Creative-based Problem Solving Tool for New Product Design

by

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Abstract

In a highly competitive and uncertain market environment, product development needs not only to satisfy the quality and speed of production but also to ensure the product contains creativity values. Introducing new products persistently is one of the major tasks of companies and one of the important determinants for their survival; introducing creative products makes companies more competitive. Creative ideas are highly valued and rewarded by the market. Nevertheless, the high rate of product failure and the difficulties of predicting product trends accurately are the reason why companies fail to make large profits.

Today's market demands unique innovations that provide a conspicuous value to the customer. Companies must meet that challenge with fewer resources, at the lowest cost, with higher quality, and with shorter design cycle times. Conventional approaches to such unconventional demands simply will not get the job done.

This thesis proposes a new product design template based on systematic design technique which does not heavily rely on marketing research. This creative-based new product design template enables companies to prepare a reserve for new products and to plan a strategy for their promotion even before the actual marketing step. This advanced preparation also makes it possible to enable companies to choose appropriate action and timing that may lead a maximum benefit.

To demonstrate the feasibility of this design template, several case studies will be conducted. By applying product evolutionary thinking, integrating the resource in product system and system matrix, several solutions will be produced.

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Chapter 1

1.1 Problem Statement

Copper (1996) indicated that new product development is a vital endeavor for modern industries. New product development is essential to be able to deliver successful products. And creativity plays a significant role in new product development (e.g. Steven, 1999). Over 25,000 products are introduced annually in the US alone, most of them doomed to fail (Bobrow & Shafer, 1987). According to Harvard Business School professor Clayton Christensen, there are over 30,000 new products introduced every year, and 95% fail. Similarly, according to University of Toronto Professor Inez Blackburn, the failure rate of new grocery store products is 70 to 80% (cited in Emmer, 2018).

Over the past decades, lack of creative ideas and accurate prediction have limited the development of exciting and attractive products. Such an assessment is reinforced by the fact that nearly 50% of product development is likely to result in a failed product. In some sectors, such as fast-moving consumer goods, the failure rate is over 75% (Bruce & Cooper, 2000). The significant financial loss occasioned by failed products may be the main reason that companies put a lot of effort to developing to similar products.

Majaro (1998) stated the very first step in new product design is the generation of new ideas, which van be described as "creativity." However, many researchers hold the view that creative thinking is different from "ordinary" thinking; thus, it can't be sufficiently analyzed or formulated (Guilford, 1950). Until the late d1970s, long after the practical approval of various creativity-enhanced method, people begin to build scientific knowledge on creativity. Weisberg (1986) indicated creative thinking is not an extraordinary form of thinking. Creative thinking becomes extraordinary only because of what the thinker produces, not because of the way in which the thinker produces it.

1.2 Need for Study

Bullinger (2000) declared that the new millennium has fostered a look towards the future, accompanied by both hopes and fears. Facing today's global information society, companies must focus on the task of meeting competition and challenges. One of the essential duties of companies is converting raw ideas or market needs (opportunities) into exciting products. Therefore, scanning the primary information resources that may determine the success or failure of the new product before actual production is extremely important for companies.

Developing a successful new product is a very complicated process that relies on creative thinking, and other related knowledge. It involves strategy, management, research, development, production, marketing, and decision making. It needs to be done by integrating creativity and innovation tools with axiomatic design methodology (Goel & Singh, 1998). Therefore, a new product design template's emergence is really important. The new product template can be one of the best methods to illustrate design thinking by scanning the reality of new product innovation and detect ideas for the new product.

Over the past generations, companies have relied heavily on marketing information to guide them in new product development. By listening to the “voice of the customer,” product developers expect to better forecast successful new products (Kotler, 1994). It is true that many popular and successful products have their roots in customer feedback (Lehmann, Gupta, & Steckel, 1998). Most market researchers have focused on ways in which the market impinges on products in terms of their development, rate of innovation and other performance predictors (Srinivasan, Lovejoy, & Bench, 1997). However, the ability to elicit truly original concepts through market research method has been questioned recently. The principle arguments are listed below (Goldenberg & Efroni, 2001, p. 41):

1. Doubts regarding consumers’ ability to provide reliable information beyond their personal experience.
2. The aggregate dynamics of the awareness propagation in the market dictates a low possibility of an exclusive discovery of an emergent need and the subsequent introduction of an innovation to market.

On the other hand, the majority of designers still hold that creative thinking hides in the "black box": either it happens without designers' consciousness, or creative thinking acts in a general problem-solving area. Using a framing approach, which follows the Function Follows Form Principle, may help to enhance the right creative thinking definition. Gold and Bela (1984) acknowledged that a structured approach to planning, actively integrating product innovation and market information, is required for firms to meet the changing market pressure. Such a view has been confirmed by the research that indicates approximately 70% of successful new products match one of the framing approaches (Altshuller, 1986). Furthermore, the framing approach has been developed in a variety of disciplines such as linguistics anthropology, random graphics, venture, transitional management, and artificial intelligence. This paper aims to develop a method which has these three features:

1. A template of the underlying product evolution can serve to predict new products.
2. The framing approach predefines the inventive routes in order to target creative thoughts.
3. Function follows form.

Tauber (1972) pointed out the search for new ideas typically suffers from a lack of synchronization between ideation and screening. Proctor (2007) also mentioned that generating and screening ideas is an important issue since vast amounts of money may be spent on researching, developing and marketing such products. This method can support designers in encouraging design creativity but also allows companies to prepare the right strategy for new products before production.

1.3 Objective of Study

The following areas of design are the main focus of this thesis for providing a creative-based systematic design template which can be applied to encourage more innovative ideas for designers.

1. To figure out how products evolve.
2. To constitute a logical method to spur innovation.
3. To inspire designers by analyzing the code of products.

4. To neaten the products systems to build well-defined conflicts.

5. To solve the design problem by applying TRIZ, one of the famous problem-solving methods in the world.

6. To evaluate the design outcomes based on market needs.

1.4 Definition of the Terms

Creative Thinking: Creative thinking means looking at something in a new way. It is the very definition of "thinking outside the box" (Dacey, 1990, p. 145).

Creative-enhanced Methods: These are methods that encourage creative actions, whether in the arts or sciences. They focus on a variety of aspects of creativity, including techniques for idea generation and divergent thinking, methods of re-framing problems, changes in the effective environment and so on. They can be used as part of problem-solving, artistic expression, or therapy (Mikics, 2010).

Creativity: Creativity is a phenomenon whereby something new and somehow valuable is formed. The created item may be intangible (such as an idea, a scientific theory, a musical composition, or a joke) or a physical object (such as an invention, a literary work, or a painting) (Sternberg, 2014).

Decision-making model: Models of decision-making attempt to describe, using stochastic differential equations which represent either neural activity or more abstract psychological variables, the dynamical process that produces a commitment to a single action/outcome as a result of incoming evidence that can be ambiguous as to the action it supports (Gianakis, 2004).

Design Template: A design template is a file that has been created with an overall layout or blueprint with a format to be used for a group of documents or a generic document. Design templates vary depending on the kind of work being creating but should share similar themes and patterns throughout the completed work. In web design, templates help structure your overall design of a web page. In programming, a template can be used as the basis for unique units of code ("What is Template", 2018).

Design Strategy: Design strategy is part of the product strategy and it focuses solely on the customer, their goals, needs and pain points (Margulis, 2017).

Design Thinking: Design thinking refers to the cognitive, strategic and practical processes by which design concepts (proposals for new products, buildings, machines, etc.) are developed by designers and/or design teams. Many of the key concepts and aspects of design thinking have been identified through studies, across different design domains, of design cognition and design activity in both laboratory and natural contexts (Visser, 2006).

External Resource: External resource based on market data, by searching for unfulfilled needs (Goldenberg & Mazursky, 2002).

Form Follows Function: Form follows function is a principle associated with 20th-century modernist architecture and industrial design which says that the shape of a building or object should primarily relate to its intended function or purpose (Greenough, 1947)

Internal Resource: An intrinsic source based on the creative thinking by thinker, termed "Ideation" (Goldenberg & Mazursky, 2002).

New Product Development: In business and engineering, new product development (NPD) covers the complete process of bringing a new product to market. A central aspect of NPD is product design, along with various business considerations. New product development is described broadly as the transformation of a market opportunity into a product available for sale. The product can be tangible (something physical which one can touch) or intangible (like a service, experience, or belief), though sometimes services and other processes are distinguished from "products." NPD requires an understanding of customer needs and wants, the competitive environment, and the nature of the market (Kahn, 2012). Cost, time and quality are the main variables that drive customer needs. Aiming at these three variables, innovative companies develop continuous practices and strategies to better satisfy customer requirements and to increase their own market share by a regular development of new products. There are many uncertainties and challenges which companies must face throughout the process. The use of best practices and the elimination of barriers to communication are the main concerns for the management of the NPD (Koen, 2017).

Product Strategy: Product strategy focuses on what a company should invest in building and why it is important. It is an intersection of user needs, business goals and technological viability (Margulis, 2017).

Product Evolution: Product evolution is a term used by companies who have the vision to not only see a product idea, but how that product can evolve over time. It's essentially the idea of mapping out, often before the first product is even manufactured, what future iterations of a product might be as it improves and grows (Morten, 2018).

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TRIZ: It is "a problem-solving, analysis and forecasting tool derived from the study of patterns of invention in the global patent literature".[1] It was developed by the Soviet inventor and science-fiction author Genrich Altshuller (1926-1998) and his colleagues, beginning in 1946. In English the name is typically rendered as "the theory of inventive problem solving" (Barry, Domb, & Slocum, 2010, p. 214).

1.5 Assumptions

This thesis assumes companies and individuals execute this template with an iterative process, which means this template may not deliver the best solution immediately, so companies or individuals may need to execute this approach multiply times to get a better solution. In addition, this paper assumes that:

1. Information about a product will diffuse only after the market shows an interest in it, which means the product must respond to the market needs.

2. The extraction of an idea is very effective when the market hits the saturated line. The market being fundamentals of creative thinking in a saturated situation means almost all of the

users are already aware of this need. In this situation, the marketing feedback will be very effective. However, the idea is not considered as a surprise or creative product at this time.

3. It is impossible for companies to extract the new idea from the market when rarely are people aware of the need. In this situation, the need for the product is hidden. The potential exists, but it has not emerged as a recognized need or one that is triggered by a specific event.

4. The espionages between competing companies do not require creative thinking, as the business competition may include the possibility that the product is copied.

Besides these assumptions, this thesis also assumes that professionals in competing companies share the same professional level and market information.

1.6 Scope and Limits

This thesis focused on how to develop a creative new product with product evolution thinking and system design methodology. It will introduce a creative-based new product design template which not only includes a new product prediction process but also contains structured design technology. This design template helps designer to target potential opportunities.

The outcomes of this design template are based on customer needs, market review, and other external resources. The existing marketing form may dramatically change in the future. Because of these uncertain factors, this study's approach is limited by time.

Using this matrix design method, designers or companies should consider the suggested approach, but also should keep an open mind and be flexible when necessary. Like every other design template, this design template is impossible for all complicated design tasks. The designer should be able to adjust.

This method acts in a specific area, not in the general problem-solving world. It is often argued that the more generalized the approach, the weaker it is. This method aims toward new product development, which is different from that for product promotion. On the one hand, this method lacks generality; on the other hand, it is more efficient.

1.7 Procedure of Study

The plan of procedure is the following:

1. Define the system and subsystem. Identify the target product and the external components which may be affected. Recognize the interaction between target product and external components.
2. List the internal and external parameters of the product. Based on evolutionary thinking, the parameters are the genes of products. Therefore, internal parameters (the variables under manufacturer’s control) and external parameters (the variables outside manufacturer’s control) are crucial elements to extract new idea.
3. Building the matrix. This step is designed to search for conflicts by scanning the interaction between different parameters.
4. Solve the conflicts by applying system or physical conflicts approach.
5. Decision making. This phase has seven steps: brainstorming criteria for target system, formulate the decision matrix, run the matrix, evaluate the rating.

1.8 Anticipated Outcomes

The anticipated outcome of this thesis is the creative-based new product design template which will help companies to predict new candidate products by providing the context for ideation.

This method will also help develop a shared vision of creative thinking and visualize the relative value of alternatives.

This template helps to channel thinking along pre-defined inventive routes in order to target creative thoughts.

This technique follows the Form Follows Function principle, which is one of the crucial rules of the new product development.

Chapter 2

2.1 Creativity

Creativity is considered one of the critical measurements of intelligence that separates human from the rest of the animal kingdom. Researchers have discovered that creativity helps people to be better problem solvers (Sawyer, 2006). People all face problems in everyday lives that require creative responses. Some problem can be solved by experiences. However, some others need us to be creative.

Not only creative products, but creative ideas are also believed to contribute to the enhancement of creative atmosphere, even creative ideas do not produce immediate profit (Weisberg, 1992). "Generating interesting designs is desirable not only because these designs will be better solution, but also they lead to a new way of thinking about the current problem" (Ulrich, 1988, p. 143). Before attempting to figure out "the code of creativity", the one must first understand the definition of creativity.

2.1.1 Romanticism

The romantic view of creativity is creative people are said to be people gifted with specific talent which others lack. As for how automatic insight functions, romantics offer only the vaguest suggestions. They see creativity as fundamentally unanalyzable and are deeply unsympathetic to the notion that a scientific account of creativity might one day be achieved. In the 1700s, the writers in the English Romantic Movement started to believe that creativity is built from the inner muse (Abrams, 1984). They believed that creativity requires a temporary escape from the conscious ego and liberation of instinct and emotion (Shelley, 1965).

If people take the dictionary definition of creation seriously, "to bring into being or form out of nothing," creativity seems to be not only beyond any scientific understanding but even impossible. It is hardly surprising, then, that some people have explained creativity in terms of some romantic intuition, or insight, and some other in terms of divine inspiration (Boden, 1991). Indeed, many designers and researchers consider creativity as the "creative leap," which cannot be sufficiently analyzed or formulated. They hold that creativity required a regression to a state of consciousness characterized by emotion and instinct, a fusion between self and world, and freedom from rationality and convention (Sawyer, 2006). Carl (1997) expressed that creativity is a divine spark that may not be dismantled and examined by scientific tools. There is an anecdote in the 1989 *Psychology Today* article: "Mozart wrote the overture to Don Giovanni in only a few hours, after a virtually sleepless night and without revision" (Carl, 1997, p. 241). This article claimed it is an extraordinary example of creativity, for which the only explanation seems to be supernatural intervention.

2.1.2 Rationalism

Rationalism believes that insight does not come from gods; it does not come from nowhere either. The flash of insight needs prior thinking processes to explain them (Boden, 1990). Part of rationalism explained creativity as the combination of ideas drawn from different domains. They saw creativity as exploiting specific conceptual matrices. Koestler (1964) described creativity as the 'bisociation' of two conceptual matrices which were not normally associated, and which may even seem incompatible.

During the European Renaissance, the view that reason, knowledge, training, and education were considered necessary to create good art started to rise (Sawyer, 2006). The term 'originality' was first created during that era. It meant newness and truth of observation, not a radical break with convention (see Figure 1). Scholars and artists believed that most original artists were those who imitated nature best (Smith, 1961).

Figures 1 Italian Renaissance Furniture Designs (Bergamio,16th century)

Over 60 years ago, the Gestalt psychologists proposed that there were distinctions between creative thinking and insight. The Gestalt psychologists believed that the perception triggered creative thinking. Taking the Necker cube as an example (see Figure 2), at first sight, the cube may be observed as in a specific orientation. As an observer continues looking, the cube may suddenly reverse itself in depth and direction. The Gestalt psychologists called this phenomenon 'spontaneous restructuring'. In Gestalt's view, everyone is capable of producing creative thinking. That may explain why everyone has 'Aha!' experiences at various times of their lives (Robert, 1993).

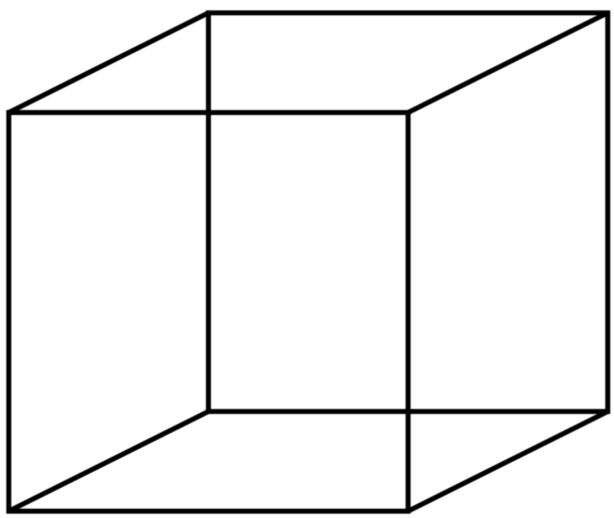

Figure 2 The Necker cube (Louis, 1832)

2.1.3 Debate on Creativity

The founder of psychoanalysis, Freud, believed the primary thinking process was dominated by creative thinking, irrational and primitive and associated with instinct and the unconscious, rather than by secondary thinking process, logical and realistic and associated with the conscious (Robert, 1993). Freud took the work of Leonardo da Vinci as an example to illustrate his view (see Figure 3). In his case study, Freud claimed that Leonardo painted the stunning smile on the Mona Lisa because of the woman who posed for Mona Lisa aroused Leonardo's emotions toward his unknown mother (Freud, 1964).

However, later scholars thought the primary thinking process goes against the rules of ordinary logic. Some of Freud's followers tried to tone down Freud's emphasis on the primary thinking process, by stressing the fact that if the creative thinking occurs under conscious control, then it will not carry purely the primary thinking process (Suler, 1980).

In ancient Greece, creativity was correlated to demonic possession. A demon was a semi-spirit and was viewed as a divine gift granted to selected individuals (Becker, 2000). Romanticism was affected by ancient Greece through the Middle Ages. Aristotle believed that creative individuals were melancholic. Nevertheless, "melancholic" did not mean depression back then. The temperament of melancholic includes eccentricity, sensitivity, moodiness, and introversion (Wittkower, 1963).

Figure 3 Mona Lisa (Leonardo da Vinci, 1503)

Another group of romanticists believed that madness was an unfortunate side effect of extreme creativity. Emil Kraepelin (1978) hypothesized mania might be one of the causes which result in creative thinking. He described, during the mania period, that the thought process was "loosened," which can result in increasing creative thinking. Base on this hypothesis, Jamison and Frederick Goodwin found a high frequency of bipolar affective disorder and suicide in creative individuals (Jamison,1989). They studied the case of the composer Robert Schumann, who is generally acknowledged to have suffered from bipolar disorder (see Table 1). There is a strong relationship between the quantity of Schumann's output and his mood. Base on the case study they assumed mania is the cause of the creativity (Goodwin & Jamison, 1990). However, Robert (1993) claimed a high level of bipolar affective disorder in creative samples does not mean there would be a link between creativity and psychopathology. He assessed the quality of Schumann's compositions, and the result showed that the highest proportion of compositions did not systematically change over Schumann's career.

Year	Number of composition
Depression	
1830	X
1831	X
1839	XXXX
1842	XXX
1844	-
1847	XXXXX
1848	XXXXX
Mean 2.7	
Hypomania	
1829	X
1832	XXXX
1840	XXXXXXXXXXXXX
1843	XX
1849	XXXXXXXXXXXXXXXX
1851	XXXXXXXXX
Mean 12.3	

Table 1 Schumann's Productivity as a Function of Mood

The concept that creativity correlates to mental illness continues into our time. The majority of people still think that madness and creativity are linked. Creative individuals are eager to distinguish themselves from ordinary people. People think of creativity as a magical searchlight which unerringly finds its target an extraordinary capacity for producing significant ideas. The only reason for this view is that they think of creativity as a hidden mental ability (Sawyer, 2006).

Another hypothesis on creative thinking was the viewpoint called ' cognitive unconscious.' The supporter of this view, Henri Poincare, believed that creative ideas come from the combination of old ideas in the unconscious. On the basis of Poincare's view, Koestler concluded that creative thinking used 'bisociative thinking' to combine two previously separate associative subject to produce a new idea (Patrick, 1935).

Nevertheless, Robert Olton, in an interesting series of studies, tried to corroborate Poincare's viewpoint by observing professional chess players trying to solve a chess problem. The chess players were divided into two groups. Each group had a few hours to work on the chess problem, but one group was given a break while the other group worked continuously. The group given the break was asked not to work on the problem during the breaking period, in order to let the bisociative thinking process work. Surprisingly, the study did not find evidence for supporting Poincare's view: the group which given a break performed no better than the other group (Olton, 1979).

2.1.4 Define Creativity

What is creativity? Numerous definitions exist for the term (Brockam, 1993). The definition of creativity has two camps. In one camp, creativity requires some socially valuable product to be generated. In another camp, creativity does not need anything socially valuable (Weisberg, 1993).

Creativity comes in a great variety of forms. Creativity may be quite ordinary and inconsequential; for example, it may be something as simple as making up a bedtime story for kids, or it may be world-shaking, as was Leonardo da Vincis's masterpiece (Fey & Rivin, 1996). Creativity is not a burst of inspiration but is mostly conscious hard work. Most of the innovations come from hard work prepared with mini-insights (Sawyer, 2006).

Hayes (1978) defined creativity in terms of valuable consequences and novel or surprising outcomes. Huap (1989) explained that creativity is the synthesis of new ideas and concepts through radical restructuring and reassociation of existing ones. In support of this idea, Altshuller, as a patent examiner, discovered that 98% of patented innovations were based on already known principles (Terninko,1998).

At this time in the history of inquiry into creativity, most researchers accept a conceptual definition of creativity that includes two elements: novelty and appropriateness. Creativity is to be different from what had been done before but also be appropriate, correct, useful, and valuable (Brockman, 1993).

2.1.5 Approaches to Train Creativity

Self-improvement is always one of the great topics in our society, and creative thinking is one area which many people seek to improve. In order to help investigate creativity, Guilford (1950) presented a set of hypothesizes concerning the specific abilities important in creative thinking.

Guilford (1950) hypothesized that individuals differ in how sensitively they faced problems, and individuals differed in fluency when people produced ideas by introducing the creativity test tasks (Guilford, 1950).

In this test, creative thinking was assumed to involve attacking a problem from a new direction, which implies flexibility of thought (Robert, 1993). Based on this test, Guilford (1950) introduced two kinds of thinking that were important to creativity: divergent and convergent. Divergent thinking uses fluency, flexibility, and originality to 'diverge' from what people know, to produce many original ideas; convergent thinking, the logical mode of thought, uses the information to 'converge' on a single solution or idea (cited in Mansfield & Busse, 1981). However, Guilford's creativity training lacks corroboration from scientific psychology, partly because of most psychologists at that time were not interested in creative thinking.

The concept of divergent thinking is closely related to 'brainstorming,' a hugely influential group-problem-solving, developed over 40 years ago by Alex Osborn. The brainstorming technique was designed to help thinkers produce ideas by diverging from their habitual way to approach problems (Osborn, 1953). However, the hypothesized effect of brainstorming has been eroded by many recent studies (Diehl, 1991). Researchers have found that while wide-ranging thought increases the randomness of ideation, it might decrease the useful ideas production (Jacob, 2002). Another study showed that ideas suggested by individuals working alone were evaluated as superior to ideas suggested in brainstorming sessions. The main conclusion of the study was that randomness and disorganization prevent creativity (Paulu, 1993).

Boden (1991) indicated that constraints make creativity possible. Random processes, if they happen to produce anything interesting at all, can result only in first-time curiosities, not radical surprises. This viewpoint can be proved by Altshuller. Altshuller refused to accept the fact that inventions and creativity were random or chance act. He discovered that 98%of patented innovations were based on an already known principle (cited in Alla & Boris, 1998). Perkins (1981) also indicated that thinking within a frame of reference requires sensitivity to the rules of the game and that by functioning within such a frame, one is better able to notice or recognize the unexpected.

The adoption of a structured ideation process which best mimics the thinking patterns that people follow when engaged in creative thinking can improve innovation. According to the creative cognition experiment conducted by Finke, Ward, and Smith (1996), the subjects often search for new features in the forms (e.g., images and objects), then contemplate their functional properties, imagine themselves using these forms and, finally, mentally elaborate on the context in which the forms should be found. This sequence of events underlies the notion of function follows form. Accordingly, people are more likely to make creative discoveries when they analyze novel forms and then assess the benefits; they may project rather than trying to create an optimal form solely from desired benefits (Finke, Ward, & Smith, 1996).

Structured approaches have been developed in a variety of disciplines such as linguistics anthropology, random graphics, venture and transitional management, and artificial intelligence. Many current ideation techniques, such as Morphological Analysis, TRIZ, and the Zaltman Metaphor Elicitation Technique, also embed structured approaches.

2.2 Product Evolution

Every product developed today builds on earlier products or knowledge. Products that do not function well do not survive, because failed products cannot meet market needs (Eger & Ehlhardt, 2018). Products evolve in response to "environment pressures." Over time, market needs and desires are encoded into the product, the configuration of which becomes a physical representation of the past selection of the market or an "echo" of past customers' preference (Goldenberg, 2002).

Geoge Basalla (1998) pointed out that any new thing that appeared in the world was based on some object that already exists. Such an assertion appears to be proved by the case study of eating utensils. The eating utensils that people use daily are as familiar as their own hands. However, how did these convenient implements come to be, and why are they so second-hand to us? Such questions can serve as paradigms for questions about the evolution of all products. Seeking these answers can provide insight into the nature of product developing (Kaopf, 1993).

After prehistoric people were able to utilize fire, sticks came to be used in the same way as children today roast marshmallows. Pointed sticks, easily obtained from nearby trees and bushes, could have been used to keep an individual's finger from being cooked while preparing or eating food.

In ancient China, food was cooked in large pots, which held the heat long after everything was ready to be eaten. Therefore, people started to utilize two sticks to retrieve food from cooking pots (Henry, 1992). However, at that time, the chopsticks did not have any standard for the shape or length (see figure 4).

Figure 4 The Origin of Chopsticks

During the Tang Dynasty, the nobility believed silver would turn black if they contacted with poisoned food (however, sciences today has shown that silver does not react to toxicants). At that time, nobility started to use silver chopsticks (see Figure 5). Also, one end of the chopsticks became to be spindly, making it easy to insert into food (Zhao, 2015).

Figure 5 Silver Chopsticks in Tang Dynasty

Putting chopsticks into an evolutionary perspective, people could find out that the chopsticks were shaped and reshaped through the needs of their users. The formal evolution of products, in turn, has profound influences on how people use products (Knopf, 1993).

Although no single variable holds the key to new product performance, many of the widely recognized success factors share a common thread: the processing of market information and understanding customer needs which ultimately comes down to a company's capabilities for gathering and using market information. In other words, a firm's effectiveness in market information processing - the gathering, sharing, and use of market information - plays a pivotal role in determining the success or failure of its new products (Ottum & Moore, 1997). The notion that the market determines the fate of the product to success or failure is also at the heart of the practice that considers consumers' preferences the primary tool in planning a new product (Srinivasan, 2007).

2.2.1 Information in New Product

People tend to think that ideas arise from two sources: an "intrinsic" source based on creative thinking by a thinker, termed "ideation," and an "extrinsic" source based on market information, by searching for unfulfilled needs (see Table 2) (Goldenberg & Mazursky, 2002).

Table 2 Information Source for New Product

The market-pull theory focuses on searching the notion of understanding the market needs and desires and fulfilling it while satisfying organizational goals. Cooper and Kleinschmidt (1998) examined both successful and unsuccessful new products and found that a strong marketing orientation was frequently absent, especially in the case of product failures. However, Bennett and Cooper (1981) argued that strict adherence to the marketing concept could hinder significant product innovation in the long run, since it might encourage the firm to concentrate on minor line extensions and adjustments to the marketing mix and not to support "true" R&D adequately. Another theory, the technology-push idea, started to rise. The technology-push theory asserts that innovative ideas tend to come from technology-push innovation which often must proceed without a clearly defined customer need (Calantone & Benedetto, 1990).

Taking a close look at the historical data, some interesting facts can be found. Sony's Walkman came about incidentally (see Figure 6). The earlier monophonic Pressman, which had a recording device, was abandoned because the engineer failed to design a compact stereophonic capability. Instead of expending the necessary selling effort, it was put aside and played for the engineers' entertainment only. Only after the integration of this concept and that of light headphones was the Walkman concept defined. Even during the first stage following the introduction, the marketers did not consider this product a potential success (Goldenberg & Mazursky, 2002).

Figure 6 Walkman (Sony, 1979)

Over the past decades, companies have used the Market Research Method for the improvement and adaptation of their line of products to customers' needs. This popular line of thinking asserts that new product ideas may be inferred from the customers by capturing their current needs and desires (Kotler, 1994). This line of thinking may lead us to believe that the source from the market is imperative for understanding how products should be modified to meet market needs (Goldenberg & Mazursky, 2002).

However, the ability to achieve long term success through the market-pull method and the technology-push method has been questioned recently. The arguments questioned the consumers' ability to provide reliable information beyond their personal experience (Griffin, 1996). Steve Jobs (2011) claimed that people did not know what they want until it is shown to them. Companies' task is to read things that are not yet on the page.

2.2.2 Codes of Products

One and a half century after Darwin published his book, people still further explore concepts roots in his theories on evolution. Evolutionary ideas are now applied to other fields (Darwin, 2008). When biological evolution is compared with cultural evolution, it can be concluded that the basic principles are the same, but there are some crucial differences. Darwin explained how species evolve by adaption and selection. This process became known as biological evolution. Dawkins (1976) discussed the evolution of ideas and introduced the term "meme," by analogy with "gene." A meme is a unit for carrying biological information that can be compared to the gene as a unit for carrying biological information. Memes, or ideas, can be reproduced by word of mouth, by printing, by broadcasting. Memes have one important difference from genes. They can mutate or recombine without intention, randomly, or they can be mutated or recombined with intention in a particular purpose and direction, by transforming them or by adding new or existing thoughts or ideas, or by changing the original idea (Eger, 2018).

Products are, in fact, a well-defined combination of memes. Just as market research attempts to identify trends in the marketplace on which to base a new generation of products, so can market trends be identified by analyzing the product itself in order to predict the essential characteristics of the new product (see Figure 7) (Adler & Houghton, 1997).

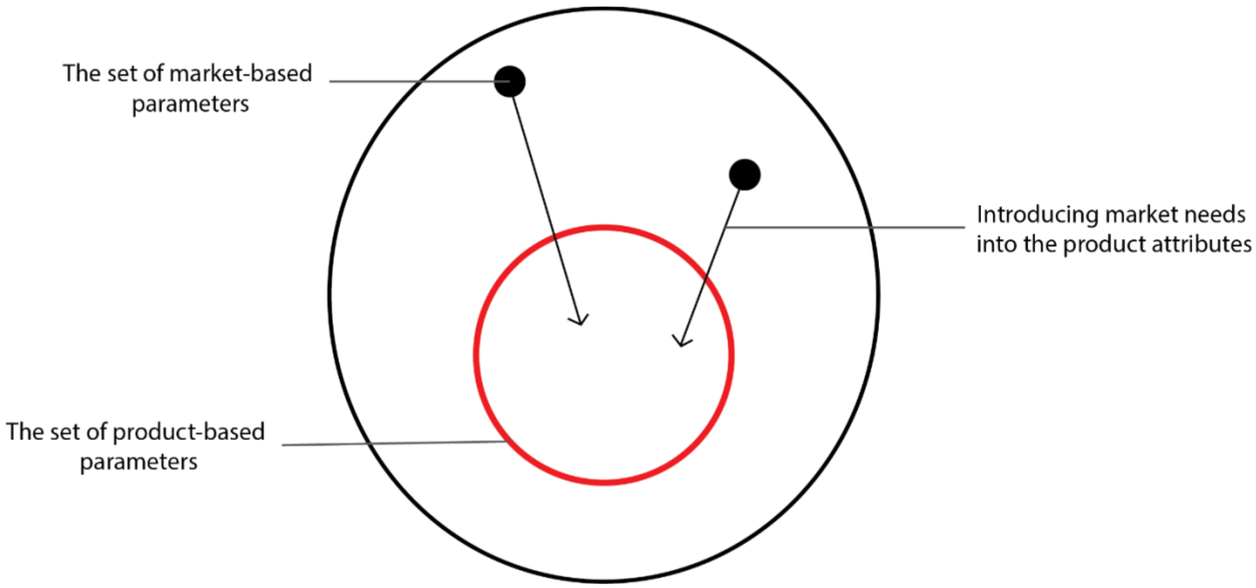

Figure 7 Mapping the Market Information into The Product (Adler & Houghton, 1997)

The following discussion demonstrates how market needs and desires are "encoded" into an everyday product-chairs.

There are some common features of different chairs.

1. Different chairs have legs of the same length, which indicates that the height of the chair is not a random parameter. There is a particular relationship between the height of the chair and the height of the table next to it

2. The backrest is meant to support the back.

3. The armrest of the dining chair support the arms.

4. The softness of the seat is meant for comfort and is related to the body and preferences of the user.

Designers may make assumptions about the chairs without asking users a single question. This can be due to the long period of evolution of chairs (Goldenberg, 2002). Over the decades, many changes and modifications of chairs have taken placed. People have proposed hundreds of ideas that the market accepted or rejected. The market, as the natural selection (in the evolutionary sense), let the good ideas survive and the poor ideas disappear. The good idea satisfies the market needs. Over time, the product becomes a physical representation of the market needs (Kolko, 2014).

Characteristics	Needs
Length of legs	Bring body to required height
Backrest	Support the back
Armrests	Support the arm
Chair on wheels	Ability to Move Chair Around the space
Adjustable backrest	Adaptability to back of user

Table 3 Characteristics and Needs of Chair

Table 3 describes the characteristics of a chair, as well as the market needs which are derived from an analysis of its characteristics.

2.2.3 Market-Based Information on New Product

Von Hippel (1987) claimed that the average user of today's product has no experience with tomorrow's products. The average user is in a weak position to provide accurate data about future products. However, late scholars indicated that valuable information might be accumulated by being attentive to "Lead Users." According to Eric Von Hippel, a Lead User has two characteristics:

1. Lead Users already have needs or requirements that other market participants, such as early adopters, will have later.

2. Lead Users benefit significantly from innovation. Some of them are already working on it themselves.

Regularly, Lead Users are used in the early stage of the innovation process; they design the innovation together with the manufacturer or in some case autonomously (Zapf, 2018).

Although this approach is valuable and well worth following, it is not qualitatively different from other market-based solutions. Altering a product according to existing market information seems to have a positive effect on the quality of an idea. However, in many cases, the relevance of a trend to a product is low, partly because the idea generation process consists of an attempt to mimic other ideas rather than to generate innovation (Goldenberg, 2002).

Goldenberg and Efron (2001) indicated that the collective dynamics of the market dictated the situation in which pioneering is likely to be initiated base on the propagation of the awareness process. The innovation-development process often begins with the recognition of a problem or need, which stimulates research and development activities intended to create an innovation to solve the problem or need (see Figure 8) (Rogers, 2002).

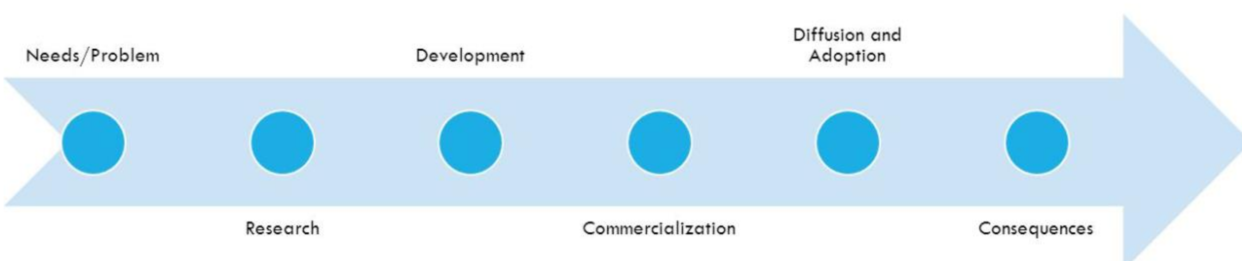

Figure 8 Six Main Stages of Innovation Process (Rogers, 2002)

The following scenario can be considered: A new, urgent need emerges, but only a few uniquely attuned individuals spontaneously discover the need. Gradually, the awareness of the need is diffused through communication (users tend to exchange or share their own needs). From a market perspective, this transition from latent to active need can be viewed as a propagation process (Efron, 2001). For each consumer, two stages of awareness can be defined: "0" represents a state of non-awareness, and "1" represents a state of awareness. The transition from "0" to "1" means some consumers become aware of the emergent need (Goldenberg, 2002).

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

(a)

0	0	0	0	1	0
0	0	1	0	0	0
1	0	0	0	0	0
0	0	0	1	0	0
0	1	0	0	0	0
0	0	0	0	0	1

(b)

1	1	1	1	1	1
1	1	1	1	1	1
1	1	1	1	1	1
1	1	1	1	1	1
1	1	1	1	1	1
1	1	1	1	1	1

(c)

Table 4 Illustration of The Propagation of Awareness (Goldenberg, 2002)

Table 4 depicts a matrix of consumers and the dynamics of the discovered propagation process at three points in time: (a) original state, (b) low awareness, and (c) almost complete market awareness (saturation of awareness). The process begins in (a), the initial state, moving through (b), the early stage of awareness formation, to (c), a market with awareness the need.

2.2.4 Analysis of the "S" Curve

Diffusion of Innovation Theory, developed by E.M. Rogers (1962), is one of the oldest social science theories. It originated in communication to explain how, over time, an idea or product gains momentum and diffuses (or spreads) through a specific population or social system. The result of this diffusion is that people, as part of a social system, adopt a new idea, behavior, or product (Wayne, 2018). Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. Diffusion is a special type of communication concerned with the spread of messages that are new ideas (Robinson, 2009). Researchers have found that people who adopt an innovation early have different characteristics than people who embrace an innovation later. For example, considering the first adopter of the telephone in the United States about 120 years ago, this innovation had zero utility to the early adopter. But when a second adoption occurred, the innovation became more valuable to both parties. And so it went until gradually there were so many adopters that an individual could assume that anyone might wish to call would also have a telephone (Singhal & Quinlan, 2018). When promoting an innovation to a target population, it is important to understand the characteristics of the target population that will help or hinder the adoption of the innovation (Wayne, 2018). There are five established adopter categories, with the majority of the general population tending to fall in the middle categories (see Figure 9).

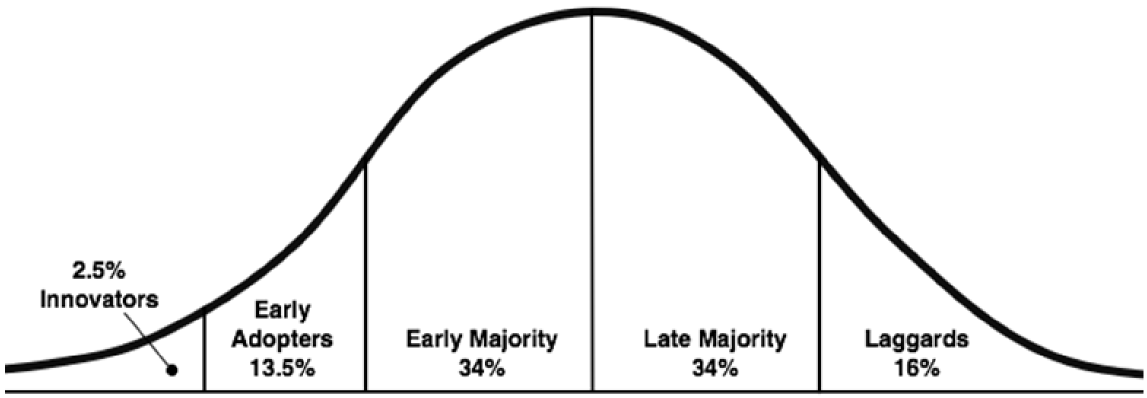

Figure 9 Five Categories of Adapter (Wayne, 2018)

The diffusion research does not have to be conducted after an innovation has diffused completely to the members of a system (see Figure 10). Such a rearward orientation to most diffusion studies help lead companies to a concentration on successful innovations. It is also possible to investigate the diffusion of innovation while the diffusion process is still underway (Rogers, 2003). Rogers also claimed successful innovation diffusion research should involve how the innovation of study was related to other innovations and to the existing practices that it replaces, and how it was decided to conduct the R&D that led to the innovation in the first place . Reinvention is a key principle in the Diffusion of Innovations Theory. The success of an innovation or a new idea depends on how well it evolves to meet the market needs (Robinson, 2009).

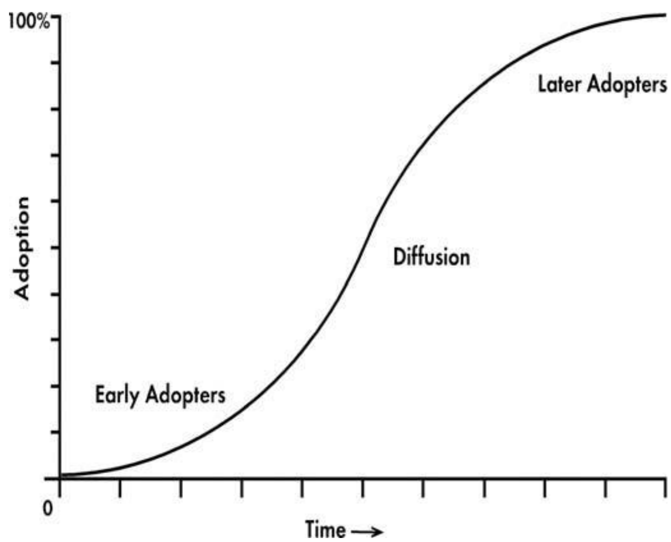

Figure 10 The Diffusion S-Curve (Rogers, 2003)

The Diffusion of Innovation explains how innovations are taken up in a population. It helps companies to understand what qualities make an innovation spread successfully (LaMorte, 2018). However, the same model can also explain the diffusion of awareness about a new idea.

When a real need is emerging, these results show that information about the need propagates slowly at first, then proceeds rapidly, gradually relaxing over time. Region II, in Figure 11, describes the fast diffusion of awareness. The market for the need is finite, and therefore the rate of diffusion tapers off as the relevant public is "saturated" with the awareness of the need or want (Goldenbeg & Mazursky, 2002).

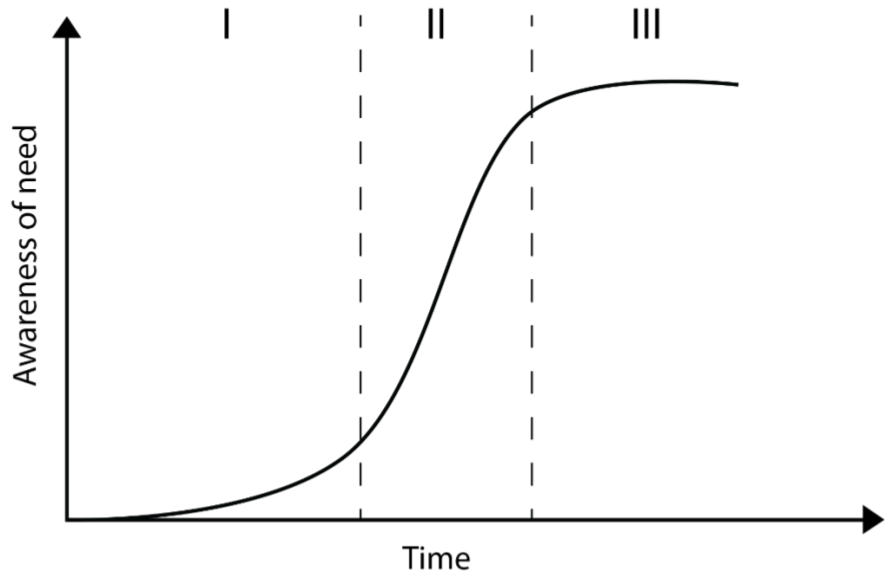

Figure 11 Diffusion of Awareness About a New Idea (Goldengerg, 2002)

Figure 11 describes the results of such diffusion of awareness process about an emerging need over time. It has three regions (Goldengerg, Mazursy, & Solomon, 1999):

Region I: It represents the initial stage in which few people are aware of the idea for a particular product. The need for the product is latent: the potential exists, but it has yet to emerge as a recognized need.

Region II: It represents the stage of fast diffusion of the awareness, in which the market moves from the initial phase to the saturation phase.

Region III: It represents a state in which the market is saturated with information about the idea.

Let us portray this concept through an example. Coca Cola and Pepsi Cola were developed during the same period, immediately after the prohibition of alcoholic beverages were declared in United States. These drinks which contained a low dosage of codeine had an effect similar to that of alcohol (Mingo, 1994).

Marketers know that they must often anticipate the competitors, so they can "climb" the steep side of Region II. The earlier they capture it, the higher the surprise effect (Lehmann, 1998). If the idea is captured later (as it nears the saturated stage), it may be possible to save the resources needed for examining its appropriateness to the market, as in this stage one may be more certain of a real need (Goldenberg, 2002). The major differences between the two extremes-Region I and Region III- are presented in Table 5 below.

Region I	Region III
Insufficient information in the market	Ample accessible information
Most ideas extracted from the market will be surprising	Most ideas extract from the market will not be surprising
High probability of surprising the competition	Difficult to surprise the competition
Location of new ideas and needs through market research is ineffective	Market research maps needs and assesses them effectively

Table 5 Region I Versus Region III

2.3 Popular Creative-Based method

In order to understand how this creative-based design template compares with other creativity-enhancing methods, the following sections critically review some of the popular creativity-enhancing approaches. The most detailed discussion will be devoted to brainstorming, which is probably the most widely recognized and implemented method in almost every occupation.

2.3.1 Brainstorming

When most organizations need to unleash creativity, they follow mainly the same formula: assemble a team of people and put them together to spit out as many ideas as they can. In short, they utilize brainstorming (David, 2013).

In 1957, Osborn developed an extensive set of procedures on freeing imagination. One central component of these procedures was the separation of judgement from the creative process. The key to free one's imagination, according to Osborn, is suspended judgment-Brainstorming (cited in Mougeau, 1993). According to Osborn (1957), in order to be maximally productive, brainstorming should follow four rules:

1. Criticism is ruled out. The adverse judgment of ideas must be withheld until later.

2. "Free-wheeling" is welcomed. The wilder the idea, the better; it is easier to tame down than to think up.

3. Quantity is wanted. The greater the number of ideas, the more the likelihood of winners.

4. Combination and improvement are sought. In addition to contributing ideas of their own, participants should suggest how ideas of others can be turned into better ideas; or how two or more ideas can be joined into still another idea.

These rules are designed to generate a large number of ideas by sparking creativity through suspended judgment.

Some scholars claimed that brainstorming, when done properly, could generate lots of ideas. However, brainstorming in practice is rarely done effectively. Most people equate brainstorming with getting a crowd together and throwing out potential ideas (Darkus, 2013).

Those scholars believe brainstorming has been abused and misused. A lot of people view brainstorming in an additive way. But that is not the power of the group. The group's power comes from the synergy beyond the additive. What the most creative companies do is tell the members of the group to come up with lists of ideas that bump up against one another and merge in surprising new ways that any person might not have thought of on their own (Sawyer, 2012). In addition, when most people brainstorm, they focus too much on ideas as individual entities, not as building blocks for more ideas. Even Osborn recognized that gathering people in a room and merely brainstorming was insufficient for producing truly creative ideas. To Osborn (1963), creative ideas and solutions involved spending time considering three things: facts, ideas, and solutions. Osborn believed that creative teams needed to spend sufficient time with each of these components individually. Instead of jumping right to solutions, which many brainstormers would do, teams should have ample time to discuss the facts and information surrounding whatever it is that needs to be done (Darkus, 2012).

However, some researchers pointed out there is not a clear advantage of the brainstorming group relative to the results of individuals who work alone (Diehl, 1991). The following is a list of some relevant factors that have been proposed (Paulus, 1993):

1. Production blocking. In the ideation phase, one person speaks while the others listen. As at any single moment in time only a single person can contribute ideas to the group, so the scope of the potential contribution of individual group members is limited.

2. Freeriding. As in many groups in which individual efforts are combined, brainstorming groups are not immune to attempts at free riding. In a group situation, individuals contribute their ideas to a group pool, consequently granting recognition on a group level. An opportunity is created for some members to hang onto the coattail of other, more productive members, and bask in the recognition won by group efforts without contributing personally.

3. Distraction. The flow of ideas spoken aloud overwhelm individuals straining to concentrate and developing their own innovative thought. Repeated interruption compels them to withdraw into more straightforward ideas that are better able to withstand the "external noise."

4. Deferred judgment creates a chaotic world. In a world with no judgment or criteria for assessment, individuals have no way of knowing if they are "on the right path." Rather than promoting uninhibited thoughts, the absence of criteria for successful ideas blocks the flow of thought. This situation creates two phenomena: one is a type of helplessness and lack of direction; the other is related to the cognitive loss of bearing whereby random attempts to generate ideas unfounded on prior reasoning typically produce routine, well-rehearsed thoughts.

5. Fear of assessment. Apparently, despite instructions of participants prior to a brainstorming session, a degree of apprehension of negative social feedback and criticism persists, inhibiting members from expressing all their original ideas.

However, the fact indicates brainstorming is adopted widely. If people assume that such a large number of people cannot be wrong, then what makes brainstorming so popular? A major reason for the method's popularity is found in the organizational functions served by the process, and the resulting organizational benefits that are its results (Sutton & Hargadon, 1996):

1. Support of common organizational memory. Brainstorming sessions help organization members acquire, store, retrieve, modify and combine knowledge of various solutions to the problems they face. The sessions create opportunities to add new knowledge and solution to organizational memory. Furthermore, the sessions serve as an efficient means of distributing knowledge among organization members, reinforcing the knowledge of elder members and imparting organizational knowledge to new members, including solutions generated previously.

2. Diversification of ability. Participants in brainstorming frequently define it as a pleasant and fun experience. Part of the enjoyment is related to the possibility of working with others in an unrestricted manner. For most participants, the session is a social encounter, an opportunity to share experiences and discharge everyday stress. In other words, brainstorming affords participants the opportunity to experience diversity and interest that is not always present in their daily functions.

3. Competition over status. Brainstorming is an important organizational arena in which competition over status takes place. The rules of the brainstorming session are known to all:

although bad ideas are not criticized, good ideas are praised, creating an opportunity to receive less threatening feedback from organization members.

4. Impressing clients. Brainstorming is an opportunity for the organization to convey the competencies of its members. Frequently clients are impressed by creativity expressed in the meeting, and they love the positive atmosphere. Organizations use the process to show their client that they understand the problem, and they rely on a wealth of experience to arrive at the best solution.

2.3.2 Six Thinking Hats

The concept of the Six Thinking Hat was introduced to people by Sir Edward de Bono (1933). This technique is a thinking tool for group discussion and individual thinking. Combined with the idea of parallel thinking which is associated with it, Six Thinking Hats provides a means for groups and individuals to think more effectively, and a means to plan the thinking processes in a detailed and cohesive way (cited in Sheth, 2012).

The premise of this technique is that the human brain is designed to think in six different manners (see Figure 12). This method uses six different "natures" of thought, each represented by a different colored "hat" (De Bono, 1985).

1. White Thinking Hat. Once you are wearing this hat, you only think about facts, figures, data, management information system, true and actual information. In a group, wearing this hat would mean no arguments, no biased opinion-just collecting all the facts and figures and keeping

them on the table. Only data should be done here. White Hat is a very fundamental hat, as without collection of facts and data, no decision should ever be made.

2. Red Thinking Hat. Once you are wearing this hat, you let out your emotions. The person wearing a red hat needs to release their feeling to all without being obliged or give an explanation for his view. On one should be asked to support their opinions or explained why they feel the way they feel.

3. Black Thinking Hat. This hat is an essential one-most often the black hat is misunderstood for being a bad hat. This hat plays a role of caution and critical evaluation. It is not a bad hat; It allows the participants to put forth their word of caution. But participants should avoid falling into the trap of using this hat too much. It should not be over-used.

4. Yellow Thinking Hat. It is the hat of optimism and positivity. Wearing this hat, the participants will put forth the strengths and benefits of implementing the idea.

5. Green Thinking Hat. It is the creativity hat. The participants wearing the hat have to come out with creative ideas.

6.Blue Thinking Hat. It is the control hat, usually used by the chairperson of the meeting. The person wearing this hat has to control the conduct of the meeting.

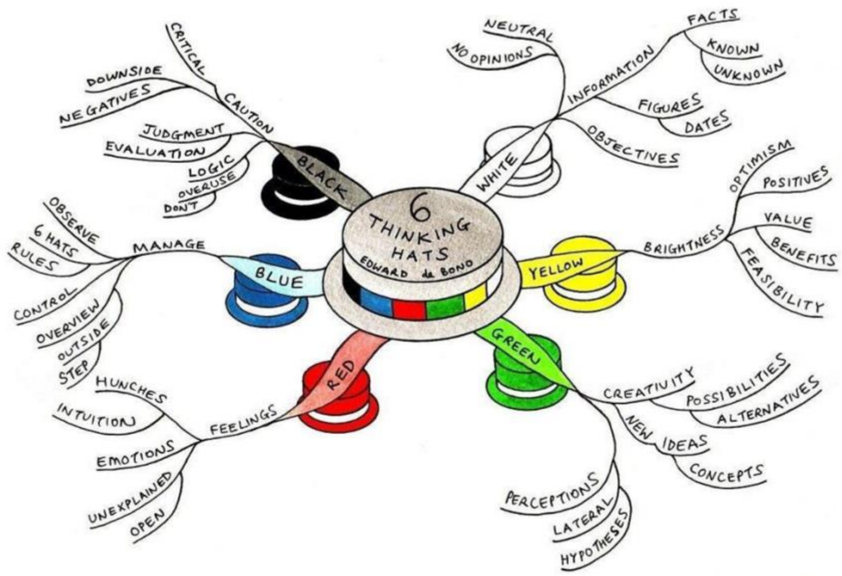

Figure 12 Six Thinking Hats

One of the great strengths of the six hats method is its design as a type of parallel thinking, which is an alternative to the argument (Elion, 2014). De Bono (1985) noted that it was typical in many cultures to rely on a traditional argument method, which is often unfriendly, personal, messy, inefficient and non-constructive. When used properly, the Six Hats Method has the potential to alleviate all of these issues. Another important benefit of the method is that the Six Hats Method helps to ensure that no mode of thinking is neglected or discounted, and people do not get bogged down in one mode of thinking too much (Kivunja, 2015).

However, how does the Six Hats Method compare to the other type of structured thinking tools? The problem here is that the model is wrapped in extravagant claims by the author, and yet the scientific data to support these claims is not very robust or credible (Macjinoon, 2007).

Another potential danger of the model is the excessive influence of the chairperson who wears the blue hat. While de Bono makes it clear that any member (in theory) can partake in blue hat thinking, it is very common in practice for a single leader, facilitator or chairperson to function in this role. This raises questions about the potential abuses of power (Allen,2013). For example, if a manager is biased towards a particular idea, she may use the hats in the desired sequence, exert undue influence on the process, and shift the conversation in a favorable direction to support her agenda. The influence of the chairperson is an area that de Bono could have explored in more detail (Hamm, 2008).

2.4 TRIZ

TRIZ, which means the Theory of Inventive Problem Solving, developed by Genrikh Altshuller (1956), states that while the evolution of technology is composed of haphazard steps, in the long run, it follows repeatable patterns. The name, Theory of Inventive Problem Solving, reflects Altshuller's initial intention when developing TRIZ. He wanted to replace the uncertainty of the trial and error process with a structured approach to resolving difficult engineering problems (Fey & Rivin, 2005). TRIZ is about providing means for problem solvers to access the good solutions obtained by the world's finest inventive minds (Mann,2001).

The uniqueness of TRIZ is that it combines knowledge of all these groups (Savransky, 2000):

1. It uses some philosophical concepts of dialectics, materialism, and idealism for its roots.
2. It uses the results of cognitive sciences for suppression of a solver's psychological inertia.

3. It uses natural science effects and phenomena for improving artificial technical systems and technological process.

4. It analyzes breakthroughs to recognize generic heuristics and design principles and to extract major trends in technological evolution.

According to TRIZ, universal principles of creativity form the basis of innovation. TRIZ identifies and codifies these principles and uses them to make the creative process more predictable.

In other words, whatever problem you're facing, somebody, somewhere, has already solved it (or one very like it). Creative problem solving involves finding that solution and adapting it to your problem (see Figure 13).

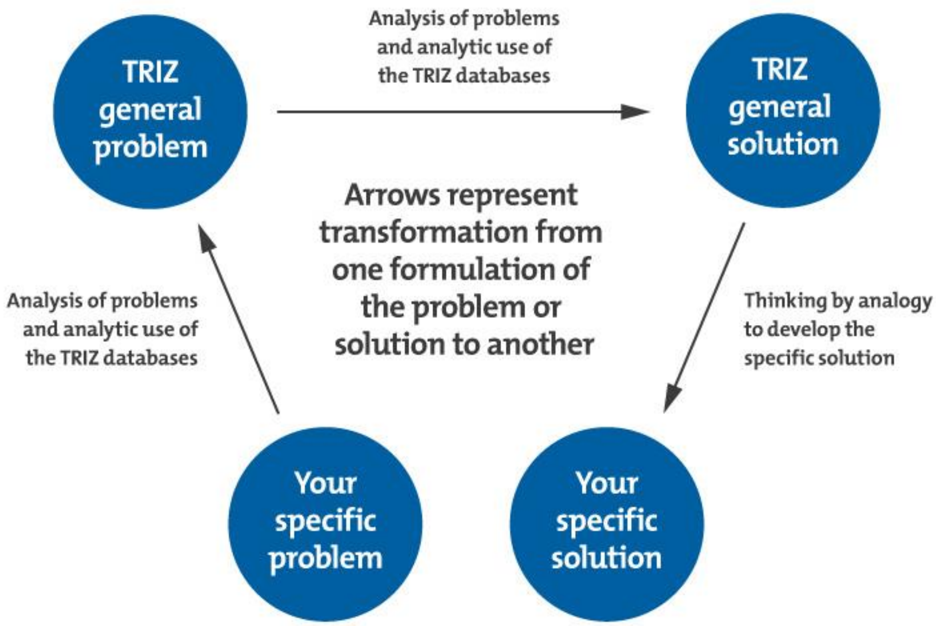

Figure 13 TRIZ

TRIZ is now a powerful methodology for technical problem solving that leads to enhancement of existing technique and strong acceleration of progress. However, after 50 years of development, TRIZ is still in its "childhood" because of political and economic situations that interfered with its progress, and its limitation-TRIZ focuses on well-defined problems.

2.4.1 Technological Systems

The father of TRIZ, Genrikh Altshuller (1986), defined the term "system" as a set of orderly interacting subsystems intended for executing specific functions. It possesses behaviors and properties that cannot be reduced to the behaviors and properties of its separate subsystems. Indeed, all entities, biological, societal, technological, and others can be viewed as systems. Most authors agree that a system is a finite set of parts collected to form a conceptual whole under certain well-defined rules, whereby certain definite relationships exist among the parts and with its environment (Savransky, 2000).

Any technology system, be it a pencil, book, beverage, vehicle, space station, or an assembly line, is designed and built to perform functions. Technological systems are organized as hierarchies (Fey & Rivin, 2005). In a hierarchy, any system contains subordinate subsystems, and itself may serve as a component for a higher-level system (see Figure 14). For example, a keyboard is a subsystem of the input equipment, which is a part of the higher-level system of "computer." One system can belong to various higher-level systems that many impose conflicting requirements on this system (Fey & Rivin, 2005). For example, a watch exists in at least three domains-technical (timekeeping), societal (conveying the owner's status), and in the domain of human physiology. However, some people are allergic to metals. When gold touches their skin, they experience an allergic reaction. This unpleasant reaction may present a challenge for the designer of high-end watches.

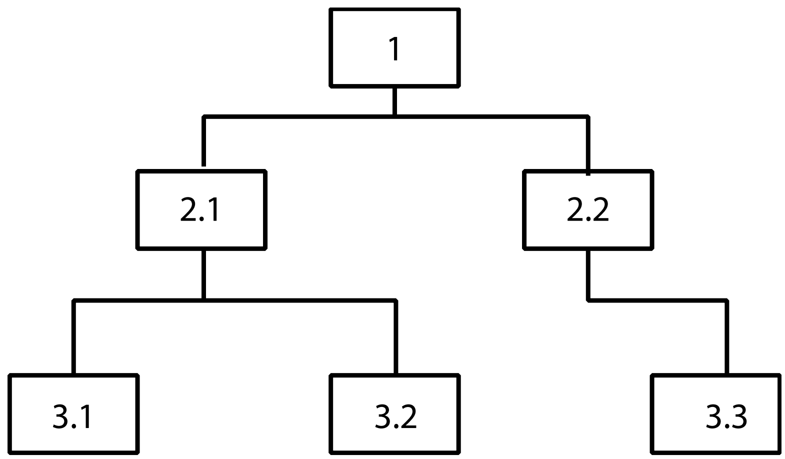

Figure 14 Typical Hierarchical System (Fey & Rivin, 2005)

Many systems originate as proto-systems, with their elements completely independent or loosely connected. Any system has specific characteristics making it not equal to a simple summation of its constitutive elements. Aristotle stated that the whole is greater than the sum of its parts. Therefore, the main advantage of a system over separate elements is its systemic effect (Terninko, Zusman, & Zlotin, 1998).

2.4.2 System and Physic Conflicts

Conflicts are indicative of inventive problems arising from the apparent incompatibility of desired features within a system. Resolving the conflicts solves the problems (Ilevbare, Probert & Phaal, 2013). A conflict is present when (Fey & Rivin, 2005):

1. a useful action simultaneously causes a harmful effect

2. the introduction (intensification) of a useful action or the elimination (alleviation) of the harmful action produces an inadequacy or an unacceptable complication of either one part or the whole system.

There are two major types of conflicts: technical contradictions and physical conflicts (Ilevbare, Probert, & Phaal, 2013).

1. System conflicts: This arises when an attempt to improve certain attributes or functions of a system leads to the deterioration of other attributes of that system (see figure 15). For example, the bigger, more powerful engine proposed for a car to increase its speed would contribute more weight to the car, which in turn limits how fast it can travel, therefore negating the desired benefit of increased speed.
2. Physical conflicts: This arises when there are inconsistent requirements for the physical condition of the same system. For instance, a system might have a function which is both beneficial and adverse or unpleasant. For example, an umbrella's big size helps with protection from rain, but may make it too cumbersome to carry around, and therefore, its size requirements (big umbrella for protection and small umbrella for convenience) present a physical contradiction.

The strength of searching conflicts lies in two characteristics. First, it is superior at illustrating the crucial elements of any systems. Second, it can help practitioners understand the conflict better, simplifies problem solving and can lead directly to a solution. However, to identify the zones of conflict, a well-defined problem need to be obtained. In real life, industrial designer, usually confront the problem or potential with very little clarity. Therefore, combining

System Matrix which building in this chapter with TRIZ will be more efficient for industrial designers.

Chapter 3

3.1 System and Problem Information

In reality, design or inventive problems are not always clearly defined, and team members do not always know all relevant information. Therefore, at the first step, people need to have a good understanding of the design system around the problem before embarking upon an improvement process.

Figure 15 Bone Screw

Take the bone-screw system as an example (see figure 15). The problem of the bone screw is people needs the screw to hold bones while recovering, but people needs to remove the screw when the bone heals. This design problem can be defined as a system which contains two subsystems:

1. Screw and bone system. The screw holds bone surfaces in position.

2. Screw and screwdriver system. The screwdriver helps to tighten the screw and to turn the screw out.

3.2 Constitute Matrix

A system provides a function when something else is affected, which means the system represents the action between tools and objects.

A function contains two components. One of these components, an object, is to be controlled. Since the object cannot normally control itself, it needs another component, a tool, to execute the required operation.

Base on the system information, the matrix can be constituted. In the case of the bone-screw system, the functions can be shown in Figure 16. To constitute the matrix, people need to collect three parameter sets: screw, screwdriver, and bone.

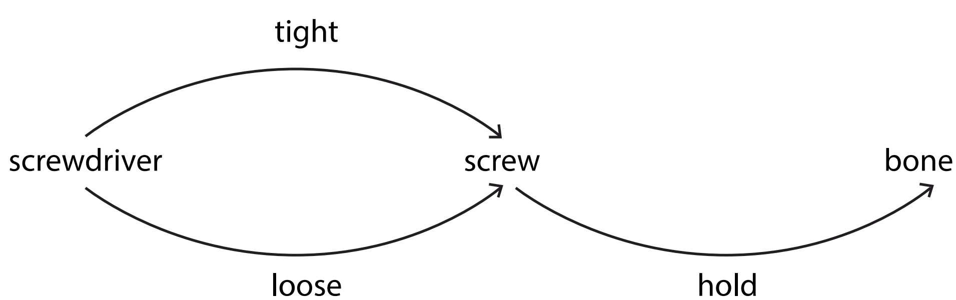

Figure 16 Functions in Bone-screw System

In this chapter, people shall focus on the systematic identification of these parameters and describe in detail the structured creativity process.

3.2.1 Parameter Sets

Applying this design template, people aims to read the "code" embedded in the product system. Therefore, the potential changes can be searched in the information map. First of all, people should search for the parameters of the product.

There are two camps of parameters: internal parameters and external parameters.

An internal parameter is a variable that is in direct contact with the product, but not under the manufacturer's control. For example, the height of a desk, the price of a phone, the material of a bike, they are all internal parameters.

An external parameter is a variable that is in direct contact with the product, but not under the manufacturer's control. Such as the environment temperature, the time, user's physical condition. They are all outside of the manufacturer's control.

Taking the drinking glass as an example, its internal parameters and external parameters cane be listed (see Table 6). In Table 6, the feature belonging to each parameter can be observed.

Internal parameters	External parameters (drink)	External parameters (user)
Height	Temperature	Sensation
Diameter	% alcohol in drink	Lip size
Color	% sugar in drink	Hand size
Heat conductivity		
Transparency		
Weight		

Table 6 Example of Internal and External Parameter

1. As the manufacturer controls the internal parameter, the number of internal parameters is limited.

2. External parameters are variables basing on experience or observation. It may have direct contact with the product at a certain place or time. Usually, there are two sets of the external parameters, which represents the other two components besides the product.

Observing internal and external parameters, designers may deduce and define the relationship between parameters. Therefore, it is possible to develop a method to extract the potential information which applies to the new design process.

3.2.2 Constructing the Matrix

Last section taught people to define the elements of the system as internal and external parameters. The next step is to extract the potential information between those parameters.

Designers can use a structured matrix to scan these parameters, searching for the opportunity to build a new idea. The System Matrix represents a system, which is composed of three axes. Each parameter set locates on one axis. Off-diagonal cells indicate the interaction between different parameters.

Let us assume the problem for drinking glass company is optimizing the drinking experience of the drinking glass. Designers can list three parameter sets which relate to drinking experience: drink, user, drinking glass. The internal parameters of the drinking glass are easy to list; height, diameter, color, heat conduction, transparency, weight. According to our experience, designers also can list the typical external parameters.

Drink: temperature, the percentage of alcohol or sugar in the drink.

User: the range of movement, lip size, hand size.

Table 7 shows the matrix of the drinking glass system. One needs to pay attention to those external parameters from the same component and they should be listed on the same axis. For example, the temperature, the percentage of alcohol and sugar in the drink come from the same component-drink. The range of movement, size of lip and hand come from one component-user.

The reason designers need to separate external parameters into different categories is that different component interacts with the product differently.

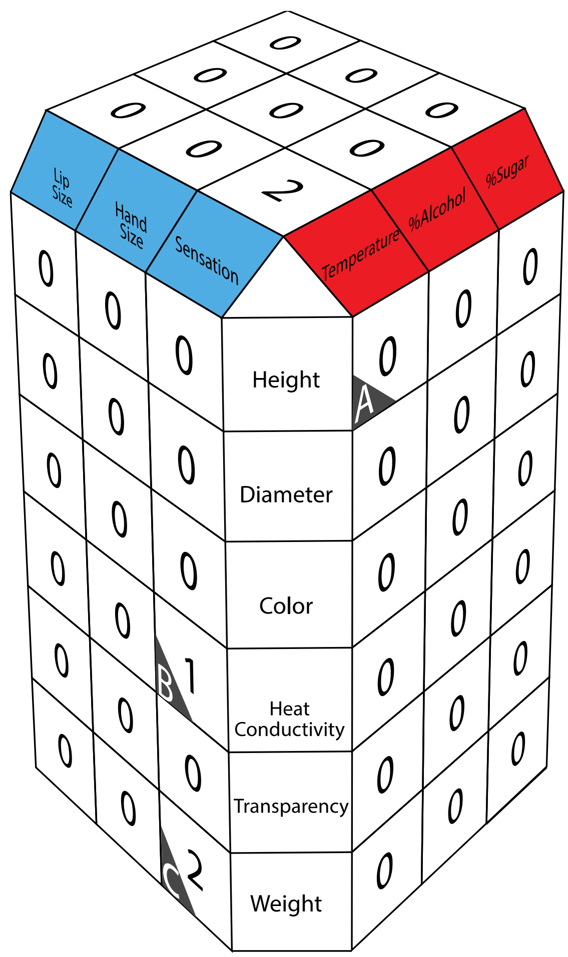

Table 7 System Matrix of Drinking Glass

Each cell in the matrix indicates the interaction between two parameters. Let us focus on the Cell A marked on the matrix. In an ordinary situation, height would not bring any change to the temperature of the drink. Therefore, there is no interaction between this pair of parameters. Base on the diffusion awareness, people can see this need may still lay in Region I (initial stage, which almost nobody knows this need) or Region II (early stage, the stage of fast diffusion of the awareness). In this case, "0" represents no interaction between two parameters.

Looking at the matrix Cell B, there is an indirect interaction between "sensation" and "heat conductivity"-user can feel the temperature because of the heat conductivity. Then designer can mark "1" which means there is a weak interaction between each other.

For the matrix Cell C, there is direct interaction between "sensation" and "weight". Then designers should mark "2" which means there is a strong interaction between the two.

3.2.3 Extreme Condition: Empty Matrix and Saturated Matrix

When designers apply Design Structure matrix, they may face some extreme condition-empty matrices and saturated matrices.

An empty matrix means, in one matrix, most or all cells are in "0" mode (see Figure 17a).

A saturated matrix means, in one matrix, most or all cells are in "1" mode (see Figure 17b).

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

a

1	1	1	1	1	1
1	1	1	1	1	1
1	1	1	1	1	1
1	1	1	1	1	1
1	1	1	1	1	1
1	1	1	1	1	1

b

Figure 17 Empty Matrix and Saturated Matrix

An empty matrix indicates a high potential for this product. There are several benefits that have not been seized. However, an empty matrix also implies some risks; the new idea comes from this matrix may not arouse the user's resonance. The company needs to screen the market resource very carefully to arrive at a successful decision.

Contrarily, a saturated matrix means the company may miss the chance to catch the benefit. The need is almost fulfilled by existed products. In such a case, two alternatives should be examined:

1. Apply this template to another product.

2. Use another method. Unfortunately, this template may not be an absolutely universal template. There is always another way to extract potential information.

In reality, the matrix is rarely that sharp, but rather exhibits intermediate situations. However, it is still necessary to discuss those extreme situations. Designers should be agile enough to select the best approach.

3.2.4 Extract Interaction Through Heuristics

Let us go back to discuss the common situation. The volume of a matrix is based on our target product. As simple as drinking glasses are, the matrix may contain 15-20 parameters. When designers are dealing with a complex product or system, they may have a much larger matrix.

Comparing with extracting information from the market study, extracting information yielded by the analysis of the design structure matrix is more efficient.

	A	B	C	D	E
a	0	1	0	0	0
b	0	0	0	0	0
c	0	0	2	0	0
d	0	0	0	0	0
e	0	0	0	0	0

Figure 18 Extract Interaction in Matrix

Figure 17 indicates a simple and small volume matrix. Cell Cc is in "2" mode, which means people already built the interaction between parameter C and parameter c. Based on the product evolution thinking, this feature, selected by the market, is embedded in the product itself. Designers may conclude that the parameter C may be manipulated, and parameter c may be easily linked with another parameter (there may be more information of parameter 4 in the market can be collected).

In most cases, designers will face a matrix with many "0" and a small amount of "1". In this case, designers should randomly select one "0' modes on each coordinate plane for examining interaction.

3.3 Solving Problem

After the system matrix, a well-defined problem will be found. Solving problems usually starts with attempts to find solutions by using conventional means. However, such an approach usually fails. For example, people want to optimize the comfort of sets of the plane. One of the simplest know ways to achieve this goal is to enlarge the passenger compartment. This approach will result in increased weight and size, and consequently in increased fuel consumption. Thus, bringing one advantage may also bring more disadvantages. In this section, designer will define the conflicts between the parameter pairs, and solve those conflicts.

To solve the well-defined problem, at first, designer need to discriminate the conflict between those parameters.

3.3.1 System Conflicts

From a TRIZ standpoint, as discussed in Chapter 2, a system conflict is present when a useful action simultaneously causes a harmful effect. The introduction of a useful action or the elimination of harmful action causes an inadequacy, an unacceptable complication of either one part or the whole system.

Mostly, system conflicts may present between external parameters, as two external parameters only can interact via an object.

To resolve a system conflict means to eliminate the harmful action while retaining the useful. Four generic approaches are used for resolving system conflicts.

1. elimination of conflicting components.

2. Changing the conflicting components.

3. Introducing a special component.

4. Converting it to physical conflicts.

For the sake of convenience, the same case, drinking glasses, can be example (see table 18). Cell D represents a none interaction between external parameter (temperature) and external parameter (heat conductivity).

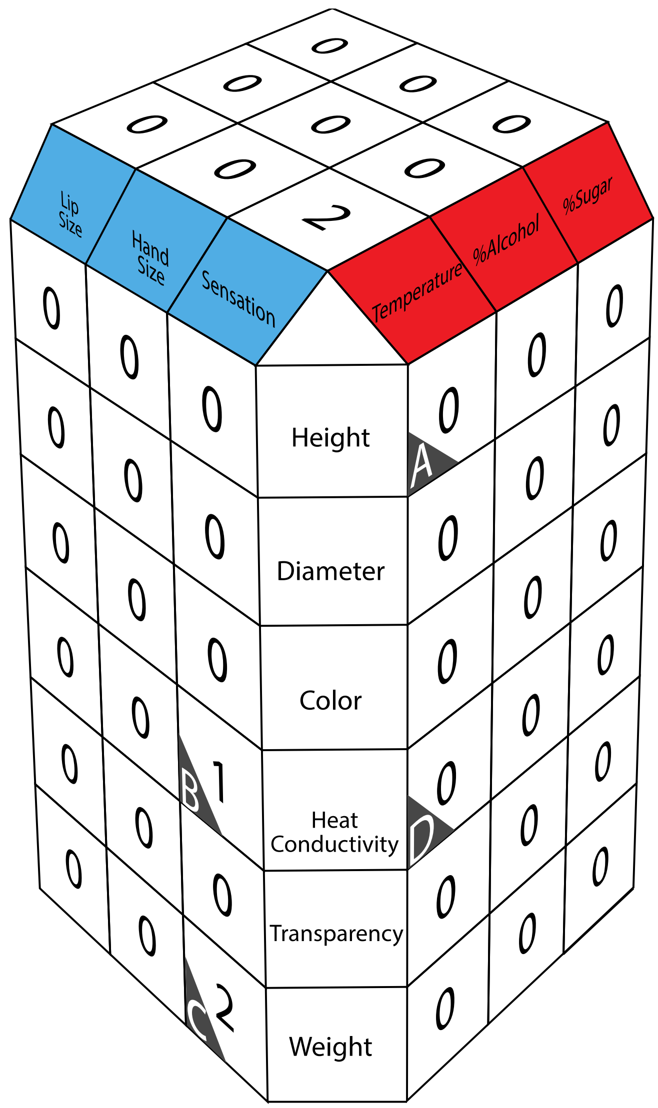

Table 8 System Matrix of Drinking Glass

In the Temperature-Heat Conductivity-Sensation system, the heat conductivity allows designer to feel the drink's temperature, but also allows the hot drink to burn our skin. Designer can figure out this is a system conflict. Following the approaches of system conflicts, They can easily see approach 2 is more appropriate, which means designer needs to change the material. The ideal situation is people can feel the temperature of the drink while preventing from being burned by the drink. Though seeking new technology, designer can find there is a new ceramic material (when it contacts hot drink the heat conductivity becomes low) that can solve this design problem. Figure 19 indicates the solution for Cell D.

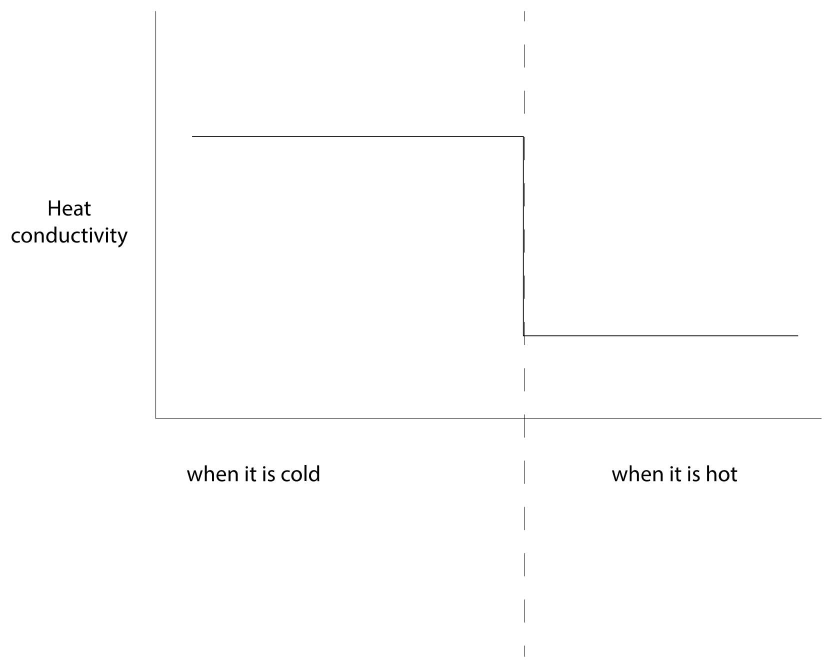

Figure 19 Solution for Cell D

3.3.2 Physical Conflicts

To perform the function, products must be in opposite physical state or must possess mutually exclusive properties. The airplane is a classic example – it must be streamlined to go fast, but it must have protrusions (a landing gear) to maneuver. McDonald’s coffee must be hot to be enjoyable to drink but must be cool enough to not burn people who spill. Physical conflicts are resolved using separation principles, subsystems.

1. Separation of opposite properties in time: at one time a component has property P, and at another time it has an opposite property -p.

2. Separation of opposite properties in space: one part of a component has property P, while another part has an opposite property -p.

3. Separation of opposite properties between the whole and its parts: a system has property P, while its components have opposite property -p.

3.4 Decision-making Matrix

Following previous steps, designer can get three new concepts which can be named as Concept 1, Concept 2, Concept 3. A fourth option is to stay with the current product (do not choose any of the new concepts).

To evaluate the options, designers need a set of criteria – a mix of qualitative and quantitative measurements. Even though all these criteria should be quantitative, there are some that are not worth refining at this stage in the development. For the quantitative criteria, designers agree on two targets, a delighted value, and a disgusted value.

In the case of the drinking glass, designer can locate the criteria in three categories:

Human	Technical	Production
Feedback General appeal	Performance	Production cost

Table 9 Criteria in Three categories

1. Production cost/ unit. It will great if each product cost less than 3 dollars; it will be bad if each product cost more than 7 dollars.

2. The general appeal of the concept.

3. Performance relative to the opponent.

4. Customer feedback. It will be great if more than 2/3 of test users appreciate the product; it will be bad if less than 1/3 of test users think it is futile.

Those criteria can be the result of a team discussion. To achieve a team agreement, designers need to ask team members or text users to rank the order of the criteria. Table 20 shows the rank result of three text users according to their needs.

Tom	Jim	Franck
Production cost	Production cost	Feedback
Performance	Feedback	General appeal
Feedback	Performance	Production cost
General appeal	General appeal	Performance

Table 10 The Rank Ordering of The Criteria Importance

Once designers finish the list, an evaluation needs to be conducted. A decision-making matrix, which is filled by target users, can help us choose which concept is better (see Table 21). It is a repeatable, consistent and flexible process to itemize the important criteria, enough to make it worthwhile.

		Wt	Concept 1	Concept 2	Concept 3
Criteria	Production cost	4	1	1	1
	Performance	2	0	-1	-1
	Feedback	3	-1	0	1
	General appeal	1	1	0	-1
	Total		1	0	0
	Weighted Total		2	2	4

Table 11 Decision-making Matrix

Chapter 4

4.1 Introduction

Within the application of the design consideration, a cup project which focuses on blind people is referenced. This project is used to test the creative-based new product design template.

This chapter will discuss the consideration which is how to provide blind people the experience of enjoying the hot drink.

4.2 Define the Product System

To begin the process of designing a cup that better serves the wants and needs of blind people, designers need to understand the product system of the cup. Figure 1 shows the hierarchical system. Based on our design requirements which is "providing blind people the experience of enjoying the hot drink," designers can easily define our product system as hot drink experience system. According to Figure 20, there are three subsystems below hot drink experience system.

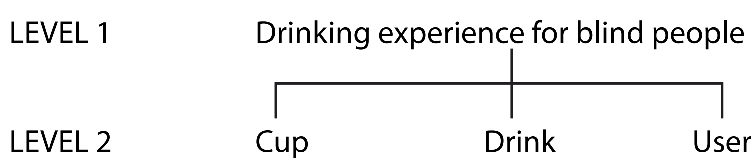

Figure 20 Hierarchical System

1. User and cup system. User needs to hold the cup while adding water or drinking water.

2. Cup and drink system. The cup provides volume for the drink, which means the cup contains the drink.

3. User and drink system. User takes the drink from the cup.

4.3 Search Parameters of Products.

With the well-defined product system, designers can easily list the internal parameters of the cup. As the internal parameters are under the manufacturer's control, this means the internal parameter is limited.

The internal parameters: Height, color, heat conductivity, rigidity, shape, texture, material of handle, shape of handle, color of handle.

The user and hot drink cannot be controlled by the manufacturer. Therefore, they are the external parameters which need to be collected via experience and observation.

The external parameters of user: hand size, tactility, hearing, lip size, operation.

The external parameters of drink: color, water level, temperature, density.

Table 22 presents the internal and external parameters of the hot drink experience.

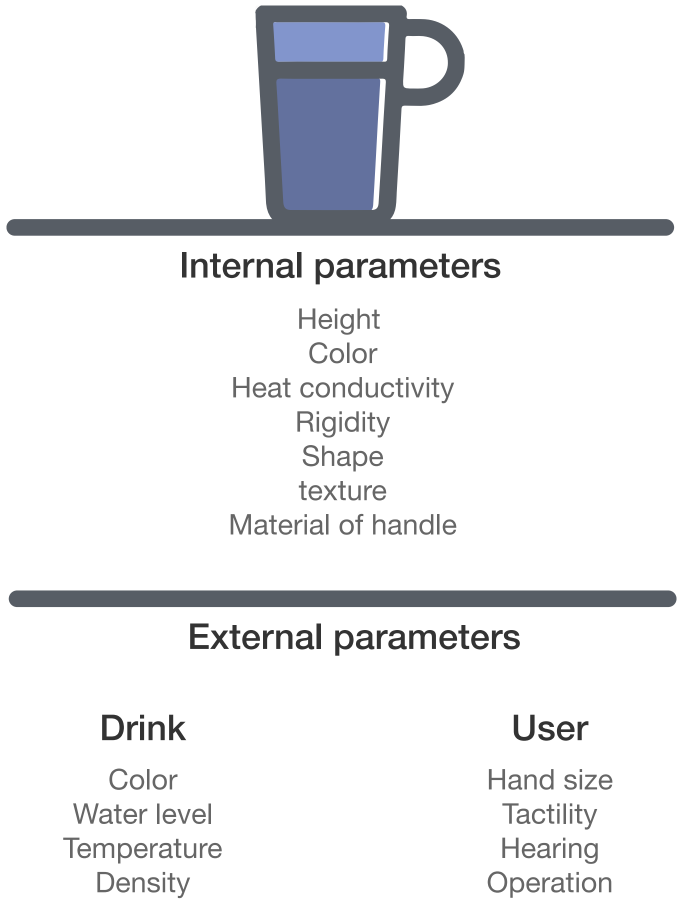

Table 12 Internal and External Parameters for Dinking system

4.4 Construct System Matrix

In order to enhance the search for the interaction between parameters, it is recommended that the product is analyzed using the system matrix developed in Chapter 3. System matrix is a tool for systematic scanning of variables, making it possible to predict developments in the product.

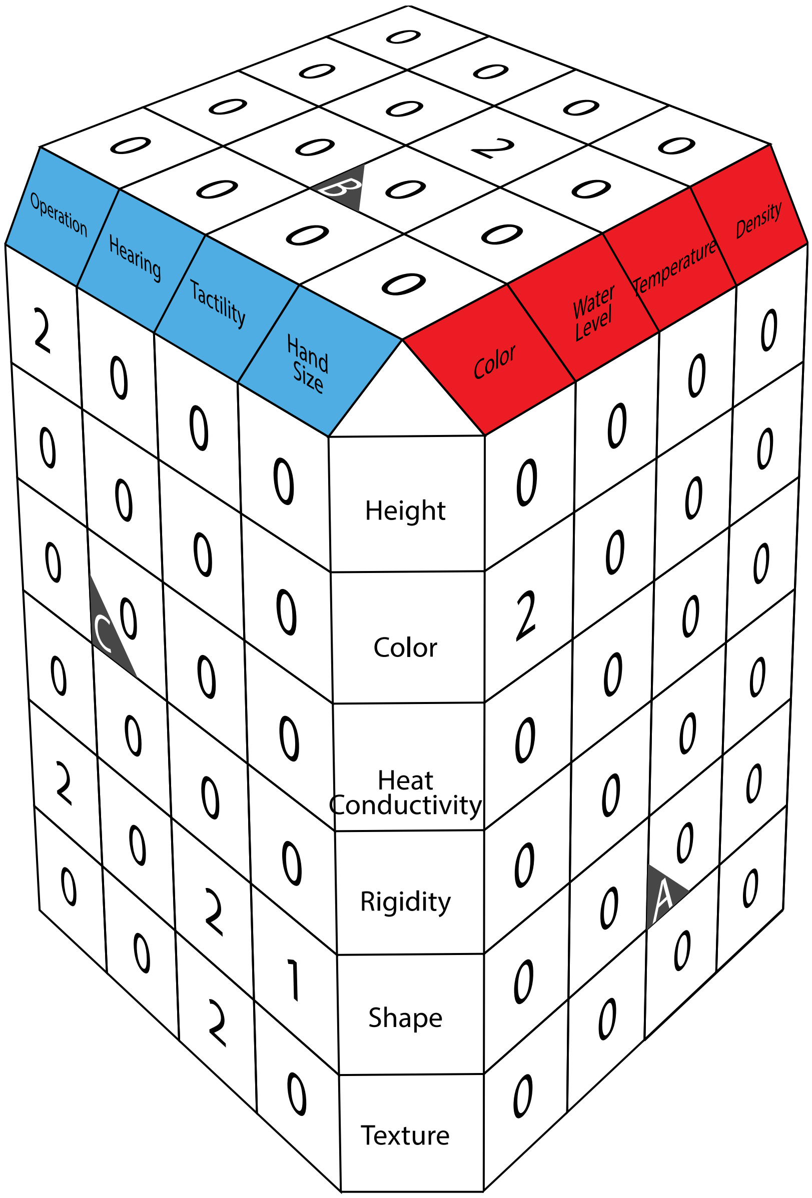

Table 13 System Matrix of Drinking Experience System

As discussed in Chapter 2, the system matrix is composed of three axes. X and Y axes are two sets of external parameters; Z axis is a set of internal parameters. Table 23 is in the form of a system matrix of drinking experience system. designer will mark a mode in which there is an indirect interaction of two parameters by the digit 1, such as the heat conductivity of the cup may affect the drink's temperature change; however, the cup's heat conductivity cannot determine the temperature of the drink. Designer will mark "2" while the two parameters have direct interaction. For example, the cup's shape may influence use's tactile sensation directly.

According to the system matrix scanning rule discussed in Chapter 2, designer should search "0" or "1" mode on each plane to detect potential information for the new idea. On plane one, designer should select Shape - Temperature which is in "0" mode (Cell A); on plane two, they should select Water level - Tactility (Cell B); on plane three, they should pick Hand Size – Shape (Cell C). Shape - Temperature and Shape - Hand Size are two internal - external pairs; Water Level - tactility is external - external pair, which requires to match an internal parameter which has direct or indirect interaction with either of these two external parameters. According to the matrix, designers can easily discover the relation below.

The internal parameter which has interaction with Tactility: Shape.

The internal parameter which had interaction with Water Level: none.

Therefore, designer can only choose the matching internal parameter-Shape. For cell A, designers also need to find a matching external parameter on the other axis. In this case, they can only select the external parameter - Tactility. For cell B, the internal parameter - Shape can match with it. For cell C, there is no another external parameter corresponding here. So far, this approach already helped designers to extract three potential interactions from the matrix. Next step is formulating the problem.

4.5 Formulate and Resolve Conflicts for Cell A

In the case of the Cell A, designer need to examine the conflict from the system which involves internal parameter - Shape, external parameter - Temperature, and another external parameter - Tactility. Figure 20 describes the relations in this system.

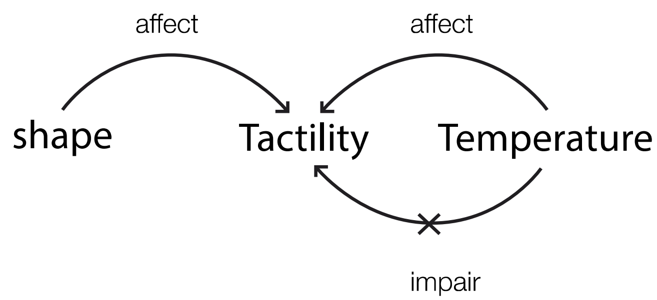

Figure 20 System Relation for Cell A

1. The cup's shape will influence user's tactility.

2. User will respond to drink's temperature accordingly. However, high temperature may burn the user's fingers.

3. There is no useful action between the drink's temperature and the cup's shape (when the cup's shape as "tool"). Besides, no action can be found between the cup's shape and the drink's temperature.

According to the definition of the conflicts, designers can infer cell A is system conflict. As when they eliminate a harmful action - temperature impairs tactility, an unacceptable complication (user cannot feel the temperature) will emerge.

As discussed in Chapter 2, three generic approaches can be used for resolving this conflict:

1. Elimination of either the tool or the object.

2. Changing the conflicting components such that the harmful action disappears.

3. Introducing a special component intended to eliminate or neutralize the harmful action.

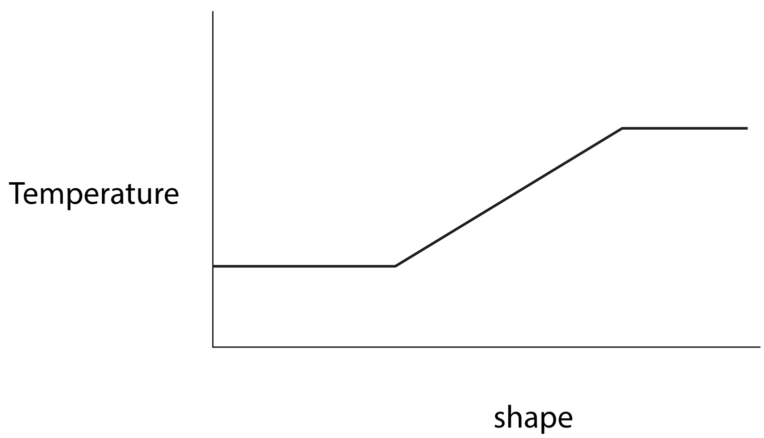

Figure 21 Interaction Between Shape and Temperature

Approach 3 is a better solution to this conflict. Consequently, designers need to explore a component to solve this conflict. Following the concept of the ideal technological system, they can assume that a possible attribute addition to this technological system would be a cup whose shape changes depending on the drink's temperature. Figure 21 shows that at a specific temperature, the cup's shape is going to change accordingly. Figure 22 is the solution for cell A.

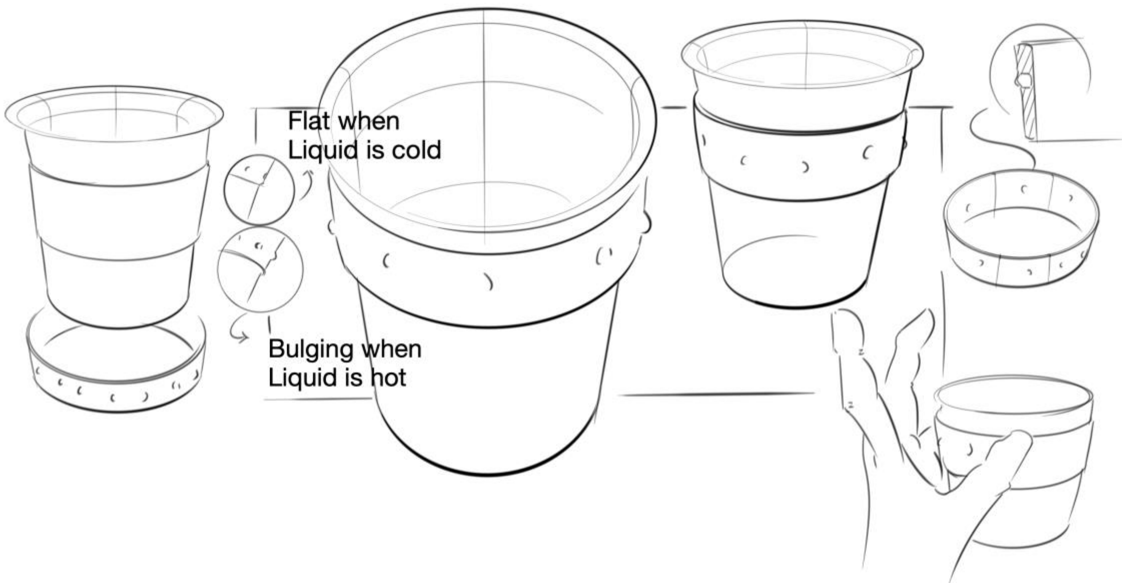

Figure 22 Concept for Cell A

4.6 Formulate and Resolve Conflicts for Cell B

For cell B, designers got the external parameter - water level (drink) and tactility (user), and internal parameter (the cup's shape). The system relation can be explained as Figure 23.

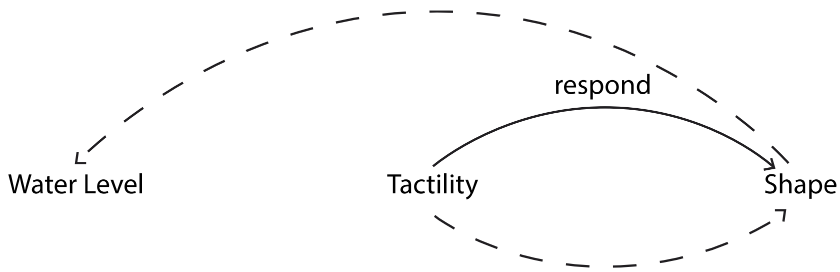

Figure 23 System Relation for Cell B

1. User's feeling can respond to the cup's shape

2. There is a lack of interaction between both Tactility - Water Level and Shape - Water Level.

Cell B expresses two conflicting demands. To bring interaction between water level and the user's tactility, the cup should contain an action between water level and shape (as the user's tactility responds to the cup's shape); however, the cup's shape is invariable. Therefore, designers can define cell B as a physical conflict.

As discussed in Chapter 2, conventional design philosophy implies an inevitability of compromise: if a component has to be both snow white and pitch black, it usually ends up with being a shade of gray. Since the same component cannot possess mutually exclusive properties in the same point of space or at the same time, three generic separation principles can be used.

1. Separation in time. At one time a component has property P, and at another time it has an opposite property -p.

2. Separation in space. One part of a component has property P, while another part has an opposite property -p.

3. Separation between the whole and its part. A system has property P, while its components have an opposite property -p.

To solve Cell B's physical conflict, one should do the following.

1. Identify the conflicting component associations with both useful and harmful actions. In this case, tactility is the parameter which associates with the conflicting component - shape.

2. Formulate a pair of mutually exclusive demands to the physical state of this component.

3. Attempt the separation principles, individually or in combination, to satisfy these demands. In order to solve this conflict, designers shall combine principle 1 and 3.

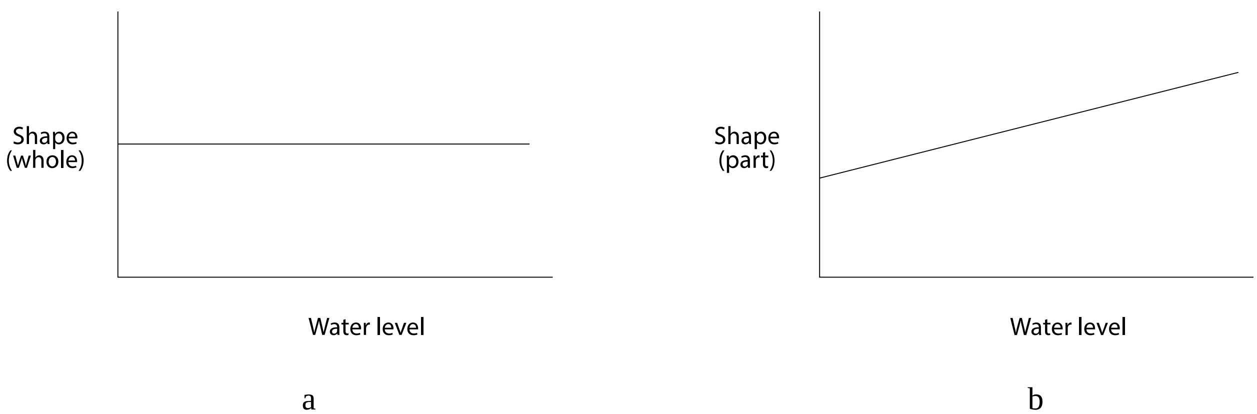

Figure 24 Interaction Between Shape and Water level

Figure 24a shows the ideal concept. To meet the demand that the cup's shape is invariable, designers can separate the opposite properties between the whole and its part, which means, overall, the cup still invariable, however part of it is changeable. To bring an action between tactility and water level, they can apply separation principle 3, which means the variable part changes according to the water level (see Figure 24b). Therefore, a concept for cell B shall emerge (see Figure 25). Inspiring from the seesaw, this concept made part of the cup as a water level detector. When the water level reaches a certain height, the other side of seesaw will knock the user.

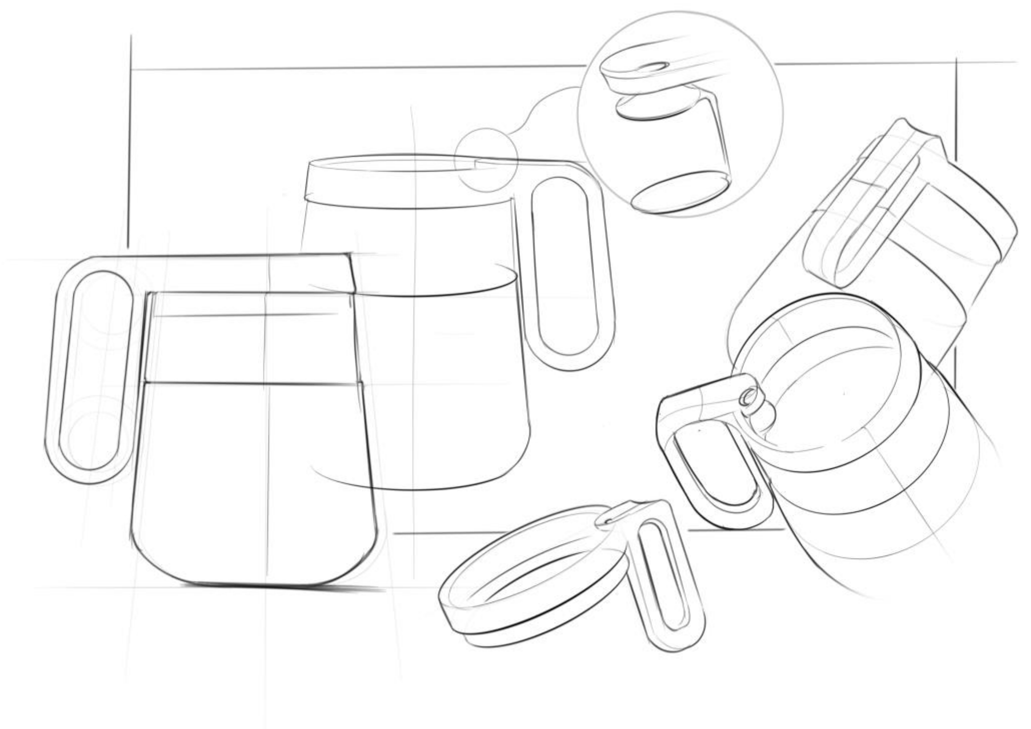

Figure 25 Concept for Cell B

4.7 Formulate and Resolve Conflicts for Cell C

As for Cell C, designer only have the internal parameter - Shape, and the external parameter Hand Size. obviously, it is physical conflict. On one side, designer need to bring action between hand size and shape; on the other side, the shape is invariable. Experiences shows us that a large hand may have some problems to hold the cup without burning it, while the cup is filled with the hot drink. Accordingly, the hand's size should determine the shape. Thus, the conflicting requirements are separated in time.

The solution for Cell C is shown in Figure 26. An adjustable handle allows people to change its shape. User with a pair of large hand can rotate the handle to create a large angle between the handle and the cup wall, which prevent to burning the finger.

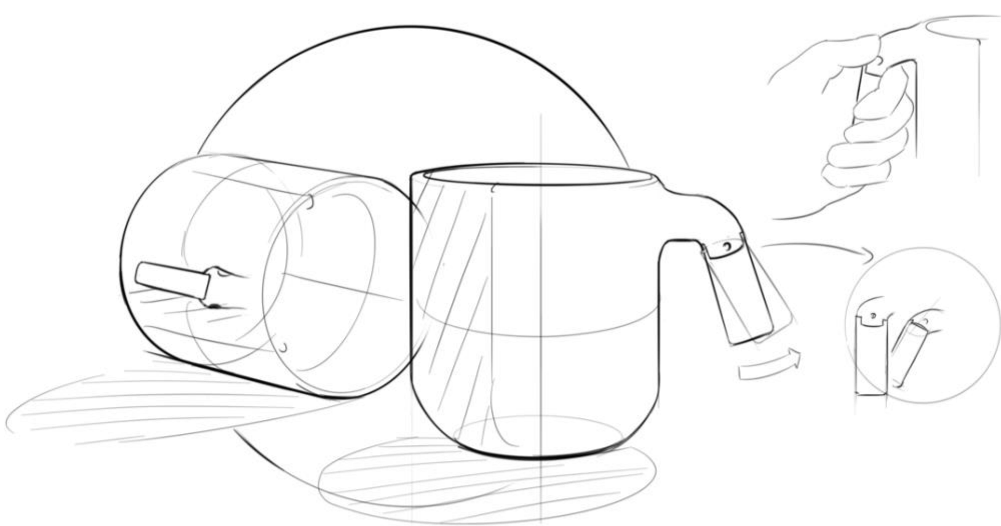

Figure 26 Concept for Cell C

4.8 Decision making

According to Chapter 2, designers need to brainstorm the evaluation criteria which are appropriate to the situation, in order to decide which concept is better. The criteria which designers think are essential to optimize the drinking experience for blind people are listed below.

Human	**Technical**	**Production**
Feedback General appeal	Performance	Price

Table 14 Price Analysis of Mug

1. Price/unit. Base on the price analysis which is collected from Amazon (See Table 15), it will be great if price less than 21 dollars; it will be bad if price is more than 35 dollars.

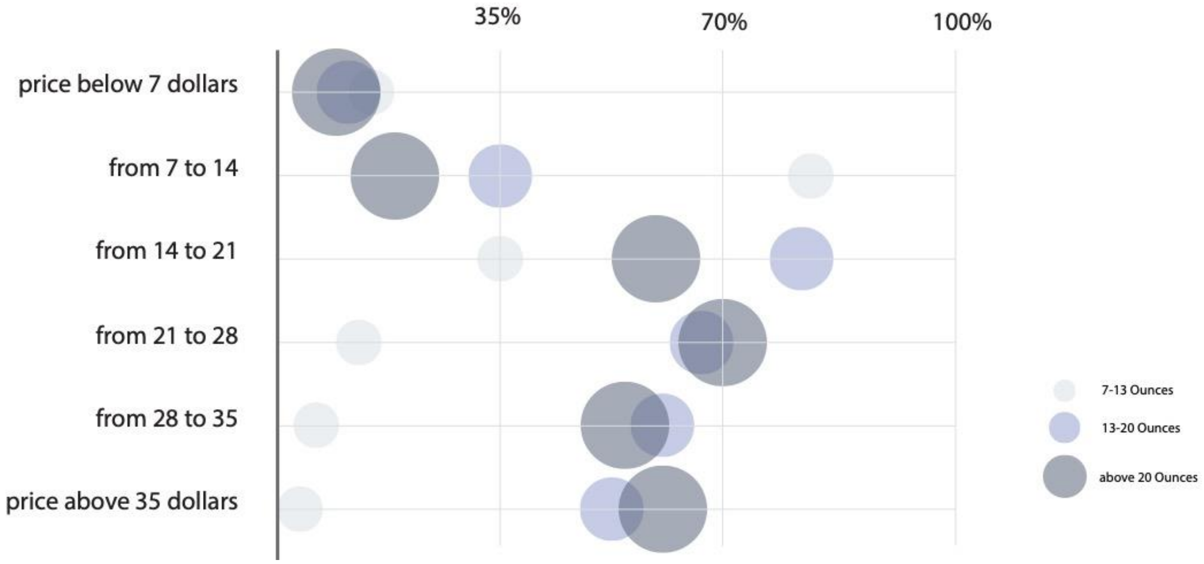

Table 15 Price Analysis of Mug

2. The general appeal of the concept.

3. Performance relative to the opponent.

4. Customer feedback. It will be great if more than 2/3 of test users appreciate the product; it will be bad if less than 1/3 of test users think it is futile.

Next step, designers shall assign a relative weight to each criterion. Table 16 shows the rank of the criteria based on estimate of team members.

Chao	Quinton	Jeremey
Price Performance Feedback General appeal	Price Feedback Performance General appeal	Feedback General appeal Price Performance

Table 16 Price Analysis of Mug

The previous two steps led to the final decision-making model as Table 17.

		Wt	Concept A	Concept B	Concept C
Criteria	Price	4	0	0	-1
	Performance	2	0	1	1
	Feedback	3	1	1	0
	General appeal	1	-1	1	-1
	Total		0	3	-1
	Weighted Total		2	6	-3

Table 17 Decision Making Matrix

Base on the result, people can see that the concept for cell B contains more market potential. Figure 27-29 shows the further developing of Concept B.

Figure 27 Rendering of Concept B

Figure 28 Rendering of Concept B

Figure 29 Rendering of Concept B

Chapter 5

5.1 Introduction

This thesis discussed how to generate multiple concepts by applying this design template. In this chapter, a more complicated condition will be considered.

This chapter will discuss how to create a new speaker to fulfill people's need.

5.2 Define the Product System

As our purpose is to create a new speaker to fulfill people's need, A system structure can be constituted. Figure 30 shows that speaker, user, and environment are the components in the subsystem.

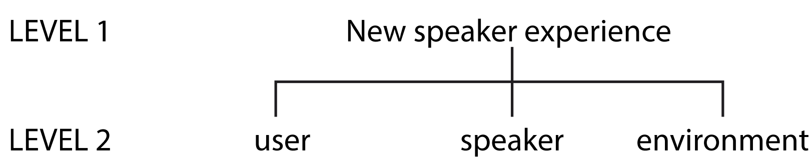

Figure 30 Hierarchical System

1. Speaker and user system. User needs to control the speaker by interacting with it. And the speaker needs to respond to the user's action.

2. Speaker and environment system. The environment can affect how the speaker works.

3. User and environment system. Users and the environment respond to each other.

5.3 Search the Parameters of The System

As this tool already constituted the product system structure, the parameters of those three components from the subsystem will reveal. The internal parameter, which is the parameter of the speaker, is material, control mode, charging mode, working mode, color, shape, and texture.

The two external parameter set are the parameters of the user, the parameters of the environment.

Parameters of the user: tactility, hearing, small, vison, gustation, and operation.

Parameters of the environment: temperature, humidity, other devices, surface, placement, luminance, space.

5.4 Construct System Matrix

After searching all three parameter sets, designers can scan the interaction between each parameter set by applying the matrix method in chapter 3. Three axes in the matrix are the internal parameter which locates at the z-axis; the parameter of the user locates at the x-axis; the parameter of the environment is at the y-axis. Table 18 indicates a system matrix of the smart speaker system. As this thesis discussed in chapter 2 and 3, designer should mark all the none-interaction cell by digital 0, all the indirect interaction by digital 1, and all the direct interaction cell by digital 2.

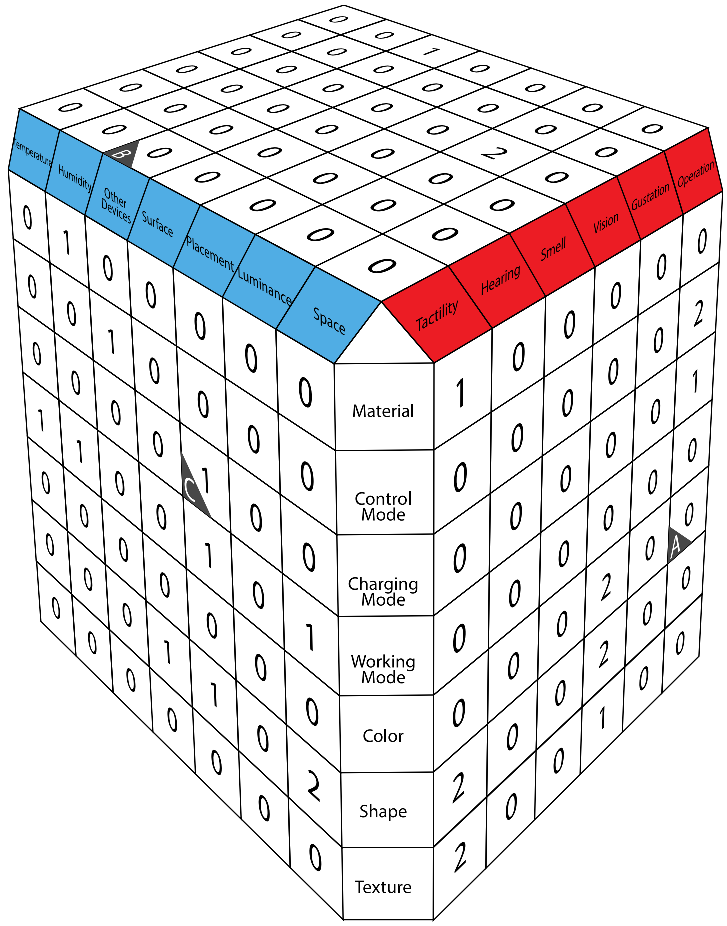

Table 18 System Matrix of Speaker Experience System

According to the system matrix scanning rule discussed in previous chapters, designers should search "0" or "1" mode on each plane to detect potential information for the new idea. On plane one, designer select Working Mode - Operation, which is in "0" mode (Cell A). Then designer go to other planes to search for another external parameter with indirect or direct interaction with either of parameters in Cell A, in order to constitute a system. In this case, designer select Other Devices, as the pair of Operation and Other Devices has indirect interaction. On plane two, designer should select Other Devices - Tactility (Cell B), pairs with another parameter Control Mode. On plane three, three parameters in our system are Charging Mode, Placement, and Operation.

5.5 Formulate and Resolve Conflict in Cell A

For Cell A, designer can form a system as Figure 31. In this system, operation affects both work mode and other devices; work mode limits operation; there is not enough relation between work mode and other devices. According to the definition of the conflicts, deigners can infer this is system conflict. As when designer eliminate a harmful action - work mode limits operation, an unacceptable complication (user can’t interact with speaker) will emerge.

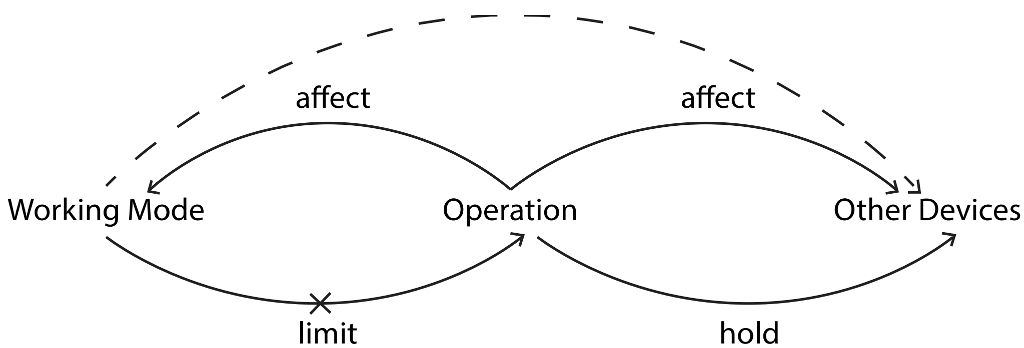

Figure 31 System Relation for Cell A

As this is a system conflict, three generic approaches are provided in chapter 2.

1. Elimination of either the tool or the object.

2. Changing the conflicting components such that the harmful action disappears.

3. Introducing a special component intended to eliminate or neutralize the harmful action.

In this case, approach 3 seems a better way to resolve this conflict. Following the concept of the ideal technological system, designers can assume that a possible attribute addition to this technological system would be designer can extend the work mode in order to expand the operation. As there is not enough relation between work mode and other devices, designer can add the parameter Other Devices to the work mode, which means integrating multiple devices to expand the work mode.

5.6 Formulate and Resolve Conflict in Cell B

For Cell B, the system relation can be described as Figure 32.

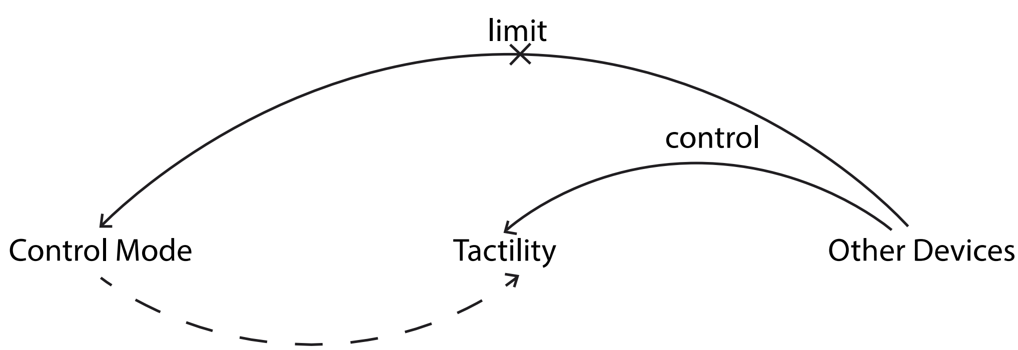

Figure 32 System Relation for Cell B

1. Other devices(like remote controller) allow us to control the speaker.

2. Other devices Limit the flexibility of the control mode. The remote controller can be a very good example. It's always so frustrating when you can't find your remote controller.

Base on the analysis of the system, designer can determine this is a system conflict. Three approaches provided in chapter 2 can be selected:

1. Elimination of either the tool or the object.

2. Changing the conflicting components such that the harmful action disappears.

3. Introducing a special component intended to eliminate or neutralize the harmful action.

In this case, introducing a special component intended to eliminate the armful action seems a better solution. Therefore, designer can introduce a touch control panel and application into the speaker. The touch control panel provides basic control function, and the application provides developed control function.

5.7 Formulate and Resolve Conflict in Cell C

As for Cell C, designers got a pair of parameters: Charging Mode and Placement. Another parameter, Operation, which has indirect interaction with charging mode, also will be select to constitute a system. Figure 33 describes the relation structure in the system.

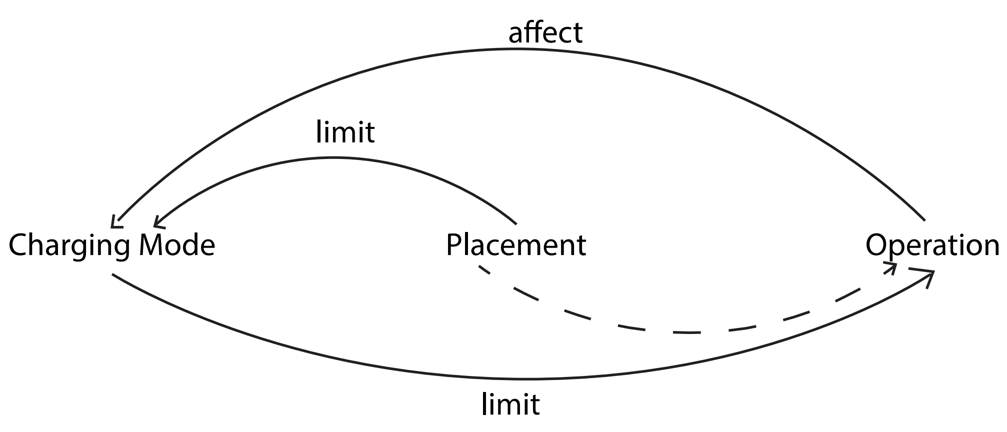

Figure 33 System Relation for Cell B

1. Operation affects the charging mode. User's action will affect the charging mode's function.

2. Charging mode limits the user's operation. Certain charging mode limits the user's action. For example, most of the speaker on the market need to connect with charging cable in order to achieve the charging function.

3. Placement also limits the charging mode. designers need to set the speaker to somewhere near the plug seat in order to charge.

Therefore, designers can discover the conflict as a system conflict. Three approaches provided in chapter 2 can be selected:

1. Elimination of either the tool or the object.

2. Changing the conflicting components such that the harmful action disappears.

3. Introducing a special component intended to eliminate or neutralize the harmful action.

In this case, introducing a portable charging station will solve this conflict. User doesn't always have to plug in the charging cable. And the placement won't bring any limitation, which means users can charge the device anywhere.

5.8 Integration

The final concept for the smart speaker integrates with three ideas designers generate from the design template can be shown as Figure X.

1. Work Mode-Other Devices-Operation.

As more and more people enjoy watching videos and movies on their own devices, the normal speaker seems can't not provide enough audio experience to users. This concept allows users to use a single speaker on a daily basis or connect with multiple speakers to build a stereo audio system in order to enhance the audio experience.

2. Control Mode-Tactility-Other devices.

To avoid losing the remote controller, but also keep the simplification of the product, this concept provides two different components to control mode. The touch control panel allows users to control the speaker very easily on basic utilization. The application provides more options for users to customize their own audio experience.

3. Charging Mode-Placement-Operation.

To bring more flexibility to the charging mode, this concept introduces a portable charging station.

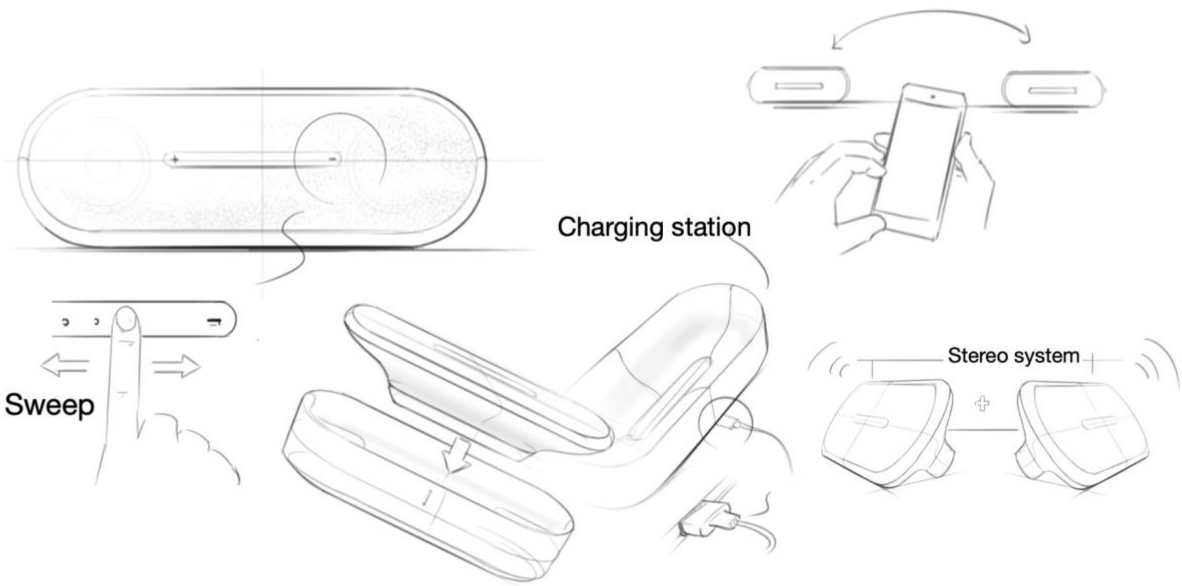

Figure 34 Final Concept

Chapter 6

6.1 Summary and Further Extension

This thesis was intended to develop a new design method for designers and companies to predict new candidate products by providing the context for ideation. Utilizing the creative-based new product design template may help to channel the ideation process and thus enable people to be more productive and focused.

Over the past decades, the fact tells us the companies that have done the best over the long are those who are the most creative and innovative. There are enormous creativity-enhancing methods to help people to be more creative in their production process. They all have excellent performance in different aspects. But where is different between the creative-based design template and other creativity-enhancing methods?

1. The creative-based design template developed in this thesis is the method which affects or manages cognitive processes; other creativity-enhancing methods, such as brainstorming, the six-thinking hat, are methods for management of the ideation session.

2. The creative-based design template is the method which is analytical and focused; other creativity-enhancing methods try to enhance randomness, on the assumption that it is instrumental to creativity.

3. The creative-based design template acts in a narrower content world and not in general problem-solving.

The main conclusion of this thesis is that a restricted approach, which draws on the design template, can contribute to the reduction of randomness characterizing the invention of many new and successful products. In addition, such an approach can be used to ideate promising product concepts for the future.

The indication that past product-based trends may serve as a useful source for ideation should shift attention from sole reliance on unrestricted ideation approached. Besides, this design template may add value to ideation methods that draw new ideas from current market needs. While responsive approaches based on analysis of current market needs are highly useful in the more advanced stages of the product life cycle.

In addition, reliance on random events is both inefficient and, for the most part, unreliable. Many new products have emerged as a result of coincidence. However, designers cannot help numerous cases in which random events led to failure or no ideas at all. The pure assumption of randomness leads to the conclusion that reliance on the occurrence of such an event is not efficient.

This thesis is built on the theory that the product itself contains necessary and sufficient information to serve as a basis for innovation, especially in cases of mutable and inconsistent markets. In other words, this creative-based design template is derived by inferring patterns in the evolution of products.

This creative-based design template is a counter-intuitive view for product emergence and a novel method for ideation, yet it does not contradict any current marketing theory. It does, however, add an important perspective to the process of product innovation by drawing on the primacy of idea itself as a driving force toward new product success.

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