

Exploring the Impact of Surrounding Factors on Design Imagination*

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Designing is a problem-solving process, which the professional designers need for higher imagination and creativity to carry on the problem-solving. In the research, we aim to develop a training program which helps designers to enhance the mechanism of imagination during industrial designing. First, imagination and creativity theories, design cognition and thinking, design methods and techniques are being explored by way of a literature survey in order to gain a deeper understanding of the structure and mechanism of human imagination. Research methods for design thinking, the pattern of imagination, the factors that affect the imagination, and developing techniques and teaching methods for imagination, have then been inducted for further studies. We then explored the forty international professional designers using secondary interview data. The data was analyzed based on the abstract and concrete, the activities, location, etc., the source of imaginative inspiration for the designers were categorized. The results showed that two designers using an abstract way of generating an imagination and inspiration mode accounted for 58%, using concrete objects to achieve the source of inspiration accounts for 42%. Indoor activities accounted for 64% inspiration of the factors of environmental stimulation, 36% were outdoor activities. Therefore, for the learning strategy, we conclude that enhancing the cognitive and experience-driven skills to gain insights from a variety of life experiences, expands the implicit design knowledge for the cognitive activities to trigger the imagination in the design thinking of designing.

Keywords: imagination; design thinking; industrial design; experiential

1. Introduction

Albert Einstein once said “Imagination is more important than knowledge. The human civilization originated from imagination and then creativity.” Designing is a problem-solving process that requiring professional designers’ higher imagination and creativity. Wallace [1] suggests that designers usually spend some time in “imagining” designing solutions after receiving instructions during such a process, followed by thinking of how to design. “Thinking” is the recursive process of questioning and answering, which eventually approaches design goals or objectives [2]. This process undergoes “exploration and production” for design proposals. In other words it uses the process of “design imagination” to execute problem-solving. Theory-based literature [3–5] reveals that the factors directly or indirectly affecting design thinking and development in a commercial environment include not only design skills, expertise of knowledge, and variables hidden in the overall design process, but also project experience, information variance and introduction, and customer relationship. These factors somewhat affect the design imagination and creativity process. The discrepancy in design behaviors or characteristics of different designers as well as the diversity in cognition and statements will lead to different thinking and produce dissident design outcomes [6].

How does the professional designers’ imagina-

tion play in thinking and problem-solving through “exploration & production?” We may ask where the specific problem-solving and content of design imagination comes from. Do designers think of possible solutions immediately or maintain the uncertainty in solutions? What is the content and process of imagination? Will the designers adopt a systematic approach for design thinking? Moreover, in executing design project management, have the clients or proprietors provided explicit instructions? Have the designers fully grasped the client’s expectation? Is a professional designer knowledge adequate for projects that have never been executed? Will designers adopt a more systematic approach for executing design projects? How do designers accomplish their mental development model and information processing strategy? How does the imagination mechanism work in the design process? How do designers achieve design objectives or the optimal services for clients through imagination and the creativity process? How do designers validate the proper decision to achieve the clients’ goals or satisfy consumers with their preferred demand and desire? The aforementioned questions are the most important core values and issues for the designer.

In the research, we aim to carry out the analysis and preparation of a structured process and the theoretical framework of imagination. We’ll also carry out the cognition process of product designing

through a literature review of the imagination and design thinking. Moreover, the research methods include: design thinking, the pattern of imagination, the factors that affect imagination, and developing techniques and teaching methods for imagination. We then explored forty international professional designers using secondary interviewed data. The data were analyzed based on the abstract and concrete methods, activities, and location, etc. to induce and analyze the source of imaginative inspiration for those designers. We intend to enhance the mechanism of the operation of imagination for design cognition through helping product design education to develop proper teaching strategies.

2. Literature review

2.1 Definition of imagination

Imagination is the free and analogical thinking that has operated an individuals' prior experience under specific situations. It is applied to conform to context, suit reality and find new meaning for specific goals [7–9]. The psychological definition for imagination, as suggested by Murray [10], indicates that imagination is not limited to the integration of the existing image. It also includes non-existent entities (such as human, incidents and objects) [11]. *Zhang's Dictionary of Psychology* [12] explains imagination as: "Imagination refers to the process of consolidating the experience and imagery of memories to generate new images." The *Comprehensive Dictionary of Psychology* also indicates that: "Imagination is the psychological process that processes, reforms and reconstructs existing images in the brain to form new images." The former two explanations consider that imagination involves the operation of psychological dynamics. The operation restructures existing mental images or experiences to form new images in the brain. The difference lies in that one emphasizes the comprehensive organization of existing imagery while the other specifically suggests the operation including processing, restructuring or reforming existing imagery. Finke et al. [11] suggest that imagination involves the operation of cognition and is guided by specific objectives that may be explicit or implicit. For example, through imagination, poetry, stories or painting can be created in art, and theories or models can be formulated in science. Imagination is highly related but not limited to existing mental images. The operation of imagination is far more complex than recalling mental images. It is actually one type of creation.

Other than the abovementioned conceptual definition of imagination, researchers also attempt to categorize imagination according to the processes

and functions involved. For example: Unwin and McKellar [13] categorize imagination as memory images and imagination images. Memory images refer to the integration of existing images coming from life experience, while imagination images refer to the creation of non-existing images [11]. According to different functions, Zhang [12] categorizes imagination into "expected imagination, "reproductive imagination" and "creative imagination". Tu [14] analyzes from the perspective of art domain, advocating imagination to include "reproductive imagination" and "creative imagination." By analyzing the development of creativity in children, Dong [15] suggests that imagination can be divided into "reproductive imagination" and "creative imagination", based on the novelty, independence and creativity of its content.

Apparently, scholars reach consistency in their categorization of imagination, whereas the majority of scholars accord with imagination comprising "reproductive imagination" and "creative imagination." "Reproductive imagination" refers to the reorganization of prior experience to reproduce them in memories because reproductive imagination only exists in memories and is hence known as memory imagination. "Creative imagination" refers to restructuring of prior experience in an attempt to surpass prior experience and to generate new concepts. Creative imagination is a new concept based on old questions and is therefore addressed as constructive imagination. Dong [15] suggests that the psychological process that does not follow the existing description but follows the specific purpose and tasks in the brain for independent restructuring, processing and creating new image may carry creative imagination. On the other hand, "expected imagination" refers to the imagination of possible occurrences in the future or the imagination of how to achieve expected purposes. For example, rehearsal aims to cope with the advent of a future interview or other practical plans for social interaction. Under the definition, "expected imagination" emphasizes the prediction and planning for the outcome that has not yet taken place, whereas the dimension of such imagination falls beyond the concerns of the researcher. Hence, the identification of the categorization and definition for "reproductive imagination" and "creative imagination" by prior researchers will be carried out further [12, 15].

The design creativity and invention phase starts with the imagination phase. We discover from the analysis on design thinking and the preparation of imagination that the pre-imagination phase of inspiration for design thinking falls into the period of "retrieval, connection, preparation and incubation" with the content attributing to "memory

recovery, memory association, memory integration, memory analogy, and other mental activities.” Such a pre-imagination phase is considerably associated with the “retrieval and restructuring” of functions of design imagination [11, 16, 17]. Design thinking and cognition require a greater imagination for problem-solving with emphasis on the use of the retrieval and restructuring function during the “imagination phase.” It is important to convert oneself between content of memory and experience to trigger the preliminary framework of design imagination. The interaction of imagination triggered by experience, perception and memory plays a critical role in design cognition.

2.2 Cognition mechanism that affects imagination

The term “imagination” refers to infinite thinking and the research analyzes the operational mechanism within. Apparently it is necessary to achieve a more explicit conceptual definition of imagination prior to carrying out the study on imagination. To solve such a difficulty, Finke *et al.* [11] applied the concept of creative cognition to analyze the impact of imagination on creativity, in addition to proposing structured imagination. The “structured imagination” mentioned implies that the imagination mechanism of individuals is not unexpected, while some factors could affect the imagination of individuals. Hence, one can assume that when individuals face imagination, the imaginative products reflected should contain considerable structure. Moreover, Unwin and McKellar [13] indicated that all forms of human thinking include an impact from prior experience (prior knowledge) and it is assumed that imagination is subject to impact from the knowledge structure of individuals. Meanwhile, Finke *et al.* even defined imagination as a substantial output to separate from fantasy and dreaming. The study also adopts such a definition for imagination.

2.3 Imagination experience methodology

“Experience” is a design method derived from the interaction of scenario application between teaching practices and scenario analysis. This is an intuitive, perceptual, logistic, and non-logistic interaction, used for helping designs to experience the user situation of target users in addition to stimulating design imagination for completion of design objectives. Imagination is triggered only by certain “stimuli” while the generation of inspiration could be a series of stimuli or only one that is related to the growing environment, experience and knowledge cultivation of designers. In view of the logistic perspective of “experience” and “scenario,” the former is attributed to a non-inferential process while the later offers logistic operational processes.

Imagination refers to the formation of “mental images,” which comprises the “intrinsic” and “extrinsic” aspects. Dong [15] defines intrinsic knowledge as the subjective and substantial knowledge that could not be expressed in words or sentences, a product that resulted from a special scenario, and included the cognition skills and experience derived skills. Extrinsic knowledge is defined as the knowledge that can be conveyed through text, number, formalized and systematic language, expressed through computer programming or graphics in terms of design. We believe that it is necessary to externalize professional intrinsic knowledge into communicable “imagination” in order to convert the imagination of industrial design into expression skills. Under the scope and assumption of imagination experience methodology, “imagination” is the extrinsic “stimulus” of individuals while “experience” is converted into the intrinsic professional knowledge of individuals, which follows abstract ways to concrete ways in the formation of “project-based innovative knowledge.” The system of formation claims “brainstorming” rather than “communication,” whereas the latter contains a voluntary proposal of various logistic and non-logistic propositions. The basis surpassing the logical thinking can be determined by the “intuition,” “inspiration,” “imagination,” and “experience” of individuals and “brainstormed” through the “logistics” and “feasibility” of the project decision-making team. In particular, “intuition” refers to individual observation, experience, and other perceptions formed over time and with professionalism. The “inspiration” refers to the “experience” relating to incidents and objects during problem-solving. “Imagination” refers to the interpretation of nonlinearity. “Experience” refers to a certain level of acquisition from self-exploration. Liu [18] indicated that logical thinking includes: “intellectual argument,” “humor” and “trade-offs.” In particular, “intellectual argument” is an argument to the affirmative and negative parties but any party holding an adequate citation will win. “Humor” is added to lifestyle, happiness and pleasant thoughts, while “trade-offs” are counterarguments to the principles of the existing framework.

Logistics refers to the deduction of thinking rules from thinking. In other words we can know the truth of different approaches while each approach to know the truth is regarded as logistics [19]. There are a number of thinking operations according to the logistic methods used in the research conducted by Wang [20], as organized in Table 1. Non-logistics is included in logistics, which contradicts, differentiates and opposes existing logistics. Liu and Su [18, 21] summarized the methods of anti-logical thinking as shown in Table 2.

Table 1. Logical thinking (prepared by the Study)

Method	Content
Inductive	A method for individuals to general inference (typical—common) that starts with individual truth, followed by discovering the universal laws of objects. People usually carry out experience generalization through inductive methods.
Deductive	A method from general to individual inference. Syllogism is a basic form of deduction (because, if, then), whereas the major and minor premises infer the conclusion. Induction and deduction are usually closely related.
Indirect	When we argue with claim P, we assume that P is false or the adversity of P ($\neg P$) is true. Based on the contradictory outcome derived from such an assumption, we can argue that the previous assumption of ($\neg P$) is false and hence claim that (P) is true.
Case study	A method to familiarize oneself with the similarities or differences of research object and known cases.

Table 2. Non-logical thinking (prepared by the Study)

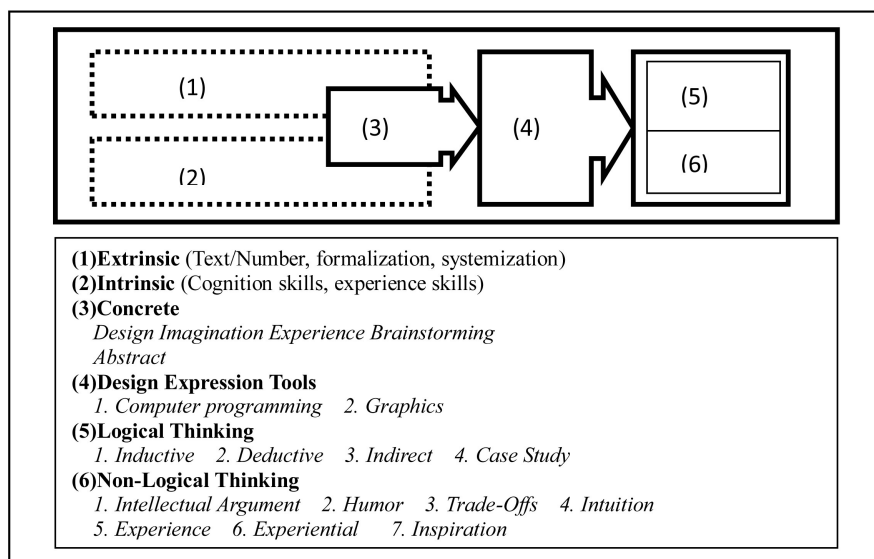
Method	Content
Intellectual argument	The argument of the affirmative and negative parties but any party holding adequate citation will win.
Humor	Adding lifestyle, happiness and pleasant thinking.
Trade-offs	Intuitive refection for the counterargument to the principles of the existing framework.
Intuition	Direct reflection of individual experiential, experience, and other perception formed following time and professionalism.
Experience	Past experience and memories.
Experiential	Certain level of acquisition for self-exploration.
Inspiration	The experiential to incidents and objects of problem-solving.

The framework of the design imagination experience model is induced from the above two discourses, as shown in Fig. 1.

3. Research method

The research organizes the relationship between the structured process of imagination and the dependence process of product design cognition through the analysis of literature related to imagination, creativity, design thinking and method, creative thinking, and experience. We then explored the forty international professional

designers using secondary interviewed data. The data were analyzed based on the abstract and concrete ways, activities, and locations, etc. to induce and analyze the source of imaginative inspiration for those designers. Moreover, the development of imagination and operation are observed and explored to understand the occurrence, content, source, and operational model, triggering mechanism, and relevance with experience and memory in designer cognitive imagination. The abovementioned outcome is used to build the preliminary concept of the teaching curriculum for product design imagination.

**Fig. 1.** Framework of design imagination experience model.

4. Imagination learning, development and strategy related outcome and discussion

4.1 Induction of imagination forms [21, 22]

1. Spatial imagination: Spatial imagination mainly refers to the appearance of the forms or images of real objects in the mind. A well-developed spatial imagination is required for designers because of the consideration of the 3D shape of the building.
2. Association of searching: Searching relevant forms or objects with consideration of the methods for adoption.
3. Combination of relevant elements: Take possible relevant elements from the brain and carry out various combinations of them to develop new models of meaning.
4. Imagination of different situations: Predict all likely occurrences and adopt relevant measures. For example, go players apply a developed imagination to the consideration of all situations on every step while extending such consideration to future steps.
5. Imagination of story plots: Simulate the imagination of development on incident occurrence in mind.
6. The abovementioned different forms of imagination do not cover all imagination but have one common characteristic regardless of the form of imagination, and that is the image of the object simulated in the mind, the operation of the simulation, and the experiment repeated in the mind.

4.2 Factors that affect imagination [11, 21, 22]

Imagination is the thinking ability of humans and is associated with many factors. The factors that affect imagination classified from the literature are described below.

1. Interests and passion: Low emotion usually inhibits the development of imagination.
2. Logical thinking: Thinking must apply to reality and be logical.
3. Imagination is based on self knowledge and experience, while imagination is usually associated with a leap in knowledge and hence requires the support of solid fundamental knowledge and rich experience. Lack of professional knowledge and experience in a certain field will correspond to relatively inadequate imagination.
4. Learning ability: Although there are many clever and skillful people in life, their imagination could not be carried out in higher hierarchy or broader scope due to a weak learning ability.
5. Awareness of interoperability of imagination in

different fields: Although different fields require different types of professional knowledge, the ability to repeat experimental thinking in the mind is necessary and universal. It is apparent that having stronger imagination in a certain area but lacking imagination in other fields will likely constrain the development of a person.

4.3 Teaching techniques for imagination and creative thinking

The different teaching techniques that analyze imagination from the existing literature are organized and induced in the following [23, 24]:

1. Vivid teaching content and language expression that is associated with scenario depiction to provide an immersive experience while triggering the imagination of students.
2. Disclosing the implications of keywords and sentences to help students to comprehend the figurative meaning, implicit meaning and conveying a meaning of a term, recalling students' imagination and association.
3. Supervise an observation to develop interests for observation and insights, which will facilitate the development of imagination in the memory. The supervision of observation allows learners to observe the objects in order and choose to propose observation methods, while timely drawing conclusions and analyzing the observation outcome.
4. Use imagination guidance to shorten the time for problem-solving and triggering opportunities for discovery, while constructing relevant fundamental knowledge. Secondly, the generation of new knowledge often includes the imaginary factors of forerunners, besides inference. Establish the scenario of imagination, provide imagination materials, and induce creative imagination based on the potential factors of the teaching materials.
5. Question, encourage and seek for differentiation: Thinking for differentiation is the basis for developing creative exploration and thinking. Encourage the students to boldly attempt: thinking, questioning, variance, and seeking for differentiation. Search for different techniques and know-how to discover and innovate from exploration and differentiation.
6. Inspiration induction: Inspiration is an intuitive thinking of imagination, which continues the accumulation of experience and knowledge through reality and context, in order to abruptly produce rich and creative thinking. It is a qualitative leap, the occurrence of which is accompanied by breakthrough and innovation.
7. Rich and perception image: Broaden the hor-

izon in social practices by expanding the reserves for various images in nature and human society. Use social surveys, visits, touring, appreciation of film and entertainment, and reading to expand image reserves.

8. Use ambiguity to discover the previously unimagined similarities between things, thereby to trigger imagination and inspiration. For example, scientists are good at thinking in a sleepy mode.
9. Integrate imagination and judgment: Reasonable imagination can only work with profound judgment. Rich imagination requires both active thinking and correct judgment.
10. Practice the use of figures, analogies and association. Use metaphors to invigorate imagination.
11. Use random imagination and open thinking images to modify or remove inappropriateness. Overcautious thinking will prevent the generation of outstanding imagination.

4.4 Association between design imagination and environmental experience

The following is the secondary interviewed data for the forty international professional designers [25]. The data were induced and analyzed for the source of imagination and inspiration in abstract and concrete ways, activities, and locations, etc, as shown in Table 3.

Designers using an abstract way of generating imagination and inspiration account for 58% and designers using concrete objects to achieve the source of inspiration account for 42%. This explains that about 60% of designers use abstract ways to generate the source of inspiration and imagination. Moreover, the statistics of achieving outdoor activities and indoor activities or objects that can stimulate the content and methods of inspiration are shown in Table 4.

The results show that 64% of the stimulus for inspiration comes from indoor activities, while 36% is attributed to outdoor activities.

5. Conclusions

Imagination is one of the most important factors that affect design in problem-solving. Designers use analogical thinking to retrieve prior experience for generating new meaning for design objectives. We

Table 3. Source of inspiration attributing to abstract/concrete statistics

Method	Statistics	Percentage
Abstract	57	58%
Concrete	41	42%

Table 4. Statistics of achieving outdoor activities and indoor activities or objects that can stimulate the content and methods of inspiration

Method	Locations	Quantity	Percentage
Abstract	Indoor	41	72%
	Outdoor	16	28%
Concrete	Indoor	22	54%
	Outdoor	19	46%

Table 5. Total source of imagination and inspiration from outdoor and indoor activities

Method	Locations	Quantity	Percentage
Source of imagination and inspiration	Indoor	63	64%
	Outdoor	35	36%

can infer from previous discussion and data analysis that the operational mechanism of imagination can indeed manipulate the cognition structure of the design process. The experiences constructed from various activities in life are usually the sources that trigger imagination in memory recall, association, integration, and analogies in creativity. Hence, we discover from the secondary data on the international professional designers that designers often increase experience and accumulate sources of imagination or trigger sources of imagination for inspiration through different experience activities such as hiking, mountain climbing, reading, photography, adventure, and surfing. For the teaching development of design imagination, the increase of interests and passion, the enhancement of cognition skills and experience derived skills, in-depth life experience in the environment, and the use of implicit knowledge in design expansion, will contribute substantial creative functions to triggering of the imagination in cognition in different phases of design thinking. However, more information is needed to assess and quantify the impact of these tools in developing creativity in the students when designing prototypes. This is ongoing research that is carried out in our group.

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