The imaginative factors of product design from design cases

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Abstract: In different stages of design process, designers must face a variety of design issues by utilizing different sorts of imagination to solve design problems. In the process of design education, especially in the concept generation stage, lectures always told students that what they saw is too less for defining deeper design problems for developing design ideas. The problems of this study are what designers and students see from design cases, and what the differences and similarities between designers and students in terms of imaginative factors. Thus, the expected results of this study will figure out the main design knowledge by semantic differential method. In the experiment, there are 20 imaginative products, which will be scored in terms of 10 imaginative dimensions by designers and students, respectively. The results will be analyzed for main factors of design knowledge for imaginative products. Moreover, the results will also compare the differences and similarities between designers and students in terms of imaginative factors. And, some key factors from design cases will also be organized at the end of this research.

Keywords: Product Design, Semantic Differential, Imaginative dimensions, Design process.

1. Introduction

Whether in the educational process for forming designers, or in well-educated designers' works, designers have to absorb new knowledge from design expertise, every-day life, different experience…etc., and to store them into particular categories of designers' brain. In an interview of a famous Japanese product designer, Chiaki Murata, he mentioned, "Imagination is like a big wall with different kinds of drawers, in which different sorts of design knowledge will be stored, respectively, based on their classifications. The process of imagination is to combine design knowledge from divergent classifications into solutions, which could solve encountered design problems. But if there is too little design knowledge in their drawers, designers could not propose problem-solved solutions by their imagination." However, how and what to get the knowledge from other designs, every-day life, and other experiences? How to store? And how to retrieve and combine suitable solutions to solve design problems? In product design domain, designer's imagination is a critical ability of the design process. There are quite a lot of researches from different viewpoints to explore the imagination, including personal characters, psychological cognitive factors, as well as external environmental factors ...and so on. Moreover, the design process could be divided into four phases: research and analysis, the idea conceiving, drawing and make-up, and optimization of manufacturing. In different stages of design process, designers must face a variety of design issues by utilizing different sorts of imagination to solve design problems. In the process of design education, especially in the concept generation stage, lectures always told students that what they saw is too less for defining deeper design problems for developing design ideas. Therefore, the problems of this study are what designers and students see

from design cases, and what the differences and similarities between designers and students in terms of imaginative factors. Thus, the expected results of this study will figure out the main design knowledge by semantic differential method. In the experiment, there are 20 imaginative products, which will be scored in terms of 10 imaginative adjectives by designers and students, respectively. The results will be analyzed for main factors of design knowledge for imaginative products. Moreover, the results will also compare the differences and similarities between designers and students in terms of imaginative factors. And, some key factors from design cases will also be organized at the end of this research.

2. Related research

Related research on imagination includes definitions of imagination, personal characteristics of imagination, and the four phases of the product design process.

2.1 Definitions of imagination

Imagination is a type of human thinking activity that is not restricted by any rule, nor is it confined by established thinking models. For comparing two types of activities, imagination and association, association is one thought linked to another when logical clues exist, but imagination may not require obvious clues. Tsai, an educator and researcher in Taiwan, suggested that imagination is a process of an individual who creates infinite mental visions anytime and anywhere to reach objectives. Objectives and processes are interrelated with the external environment [1]. Zhang proposed that imagination is the capability to form images; however, such images differ from those that are visible, and images formed by the imagination exceed existing experiences. However, image formation is not a necessary condition for imagination [2]. Zhang also stated that imagination varies from individual to individual. Some may form distinguished mental images, and others might see or hear things from the imagination or memory [2].

Certain scholars have developed different classifications for imagination. Tsai also divided imagination into four types: memory imagination, vivid imagination, fantasy imagination, and dream imagination. The first type, memory imagination, refers to people who connect and combine experiences and events from memory to new imaginary things; the second type, vivid imagination, refers to people who carefully review objects or vivid feelings of imagination; the third type, fantasy imagination, refers to people who meditate without objectives to create free and random ideas without requiring particular events or locations; the last, dream imagination, refers to "day dreaming," as a means for triggering imagination.

The public often confuses imagination with creativity; however, although closely related, differences exist. The creative thinking process perspective suggests that imagination is a thinking ability required for creativity because creativity requires not only ability but also assistance from the imagination. Thus, imagination does not necessarily equal creativity. Creative results must have novel and unique features; however, novelty and uniqueness do not necessarily provide knowledge or academic value.

With a wider interpretation for imagination, Craft, Chappell, and Twining (2008) proposed a concept of agency-focused 'possibility thinking' (or imagining), which may encourage widening participation in both access to and engagement in higher education [3]. Various scholars have indicated that the activities of the imagination can be classified into two different categories: reproductive imagination and creative imagination [6, 7].

Reproductive imagination is characterized by the capability to reproduce mental images described by others or images from less accurate recollections of reality. This type of imagination comprises four characteristics, namely crystallization, dialectics, effectiveness, and transformation [6]. With reproductive imagination, “crystallization” refers to an individual’s ability to express abstract ideas by using concrete examples [7, 8]. “Dialectics” refers to an individual’s ability to seek improvement by logically analyzing ideas [9]. “Effectiveness” refers to an individual’s ability to generate effective ideas regarding a goal [10]. “Transformation” refers to an individual’s ability to perform tasks by transforming what they have known across multiple fields of knowledge [11].

In contrast, creative imagination focuses on the attributes of initiation and originality. This type of imagination is composed of six characteristics, namely exploration, focusing, intuition, novelty, productivity and sensibility [6]. In regards to creative imagination, “exploration” refers to an individual’s ability to explore the unknown [12, 13]. “Focusing” refers to an individual’s ability to formalize ideas through focus [9, 12]. “Intuition” refers to an individual’s ability to generate immediate associations to the target [14, 15]. “Novelty” refers to an individual’s ability to create uncommon ideas [8, 16]. “Productivity” refers to an individual’s ability to productively generate ideas [12]. “Sensibility” refers to an individual’s ability to evoke feelings during the creative process [14, 17].

Imagination is the capability of forming images; however, such images differ from practical experienced objects [2]. Based on human mind theory, imagination is openness to new experiences. Moreover, the deformation capability of imagination is that of associating individual subjective feelings to change the appearance of objects through imagination; thus, the capability of imagination is the capability of subjective, internal feelings. Therefore, imagination capability has no direct relation to objective experience and logical thinking on generally established knowledge but is a product that belongs to the mental and spiritual world.

On contrary, childhood is considered the most imaginative stage because children’s thinking models are not yet formed, and they have fewer restrictions and rules on their imagination than adults. Therefore, the quality and quantity of imagination in children is rich. As mentioned, images are so-called image symbols, symbol functions, and are sometimes also called appearance functions [18]. Its representation type can be divided into tokens and symbols. To every child, the meanings these symbols represent have different interpretations according to individual experiences. Picture-description exercises can examine the significance of childhood life experiences. The theoretical basis and empirical methods of cognitive psychology include studies of perception, attention, and memory; such theories can explain preliminary thinking behaviour, which form the theoretical background of this study, including visual behaviour theories of visual attention, mental images, and sub-shapes.

In the visual cognition domain, people perceive everything through the retina but cannot simultaneously respond, think, and associate toward everything. However, because they can conduct searches within a certain scope, people selectively pay attention to an object, and further proceed with their cognitive activities. The visual behaviour of sight can be divided into two processes, “controlled” and “automatic.” The automatic process can be conducted at any time but the controlled process is orderly, "seeing" one thing and then seeing the next [19]. Therefore, a study further identified that the process of human visual cognition is first generated from “pre-attentive perception” to “stimuli,” and then selects objects through “voluntary control” and further focuses most attention to an object to generate a decision and response [20].

Through the visual cognition process, the brain conducts the imagination process to recognized objects, as described by Li [21]. The imagination level from low to high classification is divided into three types: re-creative imagination, creative imagination, and fantasy. People conduct re-creative imagination with experienced

phenomenon, including text, drawings, or melodies. For instance, to interpret various presentations of a literature process requires a certain ability to understand the literature and a rich memory of symbol knowledge. Based on the level of visual stimuli for a classification, Teng (1997) proposed "perceptive imagination," indicating that after perceiving an object, a previous mental image emerges naturally and the imagination process forms a new image [22]. The new image differs from the perceived object. However, similarities to the original features of a perceived object occur. Therefore, such an imaginative image cannot be self-generated without a visual object. The second type, "creative imagination," uses imagination without experienced objects. However, the creative imagination process requires matching with other factors, such as prototype enlightening, positive thinking, or inspiration. The creative imagination raised by Teng (1997) is not restricted by perceived visual objects but from an internal mechanism, such as feelings that trigger previously stored mental images or by recalling completely unrelated elements to conduct re-combination and permutation. The third type, "fantasy," is rambling, which involves no objectives, no process, and no results, but only empty thinking. Similar to the previous two types it requires a triggering media to trigger the imagination.

2.2 The product design process

The product design process can be divided into four phases: study and analysis, conceiving, drawing and mock-ups, and development and optimization. The main objectives of Phase 1, study and analysis, lie in studying and discussing design problems including formulating works, collecting data, analysing practical situations, and defining user target groups. Phase 2, conceiving, solves the problems raised in Phase 1 by considering various solutions, assessing, and determining a solution. In Phase 2, creative imagination is required to implement imagined objectives to a practical design concept. In Phase 3, drawing and mock-ups, the main objectives lie in evolving the solution obtained in Phase 2 into draft diagrams or draft mock-ups for analysis and evaluation. Phase 4, development and optimization, develops relevant product details, such as colour, material, and cost, conducts assessments and performs production [23].

Among the four design phases, imagination is the most necessary in Phase 2. The designer in this phase develops ideas by drawing sketches or drafts; therefore, this process is considered the "seeing-moving-seeing" process [24]. The designer in this process dialogues with the recognizable design information. Numerous studies have further considered sketching behaviour to be the most important behaviour in the idea development process, in which the designer communicates by using various sketches and drafts [25] (Purcell & Gero, 1998), by interaction of the perceived sketches. Suwa et al. (1998) concluded that drafts are not only a physical presentation of imagination in the design cognition process but also provide the designer clues regarding visual space from which to associate functional issues [26].

Goldschmidt (1991) indicated that sketches in the design process could be used to stimulate the imagination and associations of the designer [27]; therefore, in shape recognition, design thinking is considered through a figure-concept when the designer draws a sketch. Thus, the sketching process is not only depicting mental images but also triggering the imagination through visual display. Visual behaviour includes two types of behaviours, "seeing as" and "seeing that." Through drawing, the designer re-interprets through visual cognition or searches for related figures stored in his or her long-term memory, thereby emerging with new interpretations or triggering unexpected design issues [28]. Therefore, the factors affecting the results of drafts likely include perception and

recognition capabilities, accumulated drawings and related knowledge from past design experiences, draft presentation capabilities, and other knowledge association capabilities: this is imagination.

3. Methodology and steps

In Suwa and Tversky's research, they pointed out that experts have higher interpretation and lower fixation on idea generation due to their much more experience than students had. The design experiences of experts include the design activities and applying different design cases into new ideas [28]. Therefore, in order to investigate the difference between designers and students from looking at imaginative design cases, especially imaginative adjectives and the knowledge learned from cases, the steps of this research are following by the collection of imaginative cases, the imaginative adjectives and Likert scale, and the experiments of designers and students. Finally, the analysis of imaginative design cases will be illustrated at the end of this research.

3.1 the design cases with imagination

There are no objective criteria for determining the imaginative product design cases, which will be used in this research. Thus, we are randomly collecting and ranking top 20 imaginative cases by research assistants in this project. Figure 1 shows the 20 design cases with imagination.

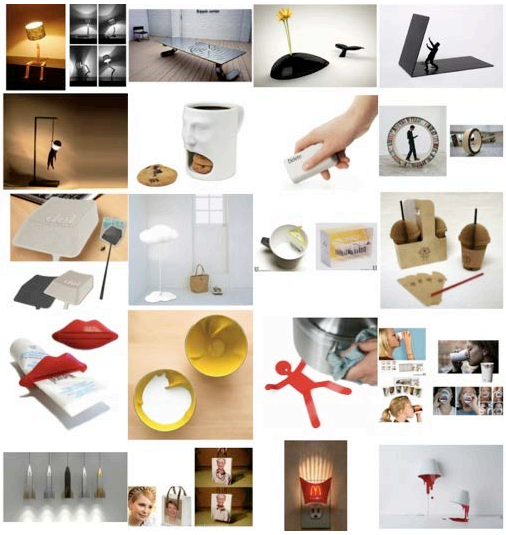


Figure.1 The 20 design cases with imagination Sample

3.2 the imaginative adjectives and Likert scale

Besemer et al. (1999) proposed the Create Product Semantic Scale (CPSS), which consists of three dimensions: 1. Novelty: including surprising and original; 2. Resolution: containing logical, useful, valuable, and understanding; 3. elaboration and synthesis: containing organic, sell-crafted, and elegant. Moreover, Sternberg (1998) proposed that a creative product must contain the characteristics of two categories: originality and usefulness. The Originality contains new, novel, and original; and the Useful is valuable, appropriate, significant, adaptive, and utility, which are related solving design problems. However, the main purpose for referring imaginative design cases is to obtain some sorts of design knowledge for generating new design ideas by transforming or combining referred cases into new design concepts to solve new design problems. Therefore, the imaginative dimensions of assessment in this study is design knowledge oriented, such as novel-shape in form,

innovative concepts, deliberated mechanic, special materials, vivid color, purchase intention, suitable for other objects, usage scenarios, seeing similar products, and imaginative space when using it.

In 1990, Osgood, a US psychologist, originated semantic differential (SD) method [29], which widely used in Kansei Engineering research area. With this method, the subjects receive various level of external stimuli, or the feelings to a product, compiling various adjective groups to conduct SD method questionnaire tests. By doing so, the subjects could choose their internal feelings by employing statistical analysis to convert into quantified data. For instance, Wang [30] employed qualitative and quantitative analysis to describe the shape of bicycles, inducing product design principles of various feeling images. In addition, Zhai et al. [31] also adopted this method to convert complex feeling factors into quantitative design rules for enhancing user satisfaction to specific products. In addition, this method has also been applied on the assessment and analysis of product feeling images, for finding out the relationship among product design factors and feelings, to conduct cell phone design. By applying SD method, this study conducts a questionnaire test for professional designers and students to score 10 adjective groups of possible imagination triggering factors. With Likert scale of 7 equivalent portions (table 1), there are four different design phases in the questionnaire test.

Table.1 imaginative dimensions of assessment

	3	2	1	0	1	2	3	
Q1 novel-shape in form	☐	☐	☐	☐	☐	☐	☐	boring-shape in form
Q2 innovative concepts	☐	☐	☐	☐	☐	☐	☐	old concepts
Q3 deliberated mechanic	☐	☐	☐	☐	☐	☐	☐	awkward mechanic
Q4 special materials	☐	☐	☐	☐	☐	☐	☐	normal materials
Q5 vivid color	☐	☐	☐	☐	☐	☐	☐	dull color
Q6 purchase intention	☐	☐	☐	☐	☐	☐	☐	no purchase intention
Q7 suitable for other objects	☐	☐	☐	☐	☐	☐	☐	not suitable for other objects
Q8 usage scenarios	☐	☐	☐	☐	☐	☐	☐	useless scenarios
Q9 seeing similar products	☐	☐	☐	☐	☐	☐	☐	never seeing similar products
Q10 imaginative space when using it	☐	☐	☐	☐	☐	☐	☐	no imaginative space when using it

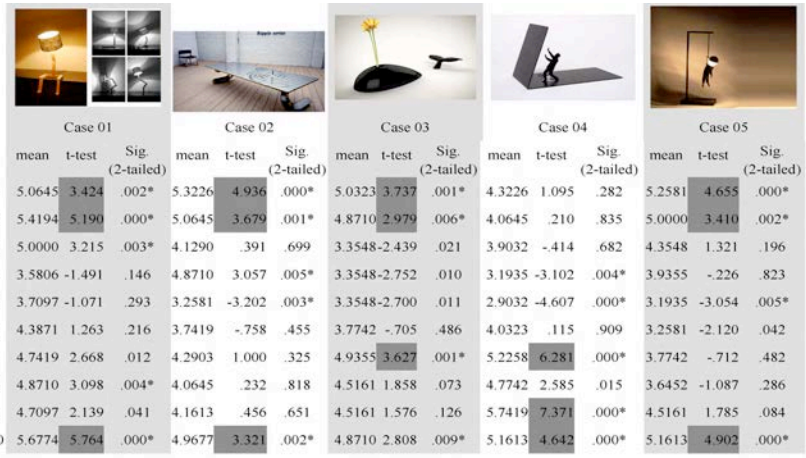
4. The analysis of experiment and discussion

Designers and students in 2nd-grade of product design department conducted the questionnaire experiment of imaginative adjective. Each participant has to evaluate 20 design cases in terms of 10 design dimensions. The following sections in 4.1 will be the One-Sample T-Test to test the adjectives assessment of imaginative design cases from designers. The 4.2 is also One-Sample T-Test to test students' adjective assessment of imaginative design cases. Finally, the section 4.3 is comparing significant similarities and differences between designer and students in terms of adjective factor.

4.1 The designers' evaluation of imaginative dimensions

Table 2 shows single sample T-test of design cases 1-5 from designers, in which the test value is 4, and * represents the level of significance is < 0.01. Moreover, the dark gray background in table shows the top three values of adjectives in t-test. In case 1, 2, and 5, the top three dimensions of imagination are Q1 "novel-shape in form", Q2 "innovative concepts", and Q10 "imaginative space when using it". Moreover, the case 3 is similar to case 1, 2, and 5 in Q1 "novel-shape in form", Q2 "innovative concepts", but different from Q7 "suitable for other objects". On contrary, top three dimensions of case 4 are quite different than case 1, 2, 3, and 5. They are Q9 "seeing similar products", Q7 "suitable for other objects", and Q10 "imaginative space when using it".

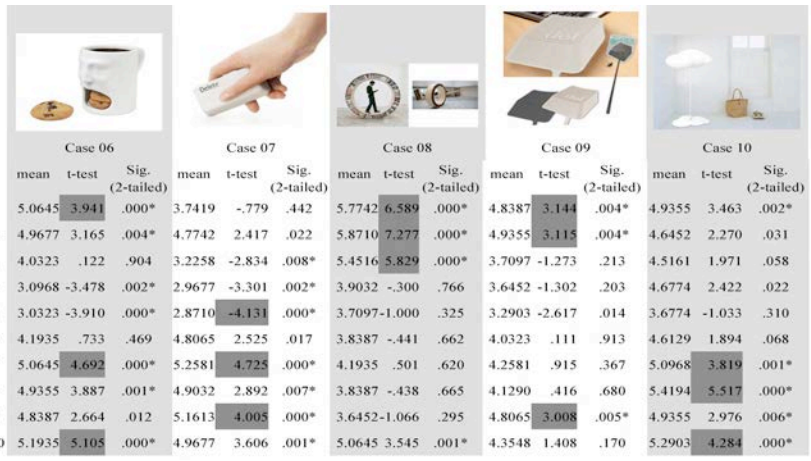
Table.2 Single sample T-test of design case 1-5 from designer



	Case 01			Case 02			Case 03			Case 04			Case 05		
	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)
Q1	5.0645	3.424	.002*	5.3226	4.936	.000*	5.0323	3.737	.001*	4.3226	1.095	.282	5.2581	4.655	.000*
Q2	5.4194	5.190	.000*	5.0645	3.679	.001*	4.8710	2.979	.006*	4.0645	.210	.835	5.0000	3.410	.002*
Q3	5.0000	3.215	.003*	4.1290	.391	.699	3.3548	-2.439	.021	3.9032	-.414	.682	4.3548	1.321	.196
Q4	3.5806	-1.491	.146	4.8710	3.057	.005*	3.3548	-2.752	.010	3.1935	-3.102	.004*	3.9355	-.226	.823
Q5	3.7097	-1.071	.293	3.2581	-3.202	.003*	3.3548	-2.700	.011	2.9032	-4.607	.000*	3.1935	-3.054	.005*
Q6	4.3871	1.263	.216	3.7419	-.758	.455	3.7742	-.705	.486	4.0323	.115	.909	3.2581	-2.120	.042
Q7	4.7419	2.668	.012	4.2903	1.000	.325	4.9355	3.627	.001*	5.2258	6.281	.000*	3.7742	-.712	.482
Q8	4.8710	3.098	.004*	4.0645	.232	.818	4.5161	1.858	.073	4.7742	2.585	.015	3.6452	-1.087	.286
Q9	4.7097	2.139	.041	4.1613	.456	.651	4.5161	1.576	.126	5.7419	7.371	.000*	4.5161	1.785	.084
Q10	5.6774	5.764	.000*	4.9677	3.321	.002*	4.8710	2.808	.009*	5.1613	4.642	.000*	5.1613	4.902	.000*

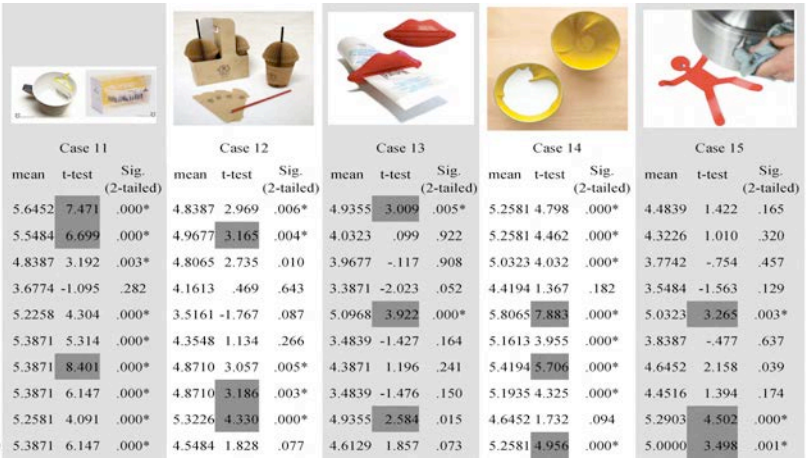
Table 3 shows the results of the t-test of design cases 6-10, in which there is not much intersection of the top three dimensions. But Q1 “novel-shape in form” is still in top-3 of case 6, 8, and 9; Q7 “suitable for other objects” is also significant in 3 cases (case 6, 7, and 10); Q2 “innovative concepts” is still significant in 2 cases (case 8 and 9); Q10 “imaginative space when using it” is also significant in 2 cases (case 6 and 10). Interestedly, the top-3 dimensions of Case 7 are Q5 “vivid color (negative)”, Q9 “seeing similar products”, and Q7 “suitable for other objects”, in which might indicate Case 7 is less imaginative than other cases.

Table.3 Single sample T-test of design case 6-10 from designer



	Case 06			Case 07			Case 08			Case 09			Case 10		
	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)
Q1	5.0645	3.941	.000*	3.7419	-.779	.442	5.7742	6.589	.000*	4.8387	3.144	.004*	4.9355	3.463	.002*
Q2	4.9677	3.165	.004*	4.7742	2.417	.022	5.8710	7.277	.000*	4.9355	3.115	.004*	4.6452	2.270	.031
Q3	4.0323	.122	.904	3.2258	-2.834	.008*	5.4516	5.829	.000*	3.7097	-1.273	.213	4.5161	1.971	.058
Q4	3.0968	-3.478	.002*	2.9677	-3.301	.002*	3.9032	-.300	.766	3.6452	-1.302	.203	4.6774	2.422	.022
Q5	3.0323	-3.910	.000*	2.8710	-4.131	.000*	3.7097	-1.000	.325	3.2903	-2.617	.014	3.6774	-1.033	.310
Q6	4.1935	.733	.469	4.8065	2.525	.017	3.8387	-.441	.662	4.0323	.111	.913	4.6129	1.894	.068
Q7	5.0645	4.692	.000*	5.2581	4.725	.000*	4.1935	.501	.620	4.2581	.915	.367	5.0968	3.819	.001*
Q8	4.9355	3.887	.001*	4.9032	2.892	.007*	3.8387	-.438	.665	4.1290	.416	.680	5.4194	5.517	.000*
Q9	4.8387	2.664	.012	5.1613	4.005	.000*	3.6452	-1.066	.295	4.8065	3.008	.005*	4.9355	2.976	.006*
Q10	5.1935	5.105	.000*	4.9677	3.606	.001*	5.0645	3.545	.001*	4.3548	1.408	.170	5.2903	4.284	.000*

Table.4 Single sample T-test of design case 11-15 from designer



	Case 11			Case 12			Case 13			Case 14			Case 15		
	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)
Q1	5.6452	7.471	.000*	4.8387	2.969	.006*	4.9355	3.009	.005*	5.2581	4.798	.000*	4.4839	1.422	.165
Q2	5.5484	6.699	.000*	4.9677	3.165	.004*	4.0323	.099	.922	5.2581	4.462	.000*	4.3226	1.010	.320
Q3	4.8387	3.192	.003*	4.8065	2.735	.010	3.9677	-.117	.908	5.0323	4.032	.000*	3.7742	-.754	.457
Q4	3.6774	-1.095	.282	4.1613	.469	.643	3.3871	-2.023	.052	4.4194	1.367	.182	3.5484	-1.563	.129
Q5	5.2258	4.304	.000*	3.5161	-1.767	.087	5.0968	3.922	.000*	5.8065	7.883	.000*	5.0323	3.265	.003*
Q6	5.3871	5.314	.000*	4.3548	1.134	.266	3.4839	-1.427	.164	5.1613	3.955	.000*	3.8387	-.477	.637
Q7	5.3871	8.401	.000*	4.8710	3.057	.005*	4.3871	1.196	.241	5.4194	5.706	.000*	4.6452	2.158	.039
Q8	5.3871	6.147	.000*	4.8710	3.186	.003*	3.4839	-1.476	.150	5.1935	4.325	.000*	4.4516	1.394	.174
Q9	5.2581	4.091	.000*	5.3226	4.330	.000*	4.9355	2.584	.015	4.6452	1.732	.094	5.2903	4.502	.000*
Q10	5.3871	6.147	.000*	4.5484	1.828	.077	4.6129	1.857	.073	5.2581	4.956	.000*	5.0000	3.498	.001*

Table 4 shows the results of the t-test of design cases 11-15 from designers. There are less significant dimensions in top-3, but Q5 “vivid color” and Q9 “seeing similar products” is still significant in 3 cases.

Table 5 shows the t-test results of case 16-20 from designers. Q5 “vivid color” and Q10 “imaginative space when using it” are quite significant in all 5 cases. Others are Q1 “novel-shape in form” (case 17 and 20), Q2 “innovative concepts” (case 19), Q4 “special materials” (case 16), and Q9 “seeing similar products” (case 18).

Table.5 Single sample T-test of design case 16-20 from designer





	Case 16			Case 17			Case 18			Case 19			Case 20		
	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)
Q1	4.6774	2.491	.018	5.0323	4.246	.000*	5.1935	4.667	.000*	5.2258	4.553	.000*	5.6774	7.822	.000*
Q2	4.8065	2.843	.008*	5.0645	3.679	.001*	5.3871	4.873	.000*	5.5806	6.247	.000*	5.0000	3.873	.001*
Q3	3.5161	-1.909	.066	4.8710	3.098	.004*	4.7419	2.745	.010	5.0968	3.437	.002*	5.1290	4.541	.000*
Q4	2.6452	-5.201	.000*	4.4516	1.327	.194	4.1613	.460	.649	3.8387	-.482	.633	4.4194	1.512	.141
Q5	5.3871	4.939	.000*	5.0645	4.127	.000*	5.3548	5.044	.000*	5.4516	5.157	.000*	5.6452	7.642	.000*
Q6	4.7419	2.198	.036	4.3871	1.072	.292	4.2581	.744	.463	4.3871	1.129	.268	4.1290	.373	.712
Q7	5.0645	4.267	.000*	4.8710	2.777	.009*	4.7419	2.386	.024	4.5806	1.937	.062	4.6774	2.422	.022
Q8	5.1290	4.131	.000*	4.9677	3.606	.001*	4.4516	1.340	.190	4.6129	1.787	.084	4.6774	2.299	.029
Q9	5.1935	4.387	.000*	4.3226	1.068	.294	5.5484	6.218	.000*	3.7419	-.839	.408	5.3226	5.091	.000*
Q10	5.5161	5.459	.000*	5.0645	3.941	.000*	5.5484	5.740	.000*	5.3226	5.353	.000*	5.6129	7.470	.000*

4.2 The students’ evaluation of imaginative dimensions

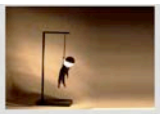
Similar to designers’ experiment, Students also conduct a questionnaire with 20 design cases based on 10 imaginative dimensions. There are 39 students who are in the 2nd-grade of Industrial Design Department. The results of the assessment will be tested by One-Sample T-Test to investigate the design knowledge of imaginative dimensions from design cases.

Table 6 shows single sample T-test of design cases 1-5 from students, in which the test value is 4, and * represents the level of significance is < 0.01. Moreover, the dark gray background in table shows the top three values of adjectives of each case by t-test. In case 1, 2, 3, and 5, the top three dimensions of imagination are Q1 “novel-shape in form”, Q2 “innovative concepts”, and Q10 “imaginative space when using it”. On contrary, case 4 is similar to case 1, 2, 3, and 5 with Q1 “novel-shape in form” and Q10 “imaginative space when using it”, but is different from Q9 “seeing similar products”, in which the case 4 might be seen as similar ideas from other cases.

Table.6 Single sample T-test of design case 1-5 from student



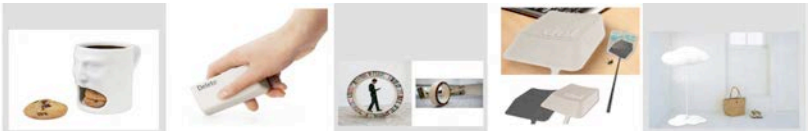




	Case 01			Case 02			Case 03			Case 04			Case 05		
	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)
Q1	5.5385	9.913	.000*	5.7436	13.865	.000*	5.3077	5.357	.000*	5.0769	5.502	.000*	5.7436	11.276	.000*
Q2	5.5128	7.664	.000*	5.5385	10.203	.000*	5.2051	4.992	.000*	4.4615	1.798	.080	5.4103	6.423	.000*
Q3	5.1282	4.906	.000*	4.7949	3.756	.001*	4.2051	.928	.359	4.3333	1.466	.151	4.5385	2.683	.011
Q4	3.3846	-2.807	.008*	4.5897	2.374	.023	3.8974	-.530	.599	3.3590	-2.709	.010*	3.8462	-.813	.421
Q5	3.4359	-2.913	.006*	3.5641	-1.793	.081	3.6154	-2.029	.049	2.9744	-4.622	.000*	3.3846	-2.889	.006*
Q6	4.4103	1.709	.096	4.2821	.960	.343	4.5385	1.780	.083	4.5128	1.902	.065	4.0000	.000	1.000
Q7	4.7179	3.017	.005*	4.2308	.884	.382	5.0513	4.773	.000*	4.9487	3.852	.000*	4.3846	1.754	.087
Q8	4.7179	2.852	.007*	3.7692	-.893	.377	4.7949	4.076	.000*	4.8974	4.141	.000*	4.1282	.493	.625
Q9	5.0000	3.775	.001*	3.6154	-1.204	.236	4.4103	1.538	.132	5.4615	6.225	.000*	4.7436	2.762	.009*
Q10	6.2051	17.953	.000*	5.7692	8.726	.000*	5.8974	10.818	.000*	5.8462	11.369	.000*	5.6667	7.234	.000*

Table 7 shows single sample T-test of design cases 6-10 from students. Similar to Table 6, the top-three dimensions with Q1 “novel-shape in form”, Q2 “innovative concepts”, and Q10 “imaginative space when using it” are cases 6, 8, and 9. And case 10 still has 2 dimensions (Q1 “novel-shape in form and Q10 “imaginative space when using it”), but the third is Q7 “suitable for other objects”. Interestedly, the top-three of case 7 are Q5 “vivid color”, Q7 “suitable for other objects”, and Q8 “usage scenarios”, in which Q5 “vivid color” is negative.

Table.7 Single sample T-test of design case 6-10 from student



	Case 06			Case 07			Case 08			Case 09			Case 10		
	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)
Q1	5.4872	7.061	.000*	3.6154	-1.550	.129	5.9231	10.601	.000*	4.9487	4.432	.000*	5.1282	5.590	.000*
Q2	5.2564	5.569	.000*	5.0513	4.912	.000*	6.1795	15.384	.000*	4.8462	3.864	.000*	4.7692	3.858	.000*
Q3	4.7692	3.333	.002*	3.2051	-3.332	.002*	5.2564	5.569	.000*	3.7179	-1.215	.232	4.4615	1.966	.057
Q4	3.4359	-2.113	.041	3.0513	-4.086	.000*	3.8462	-.583	.563	3.4103	-2.211	.033	4.3077	1.290	.205
Q5	3.3077	-3.916	.000*	2.8205	-5.600	.000*	4.1282	.531	.598	3.3333	-3.242	.002*	3.6923	-1.275	.210
Q6	4.6154	2.084	.044	4.2308	.851	.400	4.3590	1.096	.280	3.5385	-2.042	.048	4.4359	1.547	.130
Q7	5.0769	4.732	.000*	5.1795	5.085	.000*	4.8974	3.497	.001*	4.1026	.448	.657	4.8205	4.157	.000*
Q8	5.0769	4.928	.000*	5.3333	6.701	.000*	4.3333	1.254	.217	4.3590	1.555	.128	4.6667	3.143	.003*
Q9	4.7436	2.460	.019	4.5385	1.864	.070	3.4615	-1.729	.092	4.5897	2.349	.024	4.7949	3.085	.004*
Q10	5.6154	6.121	.000*	4.6667	2.509	.017	5.4359	6.120	.000*	4.8462	3.306	.002*	5.3590	6.593	.000*

Table 8 shows the t-test of design cases from 11-15. The results indicate there are no obvious results in top-three dimensions, but Q1 “novel-shape in form” is still in top-three of 4 cases, case 11, 12, 13, and 14.

Table.8 Single sample T-test of design case 11-15 from student

	Case 11			Case 12			Case 13			Case 14			Case 15		
	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)
Q1	5.5385	8.402	.000*	5.6410	9.027	.000*	5.3590	7.188	.000*	5.5385	9.401	.000*	5.1282	4.906	.000*
Q2	5.8462	11.369	.000*	5.4103	6.515	.000*	4.9744	4.516	.000*	5.1538	4.604	.000*	5.0256	4.052	.000*
Q3	5.2821	6.273	.000*	5.4872	7.810	.000*	4.6410	2.587	.014	5.5641	8.728	.000*	4.5128	2.268	.029
Q4	4.0000	.000	1.000	3.9487	-.169	.866	4.0769	.352	.727	4.1538	.642	.525	4.0513	.204	.840
Q5	5.1282	5.685	.000*	3.8205	-.816	.420	5.3333	8.255	.000*	5.5385	8.576	.000*	5.4872	9.081	.000*
Q6	5.6410	8.520	.000*	4.2564	.797	.430	3.8462	-.502	.618	5.1026	3.849	.000*	4.2564	.903	.372
Q7	5.4359	7.551	.000*	5.0000	4.668	.000*	4.8205	3.334	.002*	5.2051	5.972	.000*	4.8718	4.320	.000*
Q8	5.1538	4.760	.000*	5.3333	7.358	.0008	4.4615	1.762	.086	5.1026	5.593	.000*	5.0000	5.804	.000*
Q9	4.5385	1.834	.074	4.8718	2.962	.005*	5.0000	4.416	.000*	4.9744	3.382	.002*	5.1795	4.546	.000*
Q10	5.6410	7.109	.000*	5.0000	5.339	.000*	5.0769	4.304	.000*	5.6410	7.837	.000*	5.7949	12.540	.000*

In the Single sample T-test of design case 16-20 from student, the imaginative dimensions of Q1 “novel-shape in form”, Q2 “innovative concepts”, and Q10 “imaginative space when using it” are still very high in case 16-20. But another popular imaginative dimension is Q5 “vivid color”.

Table.9 Single sample T-test of design case 16-20 from student





	Case 16			Case 17			Case 18			Case 19			Case 20		
	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)	mean	t-test	Sig. (2-tailed)
Q1	5.3077	5.357	.000*	5.0256	4.443	.000*	5.1282	5.178	.000*	5.5128	8.096	.000*	6.0513	17.703	.000*
Q2	5.7179	8.692	.000*	5.1538	4.995	.000*	5.4615	7.826	.000*	5.7179	8.692	.000*	5.7692	11.525	.000*
Q3	4.4615	1.712	.095	4.6410	2.813	.008*	4.7949	3.597	.001*	4.9487	3.941	.000*	5.4359	6.626	.000*
Q4	3.2051	-3.055	.004*	4.2564	1.185	.244	3.9744	-.107	.915	4.1538	.723	.474	4.6923	3.012	.005*
Q5	5.8718	10.583	.000*	4.7692	3.468	.001*	4.9231	3.906	.000*	5.6410	8.370	.000*	5.9231	11.890	.000*
Q6	5.2821	5.040	.000*	4.0513	.169	.866	4.5385	1.849	.072	4.8205	2.911	.006*	5.1026	4.341	.000*
Q7	5.3333	6.106	.000*	4.4103	1.729	.092	4.6667	2.610	.013	4.6667	2.245	.031	5.0000	4.416	.000*
Q8	5.6923	8.532	.000*	4.4615	1.990	.054	4.7436	2.712	.010*	4.3590	1.246	.220	4.6410	2.742	.009*
Q9	5.2821	4.507	.000*	4.5385	2.056	.047	4.8718	3.224	.003*	4.6923	2.538	.015	5.3590	5.313	.000*
Q10	6.3590	20.848	.000*	5.1282	4.379	.000*	6.0769	11.950	.000*	5.5128	6.217	.000*	5.7692	7.869	.000*

4.3 the comparisons between designers and students in imaginative dimensions

The significance of top-three imaginative dimensions from the t-test of both designers and students have been reorganized in Table 10. The significant adjectives from designers marked as “d”; while significant adjectives from students marked as “s”. And the quantity of significances from imaginative adjectives (Q1 to Q10) show at the right side of table 10 by designers (quantity) / students (quantity); while significant numbers of design cases 1-20 are at the bottom of table 10.

From the results of designers, 6 more influential imaginative dimensions are Q1 “novel-shape in form” (16), Q10 “imaginative space when using it” (16), Q2 “innovative concepts” (15), Q5 “vivid color” (14), Q9 “seeing similar products” (11), and Q7 “suitable for other objects” (10). On the other side of students, there are 8 more influential imaginative dimensions, such as Q1 “novel-shape in form” (19), Q2 “innovative concepts” (19), Q10 “imaginative space when using it” (19), Q5 “vivid color” (14), Q7 “suitable for other objects” (14), Q3 “deliberated mechanic” (12), Q8 “usage scenarios” (12), and Q9 “seeing similar products” (11). On contrary, both designers and students considered Q4 “special materials” and Q6 “purchase intention” as related less imaginative dimensions.

Table.10 The comparsions of imaginative dimensions bewteen designers and students

	Case 01	Case 02	Case 03	Case 04	Case 05	Case 06	Case 07	Case 08	Case 09	Case 10	Case 11	Case 12	Case 13	Case 14	Case 15	Case 16	Case 17	Case 18	Case 19	Case 20	
Q1	d/s	d/s	d/s	s	d/s	d/s		d/s	d/s	d/s	d/s	d/s	d/s	d/s	s	s	d/s	d/s	d/s	d/s	16/19
Q2	d/s	d/s	d/s		d/s	d/s	s	d/s	d/s	s	d/s	d/s	s	d/s	s	d/s	d/s	d/s	d/s	d/s	15/19
Q3	d/s	s				s	d/s	d/s			d/s	s		d/s			d/s	s	d/s	d/s	8/12
Q4	s	d		d/s		d	d/s									d/s				s	5/2
Q5	s	d		d/s	d/s	d/s	d/s		s		d/s		d/s	d/s	d/s	d/s	d/s	d/s	d/s	d/s	14/14
Q6											d/s			d/s		s			s	s	2/5
Q7	s		d/s	d/s		d/s	d/s	s		d/s	d/s	d/s	s	d/s	s	d/s	d/			s	10/14
Q8	d/s		s	s		d/s	d/s			d/s	d/s	d/s		d/s	s	d/s	d/			s	9/12
Q9	s			d/s	d/s		d		d	d/s	d	d/s	s	s	d/s	d/s		d/s		d/s	11/11
Q10	d/s	d/s	d/s	d/s	s	d/s	d/	d/s	s	d/s	d/s	s	s	d/s	d/s	d/s	d/s	d/s	d/s	d/s	16/16
	5/9	5/4	4/5	5/7	4/5	7/7	7/6	4/5	3/4	5/6	9/8	5/7	2/6	8/9	3/7	7/9	7/5	5/6	5/6	6/10	

For analyzing the quantity of imaginative dimensions of 20 cases in Table 10, vertically, there are 6 cases (3, 5, 8, 9, 13, and 15) less than or equal to 4 significant imaginative dimensions from designers' result; while with less than or equal to 4 significant imaginative dimensions, there are only 2 cases (2 and 9). However, with less than or equal to 5 significant imaginative dimensions, there are 6 cases (2, 3, 5, 8, 9, and 17). It shows that case 3, 5, 8, and 9 are less imaginative dimensions than other cases in terms of both designers and students. Furthermore, another result shows that students have lower level of significant imaginative dimensions than designers have, because students have higher significant dimensions in the experiment.

5. Conclusions

By using semantic differential method in the imaginative dimensions in assessment, both designers and students have considered 6 more significant imaginative dimensions from design cases, which are "novel-shape in form", "imaginative space when using it", "innovative concepts", "vivid color", "seeing similar products", and "suitable for other objects". The first dimension of both designers and students is "novel-shape in form" because the shape of products is the first impression while looking at design cases. Then, the second factor is "imaginative space when using it", which means that they may be considered the novel-shapes as imaginative shapes after cognitive process in their mind. Moreover, "innovative concepts", "vivid color", and "suitable for other objects" are three factors for both designers and students to consider as key factors for triggering imaginations. Finally, the "seeing similar products" is showing whether both designers and students saw similar products before the experiment.

Moreover, both designers and students have 2 less important dimensions, which are "deliberated mechanic" and "usage scenarios", for triggering imagination. On contrary, "special materials" and "purchase intention" of imaginative dimensions are not related to imaginative design cases from viewpoint of both designers and students.

In the present study, however, the results obtained from imaginative dimensions of designers and students are only what they saw from design cases, and we could not confirm whether the designers and students learned new design knowledge for developing new ideas to solve new design problem. That would be the limitations and future of this research.

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