DESIGN TO CREATE A NEW PRODUCT MEANING

Reviews of the Product-related Role of Industrial Design in Radical Innovations

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Abstract: Radical innovation, which focuses on the creation of new product or service that are often non-existent, plays a greater role in market leadership than incremental innovation. Design has been recognized as an important contributor to innovation process and commercial success. However, the role of design in radical innovation remains largely unexplored. This paper focuses on product-related role, theoretically reviews multi-disciplinary papers and books with respect to radical innovation and related fields. On the premise of a finding that new product meaning is one of the key factors in the success of radical innovation, we find that design contributes to the creation of new product meaning by the effort on product language (i.e., create new aesthetic standard) and usability (i.e., create new experience). Moreover, we argue that design plays more significant role in technology-driven product than market-driven product in the creation of new product meaning. Finally, future trend of designing for new product meaning is suggested, and follow-up study questions are specifically proposed.

Keywords: Radical Innovation, Product Meaning, Product Language, Usability

1. Introduction

Innovation was documented as a key source of competitive advantage, especially in highly competitive market. Companies have to continuously develop new products or services to keep staying in or significantly lead the market. However, most new products are typically minor extensions to current products, which labeled as Incremental Innovations [1, 2]. The really new products, which involve development or application of significant new technologies or ideas that are often non-existent, are labeled as Radical Innovations, Breakthrough Innovations, or Discontinuous Innovations [3, 4]. Those radical innovations can offer a new, or superior solution to customer’s needs and may ultimately change the existing market or create entirely new one [5].

Sustainable market requires a combination of both incremental and radical innovations [6, 7]. To that end, companies should be flexible, capable of simultaneously managing incremental as well as radical innovations. Therefore, effectively developing radical innovation is crucial to the long-term survival of company [8].

Design has been recognized as an important contributor to innovation process and commercial success, and has gained increasing attention [9]. However, a number of studies show that design performs a variety of roles in companies, and the roles of design are dynamically changing while the field of design is evolving [10]. Moreover, Valencia indicates that different professionals perceive the contribution of design based on their own experiences with design, he proposes a classification for understanding of the varied roles of industrial design: (1) product-related roles of design and (2) process-related roles of design [11]. The product-related roles highlight the design capacities to shape the look (product appearance) and feel (end-user’s experience or usability) of products [12, 13]. The process-related roles emphasize the capacities to follow and disseminate trends, visualize ideas, and moreover, support the communication between customers and developers in company [14]. Identifying the diversity of roles that design can fulfill is important to a company,
which can help the company profit from design more strategically. While the varied roles of design in general new product development have been studied in details, the roles of design in radical innovation context are less well understood.

2. Objectives and Methodology

The present paper focuses on the product-related role of design, attempt to provide innovation participants with a systematic understanding of how design contributes to radical innovation, and activate future research on this phenomenon.

To answer the research question, we adopt documentary survey approach, by which, we gather and analyze multi-disciplinary research mainly from market, management, technology, and design perspectives. The literature resources, focus on the issue of radical innovation, are range from 1984 to 2014.

The present paper is structured as follows: First, this article proposes a ring-shaped framework to distinguish radical innovation and incremental innovation from design perspective. The concept of New Product Meaning (NPM) is introduced as core criteria that used to distinguish radical and incremental innovation. Then, product meaning is discussed based on a classification of utilitarian and symbolic product meaning. Going on that premise, we propose a framework to provide an intensive understanding of how design contributes to the creation of new product meaning. Furthermore, we discuss this topic in two different innovation contexts: technology intensive product and market intensive product. Another framework is proposed in this part. Finally, the paper is concluded with a discussion of the study results, its limitations, and research questions for future research.

3. Radical Innovation and Product Meaning

In order to research on the question of how design contributes to the radical innovation, the term “radical innovation” needs to be defined and characterized. Radical innovation is a relative concept in contrast to incremental innovation, highly related to the level of innovativeness. We agree with the understanding that innovativeness is a multidimensional phenomenon [15]. Therefore, radical innovation was defined in various ways from different perspective [16]. By a review of the extant literature regarding new product development (NPD), we found that at least 9 constructs have been used to define radical innovation in just 16 empirical studies (see Table 1).

### Table 1. Constructs used to define radical innovation

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Construct</th>
<th>Study*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>Create a completely new market</td>
<td>[15], [21], [43] [44], [45], [46]</td>
</tr>
<tr>
<td>Technology</td>
<td>New technology or technology application</td>
<td>[41]</td>
</tr>
<tr>
<td>User</td>
<td>Fulfill user’s latent needs</td>
<td>[47], [48]</td>
</tr>
<tr>
<td>User</td>
<td>Significantly change user’s behavior</td>
<td>[49], [50]</td>
</tr>
<tr>
<td>User</td>
<td>Require significant new knowledge</td>
<td>[51], [52]</td>
</tr>
<tr>
<td>Product</td>
<td>Revolutionize product categories or define new categories</td>
<td>[53], [54]</td>
</tr>
<tr>
<td>Product</td>
<td>Radically change the emotional and symbolic content of products</td>
<td>[21]</td>
</tr>
<tr>
<td>Environment</td>
<td>Change the societal value systems</td>
<td>[15]</td>
</tr>
<tr>
<td>Environment</td>
<td>Internal change of firm (process and structure)</td>
<td>[55]</td>
</tr>
</tbody>
</table>

* Some studies used more than one construct.

After reading and integrating more of this literature, it appears that radical innovation is often defined in terms of 9 issues: market, technology, user’s need, user’s behavior, knowledge, product category, emotional and symbolic content of products, social value system, and process, in the perspective of market, technology, user, product, and environment. In order to discuss the product-related role of design, this paper highlights the radical innovations that were defined from the product perspective. Those radical innovations radically change the emotional and symbolic meaning of the product rather than physically improve the performance; create a new product category rather than a single new product, and ultimately create a new product meaning.

3.1. Distinguish radical and incremental innovation, a framework

Based on the definition above, a ring-shaped framework was proposed to distinguish radical and incremental innovation from design perspective. The framework, as seen in Figure 1, is composed with four circles. Start from the inner circle, the first ring presents distinguished radical and incremental innovation strategies. The second ring shows that radical innovation involves the creation of new product meaning, while incremental innovation follows dominant product meaning [17]. The third ring gives a supplementary explanation of second ring by quoting the classifications of product meaning: utilitarian meaning and symbolic meaning.
Based on third ring, we discuss how design contributes to the creation of new utilitarian meaning and new symbolic meaning by emotional usability and new product language in the fourth ring, where a new framework will be proposed to explain it in details. This paper highlights the half ring with the gray background, which will be discussed in details in the following chapters.

3.2 Product Meaning

Meaning is the relationship between mind, object and word [18]. Product meaning is what product means to the consumers, how objects are judged, and psychological functions represented by the product [19, 20]. Verganti indicates that one of the key conditions to create radically innovative products is new product meaning [21]. He also found out that firms are not creating new meanings independently and internally, but rather relying on external networked interpreters, who share the same problem of future lifestyle trends, how socio-cultural model will evolve and how to propose new visions and meanings.

Richins suggests that Product meaning can be public or private, and proposes four major categories of product meanings: (1) Utilitarian; (2) Enjoyment; (3) Representation of Interpersonal Ties; and (4) Identity and Self-Expression [22]. Many researchers propose a simple utilitarian-symbolic distinction in product meaning [23, 24]. Based on the review of related papers, we summarized the significant differences between utilitarian product meaning and symbolic product meaning as shown in Table 2.

### Table 2. Utilitarian-Symbolic distinction in product meaning

<table>
<thead>
<tr>
<th>Utilitarian meaning</th>
<th>Symbolic meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Located in</td>
<td>Located in</td>
</tr>
<tr>
<td>Tangible attributes &amp; Partial product level</td>
<td>Intangible &amp; Tangible attributes &amp; Holistic product level</td>
</tr>
<tr>
<td>Related to</td>
<td>Related to</td>
</tr>
<tr>
<td>Physical performance</td>
<td>Aesthetics &amp; Experiences</td>
</tr>
<tr>
<td>Elucidated by</td>
<td>Culturally constituted world</td>
</tr>
<tr>
<td>Economical world (Convenience, Efficiency…)</td>
<td>(Freedom, Yuppies…)</td>
</tr>
<tr>
<td>Objective</td>
<td>Subjective</td>
</tr>
</tbody>
</table>

Utilitarian Product Meaning, which centers on the product and the product’s physical performance and located in tangible attributes, represents the overt function of product when serves users in use [25, 26]. The utilitarian meaning of a smoke detector, for instance, is its ability to detect smoke, and how it detects smoke. Similarly, the utilitarian product meaning of a vacuum cleaner is its ability to clean, and how it cleans the room. As the utilitarian product meaning located in tangible attributes and centers on physical performance, it is mostly objective. Learning from successful radical innovation products, it is not hard to discover that the radical change of utilitarian product meaning often involves behavior change of how to physically interact with product. iRobot vacuum cleaner, for instance, changed the way of cleaning rooms, in which user has to move with the cleaner, demonstrated a new way that the cleaner automatically cleans the room. Nest smoke detector also changed the interaction between detector and user by adopting the detector to smartphone generation, which does not make the user to frantically swinging towels at the smoke alarm to quiet it down, but silence the alarm only with a wave of the hand.

Symbolic Product Meaning, which located in intangible attributes, is the result of distinctive experience, and closely tied to the culturally constituted world [27]. Hence, symbolic meaning is mostly subjective. It is related to the aesthetic and experience aspects of products, which provides means for self-expression and self-identity, as well as branding [28, 29]. Creusen et al also demonstrate that, apart from bringing aesthetic delight, a product’s appearance is important as its capacity to connote symbolic meanings [30]. Similarly, Thomas suggests that symbolic meanings implied by product appearance, might best be congruent in terms of the underlying theme in order to create a first favorable impression of product and brand [31]. Many researches
indicate that symbolic product meaning becoming more and more important with respect to consumer’s decision-making and brand formation [32]. Learning from great products, we may discover that the radical change of a symbolic product meaning often refers to the definition of new aesthetic standards (e.g., Apple’s design) that may become an icon in the future, and the creation of new experience (e.g., iTunes change the way to access music) that are often non-existent. Those new aesthetic standards and new experience will contribute to the evolution of socio-culture model.

4. How design contributes to the creation of new product meaning in radical innovations.

On the premise of the two categories of product meaning: utilitarian product meaning and symbolic product meaning, we can explore the contribution of design in relation to the different categories of product meaning. As discussed before, utilitarian product meaning arises from physical performance of product, highly related to its ability to work, and how it works. Moreover, utilitarian meaning of product is interpreted into economical words, such as efficient, convenient, simple-to-use, and easy-to-learn, which are what product usability in the design field aims for. Hence, design primarily contributes to the creation of utilitarian product meaning by usability. On the other hand, symbolic product meaning arises from intangible attributes of a product, refers to the looks and feel of the product. However, intangible attributes are tied to a specific configuration of tangible attributes, resulting in the instantaneous evaluation of the product. It emphasizes the appearance, and its capacity to portray symbolic meaning, which are extremely close to the research field of product language. Therefore, design may contribute to the creation of symbolic meaning by product language. Furthermore, utilitarian product meaning and symbolic product meaning can interact with each other, easy-to-use product may produce a sense of joy, and well-designed appearance may simplify the use of product. Based on the literature review, a framework as shown in Figure 2 was proposed to systematically understand how product meaning was created by the interaction of both usability and product language.

As shown in Figure 2, X-axis represents usability, while Y-axis represents product language. The dashed circle, which represents product meaning, is divided by X-axis and Y-axis, and forming four sectors. Each sector indicates the different levels of newness of product meaning (newness: upper right sector > upper left and lower right sectors > lower left sector). The bold-lined arrow implies a nature of product meaning: new product meaning will become dominant if it is well accepted by market.

![Figure 2. How design contributes to the creation of new product meaning](image)

We categorized usability with function and emotion as shown on the left and right end of X-axis. Functional usability focuses on how to improve the physical performance of a product, while emotional usability focuses on how to create a new experience by usability improvement. Similarly, we categorized product language with new and dominant as shown on the upper and lower end of Y-axis. Dominant product language indicates mainstream style of product language that follows others, while new product language indicates a new one that will be followed by others. In general, product meaning was created by concerted efforts of both usability and product language. Moreover, from a pure design perspective, new product meaning can be created only in the upper right sector, which involves the presence of both emotional usability and new product language, which will be explained in details in the next chapters.

4.1 Design contributes to utilitarian meaning by usability

Usability is the pragmatic component of user experience, including effectiveness, efficiency, productivity, ease-of-use, learnability, retainability, and the pragmatic aspects of user satisfaction [33]. Usability, regardless of its functional and practical nature, has impact on emotional world that will influence user’s feelings. Poor performance in efficiency,
sometimes, causes the negative and unhappy feelings. Conversely, high efficiency design (i.e., functional nature) will generate positive emotional effect such as pleasure, fun, joy of use, desirability, pleasure, novelty, originality, and pride of ownership.

In radical innovation, especially in technology-intensive industry, usability of the product should aim to create a new experience by changing the way that people interact with product in use. The scroll wheel design in iPod, for instance, has been considered a significant innovation among the MP3 players in early iPod period. It creates a new utilitarian meaning by changing the way of navigating and volume control. Before iPod, the mainstream way of song selecting was button click, which in line with Walkman. However, it was quite inefficient and annoying to select among hundreds of songs. iPod radically change it by scroll wheel that offers several advantages: simple to use, reliable, supports one-handed operation, and as a tactile surface, is able to be operated without having to look at the iPod. Ultimately, it generated emotional effect of joy of use, and provided an entirely new experience of listening to the music, which help to create new utilitarian meaning as well as symbolic meaning.

4.2 Design contributes to symbolic product meaning by product language

Product language, a term commonly used by industrial designers since the 1980s which refers to the product’s appearance, indicates the ways in which form, decoration, color, and other visible features of products could communicate additional meaning. Jochen Gros is considered an important researcher in the field of product language. He developed a Conceptual Model of the Offenbach Theory of Product Language in 1976 as shown in Figure 3, where practical functions and sensual functions of product were distinguished. Moreover, sensual functions (i.e., product language functions) were categorized into three groups: formal aesthetic functions, semantic functions, and symbol functions [34, 35].

Formal aesthetic functions act as a grammar of the design concept, refers to the shapes, color, texture, material, etc. Gros suggests that we should be conscious of the meaning behind the aesthetics, and the senses it encourages.

Indication functions make product speaks for itself; enable the nature of a product to be identified; visualize and explain the various practical functions of a product and how it should be used. The first wireless telegraph for private customer, which some of the technical components were exposed and mounted on a chassis, were only used by people with expert knowledge. Few years later, with the participation of industry design, a dominant type evolved and the radio became a semantically well-defined item, which can be identified and operated easily. The challenge for industrial design here is to bridge the gap between technology and user by coming up with a significant and usable object with some signs that indicate its nature and function.

Symbol functions refer to the conceptions and associations that come to a person’s mind while contemplating an object, and convey various period styles (e.g., baroque, classicism, modernism), various partial styles (e.g., Braun design, Starks’s design, yuppies, high-tech look), and other associations (e.g., old-young, happy-serious, interesting-boring).

![Figure 3. Conceptual model of the offenbach theory of product language (Jochen Gros, 1976)](image)
5. Different role of design in the creation of new product meaning in different innovation strategies

As we discussed before, no matter which innovation strategy a company takes, a new product meaning should be created if they want to make it radical innovative. However, design contributes to the creation of new product meaning in different ways in different innovation strategies.

5.1 Source of radical innovations

Innovation process involves a combination of knowledge, competence, technology, market, and design. Innovation takes place in various ways, and can be derived from many different sources, but over time, some sources will demonstrate a stronger and more lasting impact on the product concept and its roadmap. Giada et al. examined the most influential articles from 1956 to 2010 that have debate on the sources of innovation by co-citation analysis, and came to the conclusion that there are five factors as sources of innovation: technology and competences for innovation; new product development and market learning; demand and user; sectoral systems of innovation; technology diffusion and adoption. Finally, they emphasized the importance of technology and demand, and suggested that demand and technology should be understood as the levers and sources of innovations [36].

As radical innovation mostly pushed and derived by technology and market, we will discuss and compare how design contributes to the creation of new product meaning in technology-driven and market-driven radical innovation.

Most market-driven innovation starts from analysis of well-segmented market or customers’ needs, and subsequently searches for appropriate technology and design to satisfy them. However, several authors point that traditional market research, despite its value in incremental innovation, seldom generating radical innovation [37, 38]. Many market-driven companies, such as Amazon, IKEA, Starbucks, and Dell reaches their success by addressing some potential, or unexpected need of the customer, rather than focusing on existing market. They created new market, offering an unprecedented level of customer value, and ultimately revolutionized their industries. Xiaomi, launched in 2010, is considered being one of the most successful smartphone makers in Chinese mobile phone market. By having only online store rather than having flashy retail stores, Xiaomi released its first smartphone, which has similar hardware performance but only costs 40% of iPhone, and reaches its first success in 2011. Rather than profit from its hardware, Xiaomi sells hardware almost at cost to consumers. It then makes money by selling diversified apps, games and online services. Using the hardware primarily as a medium to sell services is a typical Amazon model that has been perfected over the years with its Kindle eBook readers. That’s why Xiaomi’s founders like to compare their company to Amazon more than Apple. The strategy of selling devices at cost is the main reason why people buy a Xiaomi smartphone in the first place, and finally it helps with the creation of new meaning of their mobile phone: a hardware platform that sells feature products and services [39]. Xiaomi, as well as IKEA, are not famous for the extraordinary design of their tangible product, but for the unique business model along with nice product or service. From pure product design perspective, the furniture in IKEA was considered to be functional and universal, it’s followed the Nordic design style; the mobile phone of Xiaomi also applies the dominant design language in 2010 (i.e., iPhone and windows phone design), in these cases, design itself cannot create a new product meaning, but along with the presence of new business model.

Technology-driven innovation usually originates in scientific and technological discoveries. In technology intensive industry, technology was considered as core competitiveness, and often acts as dominant driving force of innovation. However, successful technology-driven innovation starts from technology but still need market and related complementary assets to make the transition from science to commercial applications [40]. MP3 technology was first developed in 1991. The world’s first portable MP3

Figure 4. Walkman and MP3 player before iPod
player was launched in 1997 with the name of MPMan. The biggest problem with the first MP3 player was how to get music on it. User should laboriously convert their CD music into mp3 files, or illegally download from popular sites such as Napster. After that, MP3 player was expanded by many companies and got great success by Apple iPod in 2001. To the customers, iPod was considered as the first to apply the MP3 technology, and also iPhone was the first to apply multi-touch technology. However, the truth of the matter was quite different. Disruptive technology, such as multi-touch technology and MP3 technology, is quiet essential to radical innovations [41]. However, it is not the only condition to success. In fact, disruptive technology cannot create new product meaning alone. In the case of iPod, the unique product appearance design, the usability design of scroll bar, and the service design of iTunes served as vehicles to visualize the unobservable technology, differentiate their product from others, communicate at first glance that they are radically new, and ultimately creating a new product meaning that is totally different from the mainstream.

5.2. How design contributes to the creation of new product meaning in different innovation strategies: a framework

Xiaomi and Apple are both being considered as the innovative leaders in mobile phone industry. However, succeeded with different innovation strategies. Apple was more about technology-driven, while Xiaomi used a market-driven strategy. Hence, design plays different roles in different innovation strategies. Based on Figure 2 and the discussions above, a framework was proposed to systematically understand the differences of design contribution between market-driven and technology-driven strategy (see Figure 5).

In market-driven innovation, design’s contribution starts from lower left section, in which, design makes efforts on the dominant product language and functional usability. However, product can be incrementally improved by the efforts on the emotional aspect of usability (i.e., move from lower left to lower right section). In technology-driven innovation, design’s contribution starts from upper right section, in which, design makes efforts on the new product language and emotional usability. Similarly, companies have to incrementally improve the product by the efforts on the functional aspects of usability (i.e., move from upper right to upper left section), and increase the physical performance of the product.

In market-driven strategy of radical innovation, design puts effort on well-performing product, helping to create a new product meaning along with disruptive business model. It focuses on the functional usability that emphasizes practical and functional performance of a product, follows dominant product language that follows the mainstream product language, which was already accepted by the customers (i.e., lower left sector). From the pure design perspective, in market-driven radical innovation, design aims at incremental improvement, which cannot create a new product meaning until the presence of a new business model. The mobile phone design of Xiaomi, for instance, will not create a new product meaning without the market strategy of selling at the price of cost. In market-driven innovation, disruptive business model is the core of its success. The product-related role design is not an evident here. Thus, we may research on process-related role of design in market-driven innovation in the future.

In technology-driven strategy of radical innovation, design works for disruptive technology, plays a more significant role in the creation of new product meaning. It is not sufficient to just focus on well-performing product, but putting more effort on creating a new product language and new experience that will lead others (i.e., upper right sector). iPod, for instance, will not create new product meaning without the initial design of the device that communicated at first glance, which was different from other MP3 Players.

Figure 5. How design contributes to the creation of new product meaning in different innovation strategies

6. Discussion

Researching on the issue of how design contributes to
radical innovation, however, will not only demonstrate how important design is, but also provide the future direction for design practice and research. Design should not only be applied to idea implementation, work for customer satisfaction, but also devote to the creation of new product meaning.

This paper reviewed the literatures concerning radical innovation, explained how design plays a significant role in the success of radical innovation. Still, the role of design may vary depending on the innovation strategies, industries, companies, and even different development processes. As we concluded in last chapter, design plays a more significant role in technology-driven project rather than market-driven project. Many new products (e.g., Automobile) are very similar in technological features but compete on product designs. Talke et al. also emphasize the value of creating a unique visual appearance of the technology-intensive product [42]. However, nowadays, more and more products (e.g., Smart phone) are similar not only in technology, but also in appearance, those product compete more on the users’ experiences. Therefore, from the design perspective, radical innovation should create a new product meaning to users by proposing a new aesthetic standard and new experience. However, these results are based on the literature review, which need empirical verification. Hence, limitations existed on this paper, and follow-up studies are needed.

First, only the radical innovation of physical product was analyzed, in which product appearance, experience, and physical performance plays a major role in customer’s decision-making. Although these attributes are important for many other consumer products, there may be exceptions (e.g., software or service). Hence, validating the results in other industries is important for further research.

Second, the result is mainly derived from literature review; only few radical products were used to verify what we discovered by this paper. Thus, the result remains as a hypothesis; need to be verified in other case studies, which will be discussed in the next paper.

7. Conclusion

As the scope of design broadens over time, the roles that design fulfills are dynamically changing. Exploring design in radical innovation context may help design researchers with understanding the future directions of both design practice and research, supporting non-designers, especially policy makers of the companies in understanding what design can do and deliver.

On the premise that new product meaning is one of the key factors to the success of radical innovations, we systematically discussed the product-related roles of design in the creation of new product meaning in radical innovations. To that end, we quoted the classifications of product meaning: utilitarian meaning and symbolic meaning. Each product meaning was explained and connected to a specific design field: design contributes to utilitarian product meaning by usability, and contributes to symbolic product meaning by product language. However, to provide customers with the impression of “new” for product meaning, the usability and product language should be specifically defined. On that basis, a framework was proposed to understand how a new product meaning was created by emotional usability (i.e., new experience) and new product language (i.e., new appearance). Moreover, the way that design contributes to the creation of new product meaning varies depending on different radical innovation strategies. Therefore, by characterizing market-driven and technology-driven, another framework was proposed to understand the difference of design’s contribution between market-driven and technology-driven radical innovations. We found that in terms of product-related role, design plays more significant role in technology-driven innovation. In market-driven innovation, design helps creating new product meaning even without proposing new product language or working on emotional usability. Finally, according to those discussions, future direction of designing for new product meaning was proposed. Moreover, follow-up research questions were listed to call for more studies.

In conclusion, we hope that our work stimulates scholars, especially design researchers, to further investigate this interesting and emerging topic of how design contributes to radical innovation, which seems to be increasingly important.

References
4. Song XM, Parry ME. Challenges of managing the development of breakthrough products in Japan.


23. Dittmar H. The social psychology of material possessions: to have is to be. *Hemel Hempstead: Harvester Wheatsheaf* 1992.


32. Childers TL, Jass JF. All dressed up with something to say: Effects of typeface semantic associations on brand


