated these Design Schools. Visual Communication had the most number of students while Space Design had the least number of students. These subjects' basic data are summarized in **Table 1**.

Research Tools

This study mainly used questionnaire survey method. The survey comprised six parts: basic personal data, design professional competency, interdisplinary ability, social skills capability, team cohesion, and innovation competency. The questionnaire was prepared and developed by using modified five-point Likert scoring method. Most questions included in the measuring tool were derived from existing scales. For example, the professional

Table 2. Results of reliability and validity analysis of various scales of a formal questionnaire (N = 296)

Potential Variable	Subdimension	Number of Questions	Factor Loading	Cronbach's α	CR	AVE
Professional Competency		29	.631~.882	0.950	0.8697	0.5746
	Design Literacy	7	.634~.787	0.860	0.8842	0.5231
	Design Theory	5	.672~.815	0.896	0.8768	0.5885
	Operational Practice	5	.560~.841	0.863	0.8394	0.5174
	Design Application	5	.694~.791	0.879	0.8679	0.5684
	Design Planning	7	.640~.846	0.917	0.9017	0.5699
Interdisplinary Ability		5	.731~.910	0.897	0.8995	0.6435
Social Skills		8	.551~.746	0.880	0.8772	0.4738
Team Cohesion		5	.691~.764	0.849	0.8415	0.5154
Innovation Competency		9	.850~.885	0.923	0.9061	0.7630
	Innovation Generation	3	.699~.842	0.785	0.8179	0.6009
	Innovation Promotion	3	.771~.806	0.823	0.8276	0.6154
	Innovation Realization	3	.754~.857	0.848	0.8532	0.6601
Overall Scale		56		0.965		

competency subscale utilized the scale proposed by Chiu (2014). For this subscale, there were a total of 34 questions distributed among five dimensions: design literacy, design theory, operational practice, design application, and design planning. Cronbach α coefficient values for all these dimensions were found to be between 0.82 and 0.86. The interdisplinary ability subscale adopted the interdisciplinary contact dimension scale used in a study of Teigland and Wasko (2003). This subscale comprised 5 questions with a Cronbach α coefficient of 0.919. The subscale of social skills used structured interview to measure social skills used in a study of Morgeson et al. (2005). We modified this subscale into a five-point scale. It comprised a total number of 10 questions with a Cronbach α coefficient of 0.83. The team cohesion subscale adopted the scale used in a study of Tjosvold (1988). It comprised of 5 questions with a Cronbach α coefficient of 0.935. The innovation competency subscale utilized the scale used in a study of Janssen (2003). It had a total number of 10 questions distributed across three dimensions, namely idea generation (3 questions), idea promotion (3 questions), and idea realization (4 questions). This scale's Cronbach α coefficient was 0.91. After applying reliability analysis with expert validity and confirmatory factor analysis (CFA) on a pre-test to check reliability, convergence validity, and discriminant validity of the scale to remove questions that might affect the overall reliability of the scale (5 questions for professional competency, 2 questions for social skills, and 1 question for innovation competency), the remaining 56 questions having sufficient reliability were used to make up the measurement tool of this study.

Analysis of Formal Questionnaire Data

Reliability analysis

After performing reliability analysis, the Cronbach α value of the overall scale used in this study was found to be 0.965 and Cronbach α coefficients of all potential variables and sub-dimensions were higher than 0.75, reaching the high standard for Cronbach α value at 0.7 recommended by scholars (Chiu, 2012). Results of reliability analysis showed that the internal consistency of the questionnaire used in this study was good. It was applicable for empirical research of students enrolled in design programs of Taiwan.

Content validity analysis

In this study, factor loadings of all observed variables (the five potential variables, including professional competency, social skills, interdisplinary ability, team cohesion, and innovation competency) were greater than 0.5 and the composite reliability (CR) value of all potential variables was greater than 0.6, indicating that these variables had good credibility. In addition, average variance extraction (AVE) test showed that their average variance extraction values were greater than or close to 0.5, indicating that they had convergence or aggregation validity (Fornell & Larcker, 1981). Thus, the internal quality of the measurement model was excellent. Finally, this study conducted an internal consistency reliability analysis on subscales and the overall scale in accordance with the theory proposed by Hair et al. (2010). Results showed that the Cronbach α coefficients of all potential variables and subdimensions were greater than 0.80 with an overall reliability of the scale of 0.965, demonstrating that the internal consistency of the questionnaire was good. Results are shown in **Table 2**. Internal quality and external quality of the conceptual model used in this study were good. Thus, it would be suitable for conducting structural model analysis in the next step to verify causal relationships among potential variables.

Table 3. Performance status analysis results of professional competency, interdisplinary ability, social skills, team cohesion, and innovation competency

Variable Layer	Mean	Standard Deviation	Number of Questions	Mean Score per Question	Standard Deviation
Professional Competency	105.537	15.2310	29	3.638	
Social Skills	31.016	4.4745	8	3.877	0.5593
Interdisplinary Ability	16.594	3.8115	5	3.319	0.7623
Team Cohesion	18.938	3.0238	5	3.788	0.6048
Innovation Competency	33.010	5.5763	9	3.668	

N=296

Table 4. Summary table showing the correlation matrix of variables

	Professional	Social Skills	Interdisplinary	Team Cohesion	Innovation
Professional	1				
Social Skills	.508**	1			
Interdisplinary	.509**	.455**	1		
Team Cohesion	.546**	.765**	.491**	1	
Innovation	.642**	.640**	.579**	.699**	1

RESEARCH RESULTS

Results of Performance Status Analysis for Innovation Competency and Four Variables

Results of this study revealed that current performance characteristics of professional competency, social skills, interdisplinary ability, team cohesion, and innovation competency of students enrolled in design programs were mostly distributed between 3.3 to 3.8. Therefore, they belonged to an above moderate level (Chiu, 2012), as shown in **Table 3**.

Correlation Analysis of Innovation Competency and Various Factors

This study used Pearson Product-Moment Correlation Analysis. Results showed that a high and significant correlation existed among the five variables and the performance of any of these variables had a certain influence on the other four variables.

Analysis Results of Effect paths among Dimensions of Innovation Competency－ Test of Structural Equation Modeling (SEM)

Measurement model analysis

As shown in **Table 5**, most indexes (GFI, TLI, CFI, AGFI, SRMR, and RMSEA) of the conceptual model and the actual data of these five variables met the standards. Although a small number of goodness of fit indexes did not meet the standards, they were very close to standard values. Therefore, it was judged that the goodness-of-fit of the conceptual model was quite good. Thus, external quality of the measurement model should be consistent with requirements of general academic research.

Table 5. Measurement model's goodness of fit index checklist

Statistical Test (Standard Value)		Professional Competency	Social Skills Capability	Interdisplinary Ability	Team Cohesion	Innovation Competency
Absolute Goodness of Fit Index	χ^2 (The smaller, the better)	3468.24	387.01	65.25	225.13	320.65
	χ^2/df (1~5)	9.32	19.35	13.05	45.02	13.36
	RMR (<0.08)	0.046*	0.03*註1	0.028*	0.029*	0.024*
	GFI (>0.8)註2	0.794*	0.895*	0.976*	0.913*	0.929*
	AGFI (>0.8)註2	0.759*	0.810*	0.928*	0.739	0.868*
	RMSEA (<0.08)	0.091	0.135	0.109	0.209	0.111
	SRMR (<0.08)	0.071*	0.055*	0.03*	0.051*	0.039*
Incremental Goodness of Fit Index	NFI (>0.9)	0.820	0.904*	0.972*	0.912*	0.945*
	TLI (>0.9)	0.821	0.872	0.949*	0.827	0.924*
	RFI (>0.9)	0.804	0.866	0.945*	0.824	0.918*
	IFI (>0.9)	0.836	0.908*	0.974*	0.914*	0.949*
	CFI (>0.9)	0.836	0.908*	0.974*	0.914*	0.949*
Parsimony Goodness of Fit Index	PNFI (>0.5)	0.752*	0.646*	0.486	0.456	0.630*
	PCFI (>0.5)	0.766*	0.649*	0.487	0.457	0.633*
	PGFI (>0.5)	0.679*	0.497	0.325	0.304	0.496
	CN (>200)	122	83	172	50	115

Note 1: * indicates meeting standard value. Note 2: Hair et al. (2010)
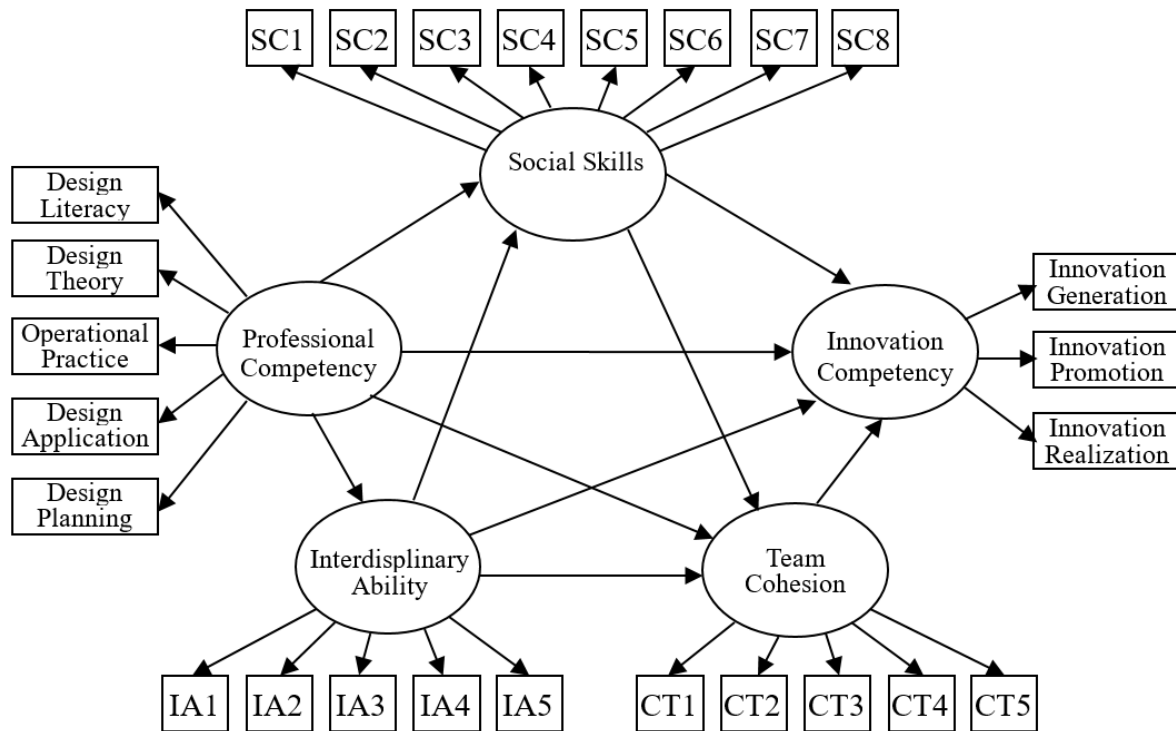
Figure 3. Structural relationship model of five variables

Structural model analysis

The purpose of this study was to explore the causal model and effect paths as well as structural relationships among the five variables (professional competency, social skills, interdisplinary ability, team cohesion, and innovation competency) with respect to students enrolled in design programs. This study adopted Structural Equation Modeling (SEM) to conduct the analysis (Chiu, 2012). The overall model in five stages (test violation estimate, overall model goodness-of-fit index, model parameter estimation test, hypothesis test, and effect analysis) was evaluated. The overall structural model is shown in **Figure 3**, including proposed influential paths of these five variables while considering single factor's effects. However, this study focused on identifying synthetic influential paths while interactive effects occurred among study variables.

Table 6. Overall model goodness-of-fit index checklist

Statistical Test		Standard Value	Test Results	Model Goodness of Fit Judgment
Absolute Goodness of Fit Index	χ^2	The smaller, the better (p≧α value)	1332.05(286)	No
	χ^2/df	Between 1 and 5 (Note 1)	4.658	Yes
	RMR	Less than 0.08	0.026	Yes
	GFI	Greater than 0.8 (Note 2)	0.903	Yes
	AGFI	Greater than 0.8 (Note 2)	0.881	Yes
	RMSEA	Less than 0.08	0.060	Yes
	SRMR	Less than 0.08	0.044	Yes
Incremental Goodness of Fit Index	NFI	Greater than 0.9	0.922	Yes
	TLI	Greater than 0.9	0.929	Yes
	RFI	Greater than 0.9	0.911	Yes
	IFI	Greater than 0.9	0.938	Yes
	CFI	Greater than 0.9	0.937	Yes
Parsimony Goodness of Fit Index	PNFI	Greater than 0.5	0.811	Yes
	PCFI	Greater than 0.5	0.825	Yes
	PGFI	Greater than 0.5 (Note 3)	0.736	Yes
	CN	Greater than 200	249	Yes

Note 1: Bagozzi and Yi (1988)
Note 2: Hair et al. (2010)
Note 3: Mulaik, James, Van Alstine, Bennett, Lind and Stilwell (1989)

Evaluation of goodness-of-fit index of overall model

As shown in **Table 6**, normalized regression weighting factors (factor loadings) of all parameters are between 0.040 and 0.898. No weighting factor was over or too close to 1. Standard errors were between 0.028 and 0.193. No standard error was too big. All variances of measurement error were positive, ranging from 0.080 to 0.309. These results confirmed that the model did not violate the test estimated (Hwang, 2015). Results of absolute goodness of fit index are shown in **Table 6**. All indices except Chi-square value passed the criteria for the model to be acceptable. Chi-square value is usually influenced by the number of samples. Chen and Wang (2010) have argued that researchers do not necessarily have to care too much about this index. They can even replace it with Chi-square degree of freedom. The Chi-square value in this study was 1332.05 with significance ($p = 0.000$), indicating that the goodness-of-fit of the model and the data were not good. However, the ratio of Chi-square value and the degree of freedom of this study was 4.658, reaching the standard value. This indicates that the goodness-of-fit of the model and the data were still acceptable. Since most absolute goodness-of-fit indices passed the standards, the model was acceptable. Incremental goodness-of-fit index showed that all indices were greater than 0.9. This means that the overall performance of the model is still within acceptable range. In the parsimony goodness-of-fit index, all indices passed the standards. Overall, these three types of indices showed that this model had good fitness.

Model parameter estimation test (Path analysis of potential variables)

Yu (2006) has argued that the most important concern is whether path relationships between potential variables proposed by the research model can be supported by empirical data regardless whether a structural model is fit. In order to be considered as fit, a structural model must meet the following three requirements: (1) All signs of the path coefficients between potential variables, whether positive or negative, must be the same as the direction assumed and expected by the researcher; (2) The estimated parameter value of path relationship (critical ratio value) must be statistically significant (the absolute value of t is greater than 1.96e); and (3) R^2 (factor loading squared) of each Structural Equation Modeling (SEM) must be significant ($p < 0.05$). Detailed parameter estimate situations of the overall model in this study are shown in **Table 7**. Estimated values of various parameters are described as shown in **Table 7**.

Table 7. Estimated values of various parameters of the overall model

Parameter			Factor Loading	Standard Error	t value	Error Variance	t value	R²
Design Literacy	←	Professional Competency	.764*	.227	9.918	.143*	18.848	.583
Design Theory	←	Professional Competency	.708*	.242	9.665	.214*	19.731	.501
Operational Practice	←	Professional Competency	.724*	.268	9.662	.239*	19.496	.525
Design Application	←	Professional Competency	.868*	.279	10.032	.100*	14.577	.754
Design Planning	←	Professional Competency	.761*	.250	9.899	.175*	18.878	.579
Innovation Generation	←	Innovation Competency	.857*	.029	35.01	.114*	16.998	.735
Innovation Promotion	←	Innovation Competency	.900*	.028	37.6227	.086*	14.172	.810
Innovation Realization	←	Innovation Competency	.862*	.030	35.0916	.125*	16.853	.744
Interdisplinary Ability	←	Professional Competency	.598*	.218	8.772	—	—	—
Team Cohesion	←	Professional Competency	.151*	.101	4.023	—	—	—
Social Skills	←	Professional Competency	.430*	.208	8.159	—	—	—
Social Skills	←	Interdisplinary Ability	.260*	.030	6.351	—	—	—
Team Cohesion	←	Interdisplinary Ability	.073*	.026	2.378	—	—	—
Innovation Competency	←	Interdisplinary Ability	.187*	.027	6.115	—	—	—
Innovation Competency	←	Social Skills	.071	.079	1.108	—	—	—
Team Cohesion	←	Social Skills	.756*	.226	9.729	—	—	—
Innovation Competency	←	Team Cohesion	.402*	.074	5.683	—	—	—
Innovation Competency	←	Professional Competency	.329*	.129	7.227	—	—	—
Professional Competency			—	—	—	.039*[1]	5.014	—
Social Skills			—	—	—	.130*[2]	10.830	.387
Interdisplinary Ability			—	—	—	.258*[3]	11.620	.358
Team Cohesion			—	—	—	.057*[4]	8.712	.802
Innovation Competency			—	—	—	.086*[5]	13.031	.728

* Indicates significant at *p* < 0.05.

- Indicates no estimated value.

1: Indicates variance of professional competency; 2, 3, 4, and 5 indicate structural error of social skills capability, interdisplinary ability, team cohesion, and innovation competency, respectively

Table 8. Path relationship test table

Hypothesis	Path			Hypothetical Relationship	Path Coefficient (t Value)	Hypothesis Is True or False
1	Professional Competency	→	Interdisplinary Ability	Positive	0.547*** (8.772)	True
2	Professional Competency	→	Social Skills	Positive	0.389*** (4.326)	True
3	Professional Competency	→	Team Cohesion	Positive	0.089 (1.524)	False
4	Professional Competency	→	Innovation Competency	Positive	0.271*** (4.311)	True
5	Interdisplinary Ability	→	Social Skills	Positive	0.273*** (3.666)	True
6	Interdisplinary Ability	→	Team Cohesion	Positive	0.061 (1.129)	False
7	Interdisplinary Ability	→	Innovation Competency	Positive	0.235*** (4.484)	True
8	Social Skills	→	Innovation Competency	Positive	0.130 (0.776)	False
9	Social Skills	→	Team Cohesion	Positive	0.840*** (7.771)	True
10	Team Cohesion	→	Innovation Competency	Positive	0.397* (2.221)	True
	p < 0.05, **p* < 0.01, ***p* < 0.001					

Test of hypotheses

Based on results of empirical analysis and test, this study constructed the relationship model path diagram of professional competency, interdisplinary ability, social skills, team cohesion, and innovation as shown in **Figure 4**. In the figure, solid lines, dotted lines, and numerical values next to lines represent significant paths after the test, non-significant paths, and path coefficients, respectively. Values of t are shown in brackets. Based on results of empirical analysis, this study carried out hypothesis test. Results are shown in **Table 8**. Using these ten-path relationships among five dimensions estimated by SEM (normalized coefficient value was used for each path), this study verified that, among hypotheses 1 ~ 10 of this study's model, seven hypotheses achieved significant level of α = 0.05, with path coefficient value of "social skills " to "team cohesion" being the highest at 0.840.
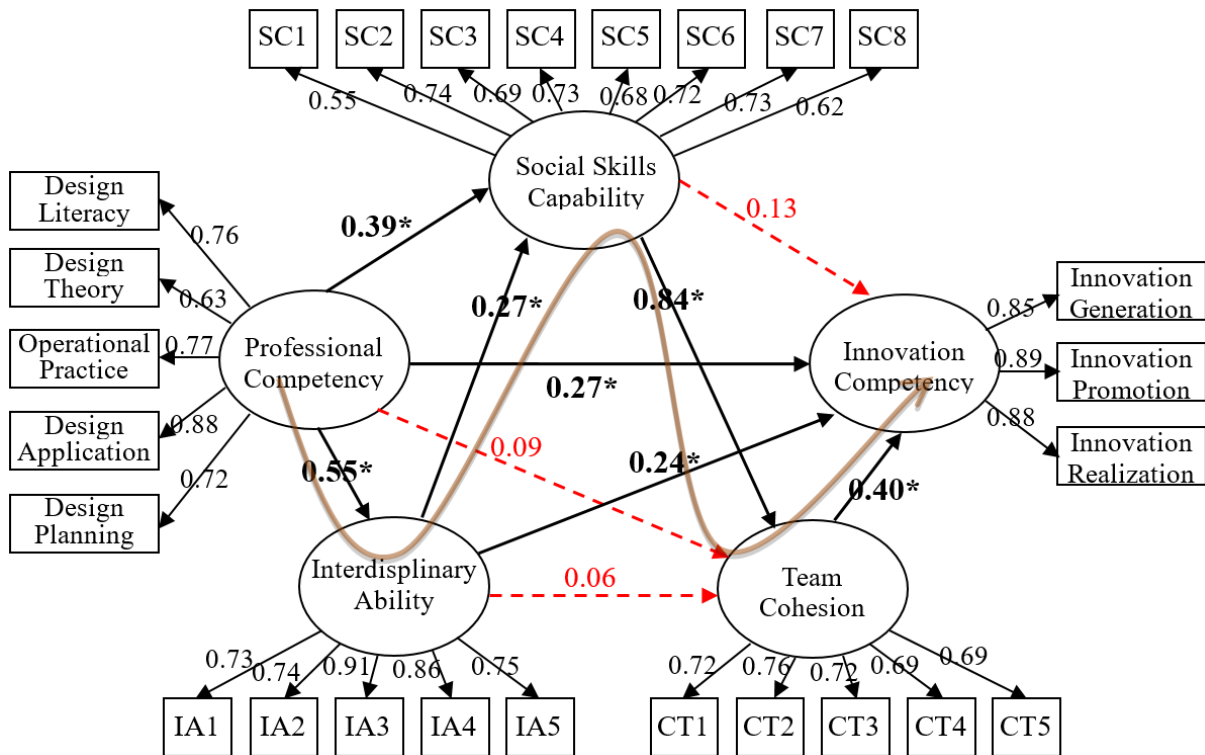
Figure 4. SEM hierarchical effect path diagram

Analysis of influential effects among the five variables

The following findings were obtained from the above analysis. When using professional competency of students enrolled in design programs as a benchmark, innovation competency is influenced by social skills, interdisplinary ability, and team cohesion in four stages. First, professional competency not only can directly influence innovation competency, but also can directly influence social skills and interdisplinary ability. Its influence on interdisplinary ability and social skills is higher than that on innovation competency. Thus, students who have better professional competency also have better interdisplinary behaviors and social status. Second, a student's professional competency influences his interdisplinary ability and social skills. A student's interdisplinary ability and social skills will eventually influence his innovation competency. Third, although a student's professional competency can influence his social skills, a student's social skills cannot directly influence his innovation competency. Fourth, high individual professional competency promotes a student's ideas on seeking interdisplinary knowledge and ability, resulting in the development of social skills The higher the maturity of a student's social skills, the more likely it will trigger his willingness toward team cohesion which will eventually generate a significant influence on his innovation competency. SEM hierarchical affecting path (thick curve line) is shown in **Figure 4**.

In summary, the following conclusion can be obtained by connecting paths mentioned above. From professional competency as the starting point, innovation competency is further influenced through intermediate influence of interdisplinary ability, social skills, and team cohesion. This result indicates that an individual's higher professional competency is more likely to lead him to seek learning opportunities through self-initiated interdisplinary behaviors, learn and conduct social communication with others in heterogeneous groups, show good team cohesion behaviors, and ultimately generate positive and significant influence of self innovation competency.

CONCLUSIONS AND SUGGESTIONS

In the process of cultivating design talents, design professional competency is the basis of all abilities of design talents. It is also regarded as an important benchmark of innovation competency by design talents. In designed and planned innovation process, besides professional competency, various social factors such as interdisplinary ability, social skills, and team cohesion are also important. The finding of this study can be summarized as follows:

1.   Professional competency significantly influences interdisplinary ability (0.55*), social skills (0.39*), and innovation competency (0.27*) simultaneously. Among them, the influence of professional competency on

interdisplinary ability is the strongest. Interdisplinary ability could also influence social skills (0.27*) and innovation (0.24*), with its influence effect on social skills being stronger. Social skills could also significantly influence team cohesion (0.84*) while team cohesion could significantly influence innovation competency (0.40*).

2.   Specifically, when considering these ability variables at the same time, the major effect path is professional competency influencing interdisplinary ability, followed by interdisplinary ability influencing social skills, social skills influencing team cohesion, and team cohesion influencing innovation competency. These indirect and hierarchical influencing effects fully reflect that innovation competency of design talents is based on deep professional competency while design professional competency will fully play out through interdisplinary ability when serving and assisting various types of industries. Due to extension of interdisplinary behaviors, designers must also improve their social communication skills and put more effort on promoting team cohesion. Interdisplinary innovation competency will be ultimately generated only through team cohesion.

3.   From this study, it is clear that design professionals generally need solid professional competency as well as interdisplinary abilities in order to effectively cooperate across their professional boundaries. They also need social skills to further communicate and build mutual trust with individuals from various professional fields. Team cohesion among members of an interdisplinary team can also be constructed through social skills of mutual understanding and communication. Innovation competency of design talents can only be fully expressed through team cohesion. From SEM hierarchical effect path results of this study, it is evident that when these abilities mentioned above are taken into account together, the play out of the innovation competency of design professionals is not affected by a single factor. Instead, it often continuously evolves and develops through interaction of multiple factors. This also echoes the description proposed by Bandura (1989) that in the process of interaction and exchange, benefits of individual factors may change, transform, or even disappear.

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