Chapter 2
Perspectives on Concept Generation and Design Creativity

Abstract In this chapter, we address the perspectives on design, *concept generation*, and creativity. First, we overview the previous research on *concept generation*, which is at the very early stage of design, by focusing on interdisciplinarity and creativity. Next, we classify *concept generation* into two phases—the *problem–driven phase* and *inner sense–driven phase*—according to the following two factors: the basis of *concept generation* and ability which enables the *concept generation* to proceed. Further, we define *concept generation* and creativity as follows: *concept generation* is the process of *composing* a desirable concept towards the *future*, and *design creativity* is the degree to which an *ideal* is conceptualized.

2.1 Very Early Stage of Design

In the field of design research, design is usually described as an activity to formulate a solution for a purpose [62]. Indeed, the process of design has been understood to be the process of rational problem solving by transforming existing situations into preferred ones [11, 41]. On the other hand, design has been viewed as a 'reflective practice' [58], and a number of studies have investigated design processes in order to identify the features of the thinking process [15, 20, 24, 48]. These studies have identified interesting issues in the design process such as rationality, expertise, and learning. In this book, we approach the essential phenomenon in the characteristics of creativity in design by focusing on the 'very' early stage of design which includes the time just prior to or the precise beginning of the so-called conceptual design.

The meanings of design typically involve two phases: the mental plan for something, followed by the creation of forms. The former phase is generally termed the conceptual design. In engineering design, conceptual design has been

T. Taura and Y. Nagai, *Concept Generation for Design Creativity*,
DOI: 10.1007/978-1-4471-4081-8_2, © Springer-Verlag London 2013

considered an ‘early stage of design’ in a systematic approach [49]. In this approach, schematic descriptions of a mechanism are important at the early stage to initialize the flow of the design process. Furthermore, methods for a systematic approach have been developed to determine the relations between a mechanism and functions [39, 45, 64]. In these processes, originality as well as rationality is required [2]. Creative techniques for systematic design such as checklist methods—for example, the Attribute Listing Method [12] based on the decomposition of the problem—as well as network modelling methods—for example, the Option Graph Method [44] based on the linkages of the elements in a flow diagram—were adopted in order to find new solutions.

Industrial design can be considered that which aims to create admired shapes and colours and which has been historically developed from art and craftwork. In industrial design, the early stage of design played the role of being an ideation process for forming whilst drawing [60, 65]. In the stage of conceptual design, a suitable goal of product design is found as a result of ideation, which will also answer to social requirements [66, 71]. Market research and surveys on product trends have been believed to be effective supplemental methods for the ideation of a product design [7, 10]. These investigations provide information on the gap between users’ or customers’ needs and the existing product in a market. Although the market research and surveys are directed towards finding the goal of product design, conceptualizing new ideas for products (novel products), which cannot be obtained through market research and surveys is thought to be another crucial approach; however, this process is still difficult and thought to stem from an inspiration.

Indeed, the critical process to produce a novel product at the very early stage of design is assumed to be shared between the multiple design domains (engineering design, industrial design, etc.) as an unsystematized phenomenon. As mentioned in Chap. 1, in this book, the very early stage of design, during which an initial idea or specification is generated, is called *concept generation*.

2.2 Interdisciplinary View of Research on Concept Generation

Some studies on modelling ideation processes corresponded to *concept generation*; for instance, those of engineering design and industrial design [5, 6, 13, 37, 38, 43, 51] as well as architectural design [1, 11]. The studies highlighted each aspect of *concept generation*.

To assist the *concept generation*, two types of methodological support techniques have been developed: the visual method and linguistic method. The visual method type is usually based on visual and spatial cognition using imagery resources or graphical media [17, 21, 31, 46, 67], including 3-dimensional design [16, 53] and virtual information [50]. The visual method type is thought to be effective in assisting a designer’s (or design team’s) image aspect of *concept* *generation* in the shape, interface, or usage scene of a product for industrial design, as well as in the mechanical aspect for engineering design. The linguistic method type is based on language and uses lexicon technology [9, 42, 56]; it is supposed to contribute more towards activating *concept generation* at the abstract level, such as the meanings or social values of a product. Both types are considered useful for accelerating or efficiently driving *concept generation*.

With regard to another methodology on *concept generation*, Brainstorming [47] is a popular method to facilitate the ideations quantitatively and is introduced to obtain the frequency of finding new solutions; however, the effectiveness of Brainstorming in engineering design is argued [36, 59, 69], and the qualitative limitations of Brainstorming have been addressed [73].

In addition, other general creativity support techniques are proposed to strengthen the originality in ideation process by providing a new method of seeing a situation. Synectics [29] is a famous example of an operational theory for the conscious use of the psychological mechanisms of creative activity, particularly with regard to the roles of metaphor in the creative process. Later, the roles of metaphor provided a computational cognitive model of analogy [8, 33, 35] such as Copycat [32, 34]. Empirically, analogy is viewed as a creative strategy for shifting the manner in which a situation is seen and is thought to be an effective stimulus for design [20, 28, 36]. For developing multiple viewpoints on seeing situations, flexibility is paid attention to and 'lateral thinking' [19] is introduced as an effective creative thinking technique which is related to a flexibility developing skill. This is further developed into the Six Thinking Hats [18] tool for human decision making. In order to obtain the meta-level skill of seeing a situation, not only human thinking but also the need for 'learning by doing' is highlighted from the viewpoint of practice. In the framework of learning in practice theory, the skill of reflection is introduced as an effective method to develop the creativity of 'practitioners' [57, 58].

To improve the ideation support methods mentioned above, it is necessary to identify the theory of *concept generation* by gauging our understanding of human cognitive features including inspiration. Indeed, the generative process lying behind mysterious phenomena and its ability at the very early stage of design should be an interdisciplinary (beyond the existing academic disciplines and across multiple design domains) research theme. In this book, we attempt to develop a systematized theory and methodology on *concept generation*, in particular, in an interdisciplinary manner.

2.3 Creativity in Design

In the field of design research, two kinds of creativity have been discussed. One is related to the process of design, while the other is related to the products that are the outcomes of the design process.

In the former, the emphasis is sometimes on rational decision making to find a design solution within the framework of problem solving. Alternatively, Cross [14] reports many cases of creative leaps that have been made during the design process, which may have been caused by the release from a mental fixation. The role of visual information is considered conducive to such releases from mental fixations. In fact, it has been supposed that experts have actual knowledge of how to break such fixations. Until now, analogical reasoning has been given the most attention because it is related to the breaking of fixations [4, 22, 26, 70]. Many studies have reported that metaphors and visual images are effective for analogical reasoning [27], and expert designers seem to understand the roles of metaphors and visual images. Referring to Arnheim's [3] theory, these studies have claimed that the capacity for visual thinking might be particularly expanded in the cognitive process of designers. Goldschmidt [27] identifies the effects of the ideas that occur in visual thinking on the abstraction level during the design process, which she relates to creativity, by carrying out experimental studies. These results were obtained through experimental observation of architectures' design protocols. Such an experimental observation of the design process has been called 'design protocol studies', and it provides information on the cognitive features of the creative design process [40].

On the other hand, the creativity of designed outcomes or the ideas governing them have usually been evaluated in terms of novelty and practicality—the two criteria offered by the study of Sternberg and Lubart [63]. They describe creativity as the ability to produce work with both novelty and appropriateness. Weisberg [72] points out the importance of 'values' for creativity evaluation. Vargas–Hernandez et al. [68] evaluate the sketches as the outcomes of the design process with two criteria: novelty and quality. Sarkar and Chakrabarti [55] propose the assessment methods of 'novelty and usefulness' in order to evaluate the values of designed outcomes. Gero [25] adds the notion of 'unexpectedness' to these criteria.

Furthermore, there are other standards with which to evaluate creativity. For instance, the value of the diversity of products or the speed at which goals are achieved is often used as a criterion for creativity evaluation (in the *Encyclopedia of Creativity* 1999) [54]. In addition, Ulrich and Eppinger [66] suggest that the actual marketing results imply the values of creativity in the real world. They also suggest that diversity of productions affect the power to create products in the next generation.

As mentioned above, many studies have discussed the creativity in design; however, further consideration is thought to be necessary to capture the essence of creativity at the very early stage of design, that is, in *concept generation*. In accordance with our attempt to develop an interdisciplinary theory and methodology for *concept generation*, we also aim to identify the creativity for *concept generation* in the following section (in this book, the creativity for *concept generation* is referred to as ***design creativity***).

2.4 Phases of Concept Generation

To specify what *concept generation* is, we classify the process of *concept generation* into two phases—the *problem–driven phase* and *inner sense–driven phase*—according to the following two factors: the basis of the *concept generation* and ability which enables the *concept generation* to proceed. These factors are related to the following questions, respectively: (1) From where is a new concept generated? and (2) What enables a designer to promote the process to generate a new concept?

2.4.1 Concept

In this book, ***concept*** is defined as that which refers to the figure of an object, along with other representations such as attributes or functions of the object, which existed, is existing, or might exist in the human mind as well as in the real world. This definition is in line with previous considerations in the field of design study (e.g. [11, 30, 52, 61]). Here, 'figure' implies the notion of an image as well as a physical shape, and 'object' involves not only a physical object but also a non-physical object: software, music, and so on. As mentioned in Chap. 1, we assume that a new concept is not generated from nothing. This declaration involves two assumptions: that the basis of generating a new concept exists, and a new concept is generated by referring to some existing concepts which lie either in the real world or in a designer's mind. However, we do not deny that a new concept might be generated suddenly in the designer's mind with no foretokening or basis, and we do not discuss this type of *concept generation* in this book owing to the difficulty in understanding these phenomena.

2.4.2 Problem–Driven Phase

We call a gap that exists between a goal of an object and its existing situation a ***problem***, and define the ***problem–driven phase*** as the process of generating a new concept (solution) on the basis of the *problem*. In certain situations, there are obvious goals that need to be achieved, such as finding solutions for natural disasters. Similarly, in cases where we need to meet customers' explicit requirements, it is also easy to set goals. In the *problem–driven phase*, the new concept (solution) can usually be obtained by analysing the *problem* (this point will be discussed in more detail in Chap. 4).

Through these definitions and considerations, we can deduce that the basis of the concept is a *problem* (the gap between a goal of an object and its existing situation) and that the ability which enables this phase to proceed is that of 'analysing'.

Next, we discuss the creativity of the *problem–driven phase*. That the solution can be obtained by analysing the gap indicates that the solution lies hidden in the gap. This consideration suggests that the creativity of the *problem–driven phase* is related to the process of discovering the hidden solution in the gap.

2.4.3 Inner Sense–Driven Phase

The ***inner sense–driven phase*** is defined as the process of generating a new concept on the basis of the *inner sense* for pursuing an *ideal*. Although the notion of the *inner sense* in design has been recognized in previous research (e.g. [30, 61]), further discussion on this aspect will aid in understanding and systematizing *concept generation*. Here, ***inner sense*** is that which involves *inner criteria* and 'intrinsic motivation' and can be the basis on which a new concept is generated by referring to existing concepts; *inner criteria* are that which is explicitly or implicitly underlying in the designer's mind and guides the process of *concept generation*; this issue will be discussed again in Chap. 12, and 'intrinsic motivation' will be addressed in Chap. 3.

An *ideal* is considered the direction pursued by the *inner sense*. In other words, in the *inner sense–driven phase*, the most important element could be the generation of a new concept for pursuing an *ideal*. From the viewpoint of engineering design, the development of the ideal functions of future artefacts is implied, while from the viewpoint of industrial design, the development of the ideal shapes or interfaces which evoke an ideal impression on a user's mind is implied.

In some cases, when an *ideal* is explicitly expressed, the *ideal* may become a 'goal' in the *problem–driven phase*. However, the notion of *ideal* in this phase is not to be approached by analysing the current state. If it can be easily obtained from an analysis of the current state, it should be categorized into the *problem–driven phase*. To approach an *ideal*, the ability of *composing*, which is the notion opposed to analysis, is considered inevitable. In the very early stage of design, one of the typical processes is the composition of elements, because the way in which we create products differs from the process of creation in the natural world. It is a well-known fact that such a composition of elements is observed in the human recognition process [23]. The ability of *composing* is also effective in the *problem–driven phase*; however, we believe this ability features in the *inner sense–driven phase*. As a notion opposed to 'analysis', 'synthesis' is also well-known. In this book, the term 'synthesis' is used later (in Chap. 5) in the more specific context.

Further, the creativity of the *inner sense–driven phase* is assumed to be related to the process of approaching an *ideal* through the composition of elements.

Table 2.1 summarizes the two phases of the *concept generation* described.

The relationship between the two phases is illustrated in Fig. 2.1.

In the actual design process, these two phases do not work independently; instead, they realize the design process complementarily. In the design process which is modelled in the framework of the so-called problem-solving process [49],

Table 2.1 The two phases of concept generation with two factors: the basis and ability of concept generation

Phase of concept generation	Basis	Ability
Problem–driven phase	Problem	Analysing
Inner sense–driven phase	Inner sense	Composing

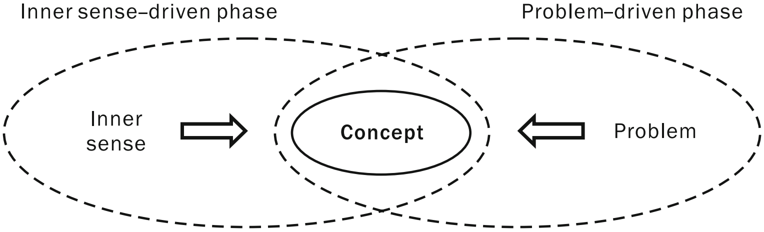

Fig. 2.1 The two phases in concept generation

a new concept through which the given goal is achieved is generated by analysing the gap between the goal and the current situation; moreover, it is achieved by creating a new solution or decomposing the *problem* on the basis of the designer's *inner sense*.

On the other hand, even if the design is captured as an activity of the artist, its very early stage can also be understood to comprise the two phases, where focus is placed on the *inner sense–driven phase*. In the very early stage of art-like design, a new concept is thought to be generated from the designer's *inner sense,* followed by fitting it into the situation by analysing the gap between the emergent vague concept and the current situation.

2.5 Definitions of Concept Generation and Design Creativity

On the basis of the above considerations, we define ***concept generation*** as *the process of composing a desirable concept towards the future.*

This definition aims at developing a framework in which the *concept generation* can be structured in an interdisciplinary manner, while focusing on our view of *concept generation*. In our previous studies, the *inner sense–driven phase* was found to be related to the essence of the very early stage of design (this point will be discussed in Chaps. 4–6), even though the relation is indirect. Accordingly, we focus on the *inner sense–driven phase*; however, this focus intends not to narrow the meaning of *concept generation*, but to clarify our stand to capture the essence of *concept generation*, which is the main theme of this book.

With regard to this definition, we will first explain what we mean by the phrase 'towards the *future*'. The notion of the *future* is thought to be, of course, extremely abstract, as follows. We can never draw an exact picture of the *future*. We can imagine what things may be like in the future, but it is impossible to visualize a precise notion of the *future* itself. We think this kind of highly abstract notion can only be represented in language. That is, the notion of *future* is considered to be recognized only by human beings through the use of language. On the other hand, *concept generation* is also a highly intellectual activity. Accordingly, these two notions of *future* and *concept generation* are believed to feature in human beings. Therefore, we would like to attempt to describe this part in order to identify the fact that *concept generation* characterizes human beings, whereas this characteristic is thought to be straightforward owing to the fact that every activity of living things is directed towards the future. In the context of *concept generation*, the *future* is considered to have two meanings. One meaning is a future that we can grasp inductively, such as a marketing forecast. The other meaning is a future that is recognized in the wish or desire for creation which is led by an *inner sense*. In our understanding of *concept generation*, we consider that the latter meaning is the more essential of the two.

Next, we explain what we mean by 'desirable concept'. It is this part which determines the object of *concept generation*. Here, the notion of 'desirable' could imply 'the pursuit of certain *ideals*', which will never be realized in the real world, as well as the 'implementation of a wish', which can be realized in the real world. Accordingly, it is suggested that there are two kinds of desirable concepts: an ideal shape or function in the *inner sense–driven phase* and obvious given goals in the *problem–driven phase*. As mentioned above, in our understanding of *concept generation*, we consider this former object to be more essential. In this case, we think a *sense of resonance* in the mind can be an *inner criterion* for an *ideality*. One important point regarding artefacts is the notion of 'naturalness'. We often assume that the process of making artefacts should come naturally to humans. However, there is no credible process that *resonates* with human beings, even though we create artefacts by copying them from the natural world. In contrast, there are some things that differ from what is found in the natural world but nevertheless, 'naturally' *resonate* with the human mind. Music is a good example. Music is composed of man-made sounds, most of which differ from the sounds which exist in the natural world, such as the sound of a breeze or a bird's song. Indeed, music *resonates* with the human mind.

Finally, we explain what we mean by '*composing*'; it is this part which determines the process of *concept generation*. For the composition, particularly in the composition of desirable concepts, finding a new concept which can be realized is thought to be insufficient. We assume it is also necessary to pursue the desirable concept towards the *future* which will never be realized, and there must be an intrinsic motivation in one's *inner sense* for this pursuit. In this book, we use the term *composing* in order to emphasize the meaning of embracing such motivations with one's *inner sense* to pursue an *ideal* in addition to the normal meaning mentioned above.

On the basis of the above considerations, we define ***design creativity*** in *concept generation* as *the degree to which an ideal is conceptualized*.

In this definition, novelty may be implemented as a by-product of *concept generation*, but not as a causal factor of creativity. Thus, if a new concept is pursued merely on account of its uniqueness, we say that this pursuit never approaches an *ideal*.

On the other hand, hereafter in this book, the unadorned term ‘creativity’ suggests the conventional meaning: originality and practicality.

With regard to the meaning of *ideal* and *inner sense* in *concept generation* and the relevance of this definition, we will discuss them again in Chap. 12.

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Concept Generation for Design Creativity
A Systematized Theory and Methodology
Taura, T.; Nagai, Y.
2013, XII, 172 p., Hardcover
ISBN: 978-1-4471-4080-1