

Design Innovation:

Historical and Theoretical Perspectives on Product Innovation by Design

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Bilge Mutlu

Carnegie Mellon University, Pittsburgh

Alpay Er

Istanbul Technical University, Istanbul

Abstract

The term 'design innovation,' while not having a universally agreed upon definition, is increasingly used in the academic and professional design discourse, e.g. popular design magazines, academic journals, etc. for the last 10-15 years. Although the modern theory of innovation in economics has begun to refer to the practical relationship between design and innovation, and to emphasize the role of design in innovation process, it still appears to be inadequate in explaining this new conceptual and terminological expansion – the design innovation.

This paper discusses the concept of 'design innovation,' by unfolding the close relationship between design and innovation; design as the core function of innovation, and innovation as the main driving force in the economy. The paper relies on both an extensive review of innovation theory, and an empirical use of the term 'design innovation' in the design industry. The elaboration of this new concept is considered to be vital since it contributes to the academic and professional discourse of design. Moreover, a conceptual and operational definition of 'design innovation' will also provide the basic tools for design studies to claim a new, a more balanced model in the innovation theory, which is currently dominated by engineering-oriented discourses.

Keywords

Design, economics, innovation, technical change, design innovation

Introduction

Economics and design are two fields with strong links. However, designers usually overlook the historical and theoretical relationship between economics and design. In fact, there is a mutually proactive relationship between the practice of design and the theory of economics on the common ground of innovation. It has been more than two centuries since Adam Smith wrote *Wealth of the Nations*, where he,

for the first time, studied 'technical change' and its impact on economic growth (Smith, 1776). Smith's classical economist argument suggests a causal relationship between technical change and the wealth of the nations. This was later challenged by Joseph Schumpeter in his "Theory of Economic Development," (Schumpeter, 1934) where he rejects the neo-classical explanation of economic development as a gradual, harmonious, and cumulative process. Schumpeter put forward a "Theory of Innovation," where he suggests that innovation is growth spurts, which are the driving forces leading a capitalist economy. This theory has later been developed by various post-Schumpeterian economists. The innovation concept has gone far beyond Schumpeter's initial theory, and has been broadened to cover a process comprising several practices. Freeman (1982) was the first to emphasize the role of design in innovation. Today, we are faced with a new terminological use of 'design' and 'innovation' concepts especially in design circles, in the phrase of 'design innovation.' The term 'design innovation,' while not having a universally agreed upon definition, is increasingly used in academic and professional design discourse, e.g. popular design magazines, academic journals, etc. for the last 10-15 years (e.g. Cawood, 1997; Chayutsahakij, and Poggenpohl, 2002; Kimbell, 2002; Meredith, 1991; Presendorfer, 1995). Although the modern theory of innovation in economics have begun to refer to the practical relationship between design and innovation (i.e. Freeman, 1982), and to emphasize the role of design in innovation process (i.e. OECD, 1992), it still appears to be inadequate in explaining this new conceptual and terminological expansion — the design innovation.

This paper, which relies on a MSc. dissertation completed at Istanbul Technical University (Mutlu, 2003) aims to discuss the concept of 'design innovation,' by unfolding the close relationship between design and innovation; design as the core function of innovation, and innovation as the main driving force in the economy. The paper relies on both an extensive review of innovation theory, and an empirical use of the term 'design innovation' in the design industry. The elaboration of this new concept is considered to be vital since it contributes to the academic and professional discourse of design. Moreover, a conceptual and operational definition of 'design innovation' will also provide the basic tools for design studies to claim a new, a more balanced model in the innovation theory, which is currently dominated by engineering discourses.

Part 1: Conceptual Background

In the last few years, there have been a number of contributions to the academic design literature by studies on design innovation or other issues within the design innovation framework (i.e. Heskett, 1997; Chayutsahakij, and Poggenpohl, 2002). Nevertheless, most of the time, design innovation has been referred to as a synonym for terms such as design, innovation, innovative design, etc. Our approach to define design innovation aims at building a design-oriented framework on basis of the theory of innovation. Therefore, it is essential as the first part of this paper to study (1) the theory of innovation from historical and theoretical perspectives, and (2) innovation as a process and design as a core practice contributing this process.

1. Broad Definition of Innovation

The term 'innovation' has its roots from the Latin word 'novus', which means 'new' and is derived into the verb 'in+novare' that covers the meaning 'to make new'. Therefore, in the broadest context, 'to innovate'

is 'to begin or introduce (something new) for the first time', and 'innovation' has the meaning of 'the act of introducing something new' (The American Heritage Dictionary, 2000).

Leonard and Swap (1999) study 'innovation' in connection with 'creativity.' Innovation is the end result of a creative activity. Within this framework, they define 'creativity' as "...a process of developing and expressing novel ideas that are likely to be useful" (Leonard and Swap, 1999). Such a definition emphasizes not only the new, novel and unusual, but also 'useful' characteristics of the 'creative activity,' which leads to the potential for utility. From this perspective, as the end result of the creative process, "innovation is the embodiment, combination, and/or synthesis of knowledge in novel, relevant, valued new product, processes or services" (Leonard and Swap, 1999).

In the everyday language, 'innovation' is recognized as a synonym for 'invention', which means 'a new device or process created by study and experimentation' (WorldNet, 1997). Known to be used etymologically well after the term 'invention', according to the Product Development Management Association, the act of 'innovation' "...includes invention as well as the work required to bring an idea or concept into final form' (Rosenau, 1996). According to Tidd et al. (2001), "innovation is more than simply coming up with good ideas; it is the process of growing them into practical use." They expose invention as "only the first step in a long process of bringing a good idea to widespread and effective use" (Tidd et al., 2001). They distinguish two actions with dramatic examples from history:

In fact, some of the most famous inventions of the nineteenth century were invented by men whose names are forgotten; the names, which we associate with them, are of the entrepreneurs who brought them into commercial use. For example, the vacuum cleaner was invented by one J. Murray Spengler and originally called an 'electric suction sweeper.' He approached a leather goods maker in the town who knew nothing about vacuum cleaners, but had a good idea of how to market and sell them – one W. H. Hoover. (Tidd et al, 2001).

2. The Theory of Innovation: A Historical and Theoretical Overview

The theory of innovation dates back to early studies on the capital system. It was Bacon, at the beginning of the 17th century, who suggested a 'science-created utopia' on the role of the developments in science and technology in society. His views were opposed by Bernal of his generation, who gave importance on the uses of new discoveries for societal wealth rather than their own creation. Later, Adam Smith, in the second half of the 18th century, suggested technological change as a major concern for the development industrial production. In the first half of the 19th century, Marx put forward the view that technological advancements –and improved industrial production- had displaced the 'worker,' causing confusion in the social order. Lately, it was Schumpeter, in the first half of the 20th century, who first mentioned 'innovation' as "keeping the capitalist engine in motion." Schumpeter suggested innovations to be imperative for economic growth, commercial profit, and thus, public wealth. Schumpeter's theory has later been developed by neo-Schumpeterian economists such as Freeman and Dosi. Recently, contributions from diverse disciplines including Design, Management, and Marketing have developed the modern theory of innovation (Smith, 1776; Marshall, 1930; Schumpeter, 1934, 1939, 1942, 1954b; Meier and Baldwin, 1957; Freeman, 1982, 1990; Elliot, 1985; Sylwestor, 2000).

During the course of the development of the theory of innovation, scholars with different approaches including the classical economists, the Marxists, the neo-classical theorists, the Schumpeterians, post-Keynesians, and post-Schumpeterians have had significant contributions. Nevertheless, two characters in

the history of innovation emerge; Adam Smith by laying the foundations of the classical understanding of technical change and economic growth and Joseph Schumpeter by challenging Smith's views with a dynamic theory of economics based on cycles of innovation.

Smith (1776) was fundamentally the first classical economist to study technical change and its impact on economic growth. He believes that economic development is a gradual, self-perpetuating process. He builds his theory on the eighteenth-century doctrine of natural law. He asserts that, within the control of the natural legal system, each member of the society is free to pursue his self-interest, resulting in a harmonious, beneficial economic order. According to him, development has a tendency to become cumulative, which results in an increase in saved capital -Smith describes it as 'Capital Accumulation,' which is a fundamental element in economic development and an increase in the extent of the market - that will eventually result in an increase in national income and growth in population (Original Source, Smith, 1776; Quoted from Meier and Baldwin, 1957). Smith's classical theory mentions developments to resulting in "improvements in art," which will lead to further specialization and productivity gains (Meier and Baldwin, 1957).

Schumpeterian analysis brings an outstanding point of view to Smith's classical theory, providing the most comprehensive and provocative analysis since Marx of the economic development and social transformation of industrializing capitalism (Elliot, 1985). Schumpeter (1934, 1939, 1942, 1954a and 1954b), in his views, rejects the classical and neo-classical explanation of economic development as a gradual, harmonious process. According to Schumpeter, instead of a gradual and smooth way, development occurs if there is a high degree of risk and uncertainty in an economic environment (Meier and Baldwin, 1957).

Schumpeter explains an 'equilibrium state' in an economic environment with the 'circular flow' principle (Schumpeter, 1954b). According to 'circular flow', there is a static equilibrium represented by a constantly repeating circular flow of money and goods. The only events in this economic environment are routine changes to which producers and consumers can easily adapt themselves (Dixon, 2000). Schumpeter's dynamic theory exposes a disturbance of equilibrium of 'the circular flow' in a constantly growing, static economy by 'clusters of innovations.' Schumpeter believes that, there is no possibility of profiting in the equilibrium state and innovations are essential to make profit. According to Schumpeter, innovations increase the economic activity by activating other innovators - by Schumpeter's definition, 'entrepreneurs'. This economic activity reaches to a mature state and alleviates itself and economy returns to the state of equilibrium. Thus, Schumpeter believes that innovations lead to the development and growth of the economy, and eventually to prosperity and wealth (Schumpeter, 1939).

According to Schumpeter (1942), innovations are the driving forces leading a capitalist economy run. He poses "the fundamental impulse that sets and keeps the capitalist engine in motion comes from new consumer goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates" (Schumpeter, 1942).

In Schumpeter's 'Theory of Economic Development', innovations stimulate new innovations, constituting 'clusters of innovations,' open new profitable opportunities, obtain profit and growth in the economy, and finally result with an enhancement in the standard of life of the public. Schumpeter suggests that each cluster of innovation -innovations subsequently appearing- is "...an avalanche of consumers' goods that permanently deepens and widens the stream of real income" (Schumpeter, 1942). If we look at those avalanches of consumers' goods, we again find that each of them consists of articles of mass consumption

and increases the purchasing power of the wage dollar more than that of any other dollar –in other words, the capitalist process, not by coincidence but by virtue of its mechanism, progressively raises the standard of life of the masses (Schumpeter, 1942). Therefore, Schumpeter’s theory of innovation suggests that innovation, which is the force behind the capitalist economic system, eventually brings about the growth of the economy and the increment in the standard of life.

3. Categories and Levels of Innovation

Categories of Innovation

Schumpeter (1934) classifies innovations in two major categories: Product and process innovations. Product innovations comprise “...the creation of a new good which more adequately satisfies existing or previously satisfied needs” (Schumpeter, 1934). Product innovations also include the creation of completely new products, which provides a monopoly position to the innovator. A process innovation replaces “...one production or consumption good by another, which serves the same or approximately the same purpose, but is cheaper” (Schumpeter, 1934). According to him, process innovations also include introducing new materials or supplies that have the potential of producing a unit of a product cheaper (Schumpeter, 1934). Although some of the post-Schumpeterian studies on the theory of innovation point out ‘organizational innovations’ as a distinct innovation category, Schumpeter (1934) includes organizational innovations in process innovations.

In Schumpeter’s theory, there are five types of innovations that comprise the following two major categories:

Process innovations:

1. A new method of production,
2. A new source of supply of raw material or semi-finished goods,

Product innovations:

3. A new good,
4. A new quality of a good, opening a new market,
5. A new industry structure as the creation or destruction of a monopoly position (Meier and Baldwin, 1957).

Utterback and Abernathy (1975) define product innovation as “a new technology or combination of technologies introduced commercially to meet a user or a market need.” For them, a production process is “the system of process equipment, work force, task specifications, material inputs, work and information flows, etc. that are employed to produce a product or service”, thus a process innovation is the improvement of process elements, a production unit’s internal organization structure, supplier interaction, etc. to improve efficiency and output productivity of a production process (Utterback and Abernathy, 1975).

OECD (1992) also categorizes innovations as ‘product innovations (major and incremental)’ and process innovations’, but distinguishes ‘technological innovations’ as a diverse category of innovation that contains both product and process innovations. According to OECD (1992), technological innovations, the same as ‘inventions’, has to be implemented in a product or process to become an innovation that has a commercial value. As indicated by them:

Technological innovations comprise new products and processes and significant technological changes of products and processes. An innovation has been implemented if it has been introduced on the market (product innovation) (OECD, 1992).

Major product innovation describes a product whose intended use, performance characteristics, attributes, design properties or use of materials and components differ significantly compared with previously manufactured products. Such innovations can involve radically new technologies or can be based on combining existing technologies in new uses (OECD, 1992).

Incremental product innovation concerns an existing product whose performance has been significantly enhanced or upgraded. This again can take two forms. A simple product may be improved (in terms of improved performance or lower cost) through use of higher performance components or materials, or a complex product which consists of a number of integrated technical subsystems may be improved by partial changes to one of the subsystems (OECD, 1992).

Process innovation is the adoption of new significantly improved production methods. These methods may involve changes in equipment or production organization or both. The methods may be intended to produce new or improved products which cannot be produced using conventional plants or production methods or to increase the production efficiency of existing products (OECD, 1992).

Although innovation theorists mention mostly two types of innovations, product and process innovations, contemporary marketing studies address further types of innovations; for instance, Campbell and Collins (2001) mention innovations in 'finance' and 'customer interface and channel'.

Levels of Innovation

Almost all of the innovation theorists agree that innovations happen in different degrees of novelty. This argument is pioneered by Schumpeter (1934), who mentions 'swarming secondary innovations' that compete for a share in the high, monopoly profits of the first new product. Tidd et al. (2001) give the example that 'increasing the speed and accuracy of a lathe is not the same thing as replacing it with a computer-controlled laser forming process.' The degrees of novelty vary from minor, incremental improvements to radical changes that totally change the way a product is perceived or a process is held in an industry (Tidd et al., 2001). Figure 1 represents the two dimensions of innovation, different levels of novelty and type of innovation.

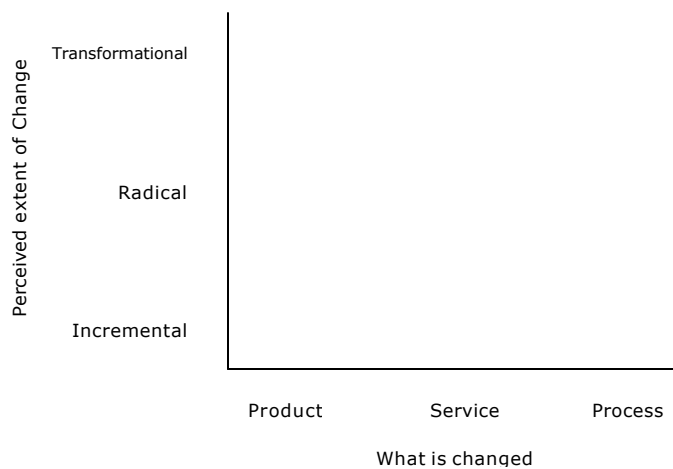


Figure 1 Dimensions of innovation space (Tidd et al., 2001).

Rothwell and Gardiner (1988) connect the importance of incremental innovations to the high rates of technological change. According to them, during periods of high rates of technological change, there exist relatively few radical innovations in each industry. They discuss that once a radical innovation is introduced to the market, it leads to various incremental innovations, and major or minor re-design variations developed on the radical innovation. Figure 2 corresponds to their identification on the technical change, consisting a radical innovation and subsequent incremental innovation.

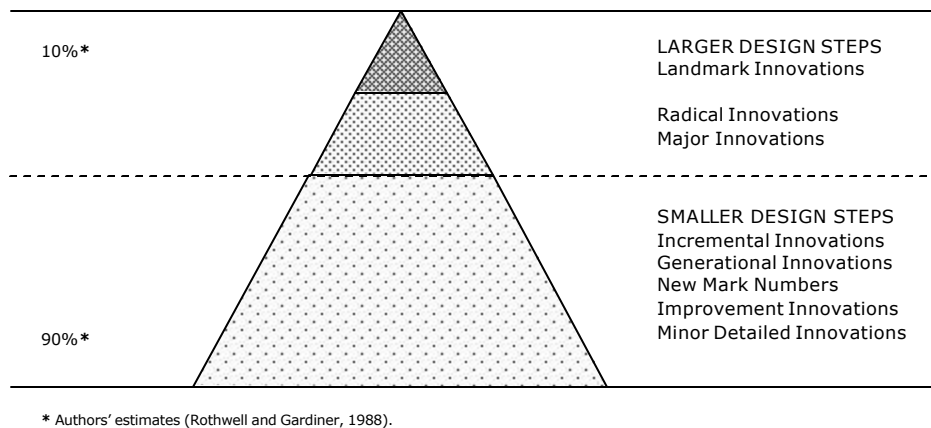


Figure 2 Levels of technical change (Rothwell and Gardiner, 1988).

Rothwell and Gardiner (1988) describe re-designs or re-innovations as “combining the existing with the new.” According to them, a re-design is a kind of product innovation that initially employs largely existing technology, but opens up a new and fast growing usage for the user. Both Rothwell and Gardiner (1988), and Walsh et al. (1992) approach re-designs and incremental innovations to be more important economically and commercially than producing the original invention or product innovation.

Management literature’s approach to the different levels of innovation is discrete. Cooper (2000) examines product innovation in terms of ‘newness’ of the product in two dimensions, ‘new to the company’ products, and ‘new to the market’ products. New to the company products activate companies to achieve process innovations that aim cost-reduction and risk minimization and incremental product innovations. On the other hand, a new to the market product is the first of its kind on the market, which closely refers to a ‘radical innovation’ with successful market implementation. Cooper (2000) identifies six categories of newness in product innovations, (1) new-to-the-world products, that are first of their kind and that create an entirely new market, (2) new product lines, that are not new to the marketplace, but are quite new to the company, (3) additions to existing product lines, that are new items to the company, but fit within an existing product line of the company, (4) improvements and revisions to existing products, that are replacements of existing products in a company’s product line with improvements in performance and perceived value, (5) repositionings, that are new applications for existing products and retargeting of old products to new market segments or for different applications, and (6) cost reductions, that are new products designed to replace existing products in the line, with similar performance and value but lower cost, which also involve significant process innovations. Figure 3 represents a matrix of the categories of new products and percentage values of the products in these categories in total new products.

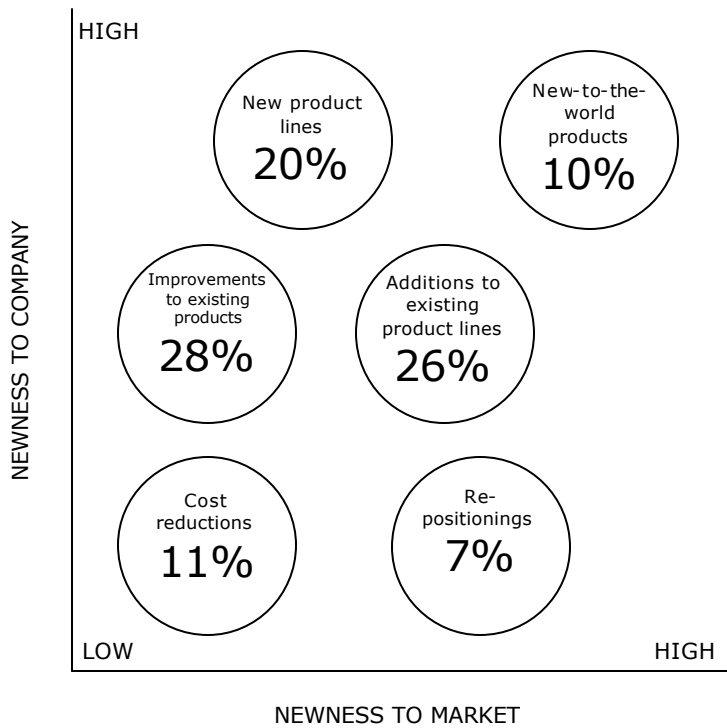


Figure 3 Categories of new products (Cooper, 2000).

4. Innovation as a Process

The studies on the theory of innovation suggest innovation to be a 'process,' but there is no agreement about the nature of this process. Coombs et al. (1987) describe a dominant linear model of the innovation process, according to which "innovation is a sequence of stages, starting from either R&D or some perception of demand and ending with a product sold on the market." In this model, the input of each stage is the output of the previous stage in a linear fashion. OECD (1992) explains this model as "the development, production, and marketing of new technologies followed a well-defined time sequence that originated in research activities, involved a product development phase, then led to production and eventual commercialization." This linear model of the innovation process is challenged with an 'interactive model' in the contemporary approaches to the innovation process (OECD, 1992). The interactive model of the innovation process is characterized by continuous interaction and feedback, which emphasizes the central role of design (OECD, 1992). This model can be visualized as a path "starting with the new market opportunity and/or a new science and technology-based invention; this is necessarily followed by the 'analytical design' for a new product or process, and subsequently leads to development, production and marketing." (OECD, 1992).

Rothwell (1992) suggests that there are five generations of innovation models that evolved over time, originating from the linear model of the innovation process. The complexity and interconnection of the model, and the feedback it supplies, increases with the evolution of each generation. In the 'fifth generation' of innovation models, Rothwell (1992) describes innovation as a process with a supreme level of interaction, within the company or with external resources, assisted by IT (Information Technology) networking systems. Although late generation models of the innovation process comprise complex interactions and infrastructures, they are based on the same basic framework of the linear and interactive

models of the innovation process (Tidd et al., 2001). Table 1 shows a summary of Rothwell's generations of innovation models.

Generation	Key Features
<i>First / second</i>	Simple linear models –need pull, technology push
<i>Third</i>	Coupling model, recognizing interaction between different elements and feedback loops between them
<i>Fourth</i>	Parallel model, integration within the firm, upstream with key suppliers and downstream with demanding and active customers, emphasis on linkages and alliances
<i>Fifth</i>	Systems integration and extensive networking, flexible and customized response, continuous innovation

Table 1 Rothwell's five generations of innovation models (Original source, Rothwell, 1992; Quoted from Tidd et al., 2001)

The 'innovation process' involves a series of sub-processes. In the case of product innovation, the 'new product development' process dominates the innovation process. The 'new product development' process, itself, also consists of sub-processes, which might include basic research, design, development, prototyping, testing, and so on. In this respect, terminological usages such as 'innovation process,' 'new product development process,' 'product development process,' 'product design and development process' are generally subject to confusion.

New Product Development

One common description of 'new product development' is "the process that transforms technical ideas or market needs and opportunities into a new product on to the market" (Walsh et al., 1992). 'New product development' and 'technological innovation' concepts are often subject to confusion. Walsh et al. (1992) illustrates the difference of new product development from technological innovation as "the 'new product' concerned might involve only changes in form, components, materials, or even just packaging rather than changes in operation principle or technology". Figure 4 represents a generic process of technological innovation and the place of the new product development activity.

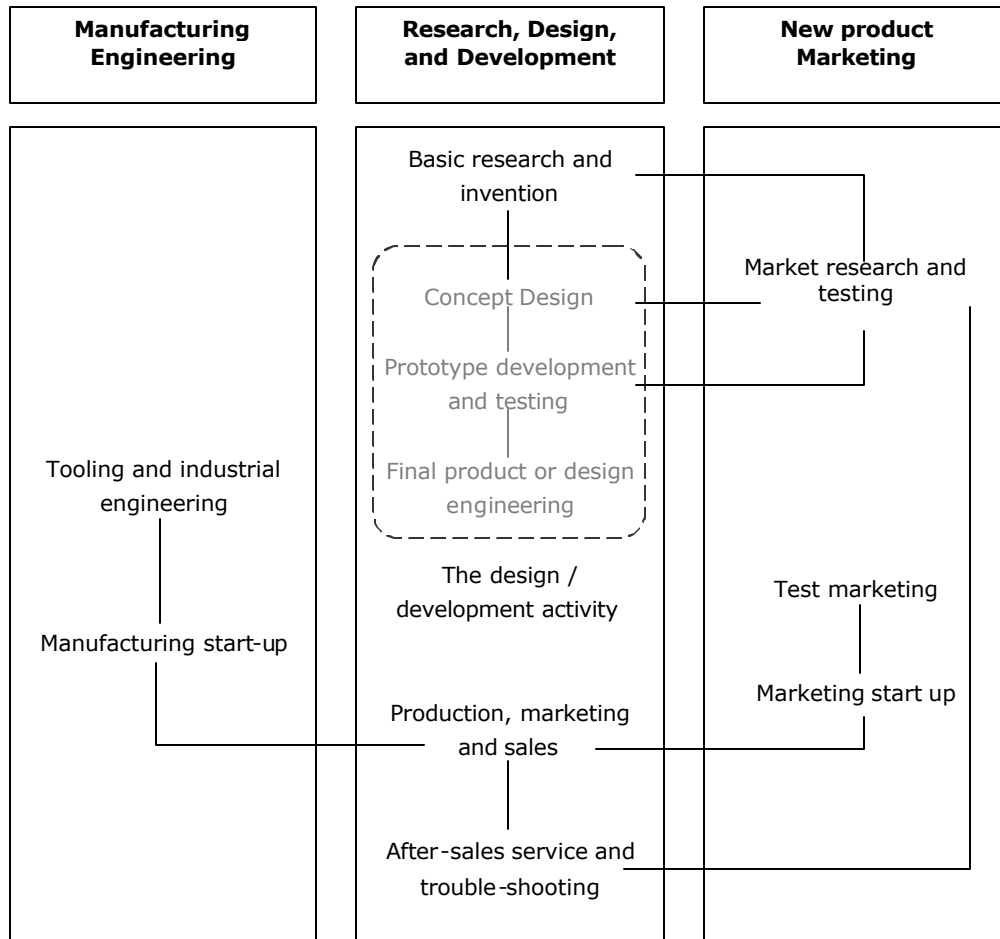


Figure 4 The process of technological innovation showing the role of the design and development activity (Roy and Bruce, 1984; Quoted from Walsh et al., 1988).

PDMA defines 'new product development' as "the overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product" (Rosenau, 1996). Therefore, 'new product development' is an integrated 'process,' which comprises "a disciplined and defined set of tasks and steps that describe the normal means by which a company repetitively converts embryonic ideas into salable products or services" (Rosenau, 1996).

Product Design and Development

In professional and academic literature, 'design,' 'product design,' 'product design & development' and 'industrial design' terms are often used as synonymous with each other. Some models of the product development process use 'design and development' as identical with the whole 'product development process' (Walsh et al., 1992). From this perspective, 'product design and development' stands in the core of the 'new product development' process. Walsh et al. (1992) describe 'product design and development' as "the activity that transforms the brief or initial market specification into design concepts and prototypes, and then into the detailed drawings, technical specifications and other instructions needed to actually manufacture a new product."

Walsh et al. (1992) mention that design activity is subsequent to a 'development' activity, "in which prototypes are tested and modified until a satisfactory pre-production version of the product has been evolved." The development activity provides feedback to the design activity for further refinement in the product or service design to improve product eligibility for manufacturing and marketing.

Design

In its broadest context, 'design' is defined as "the purposeful or inventive arrangement of parts or details." (The American Heritage Dictionary; 2000). According to ICSID (2002), 'design' is "a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles" as "the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange" (ICSID, 2002). The design activity comprises various subordinate areas and activities, which address a diversity of concerns. Figure 5 represents the main areas of the design domain comprehensively with a graphical interpretation of the connections between distinct areas.

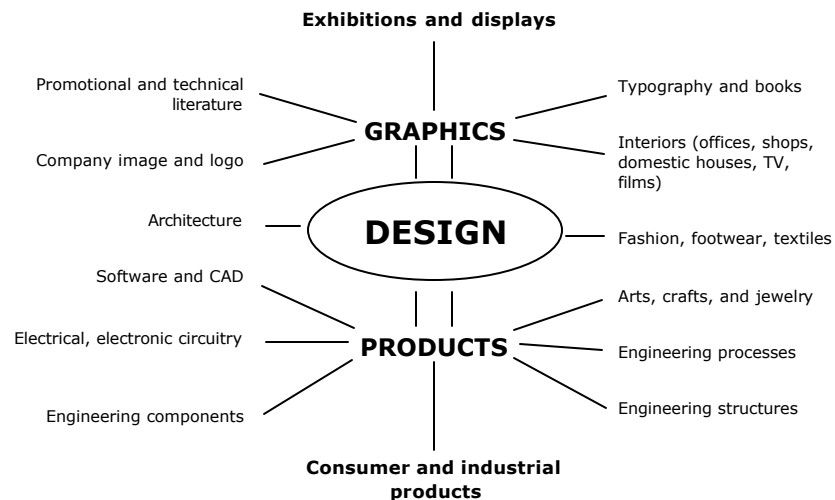


Figure 5 The main areas of design (Shirley and Henn, 1988; Quoted from Walsh et al., 1992).

Even though the theory of innovation originates from the theory of economics and studies on technical change, and technical change or 'invention' is mostly recognized to trigger innovations, some studies refer to 'design' as the core of the innovation process (Freeman, 1982; OECD, 1992). These studies emphasize the role of 'design' as the innermost part of the innovation process. While Freeman (1982) mentions that innovation entails resources such as R&D and design; OECD (1992) highlights the central role of design in the innovation process. According to OECD (1992), design is "the very core of innovation...the moment when a new object is imagined, devised, and shaped in prototype form."

Lorenz (1990) also emphasizes the emerging central role of 'design' at a strategic perspective. According to him (1990), "the old weapons for achieving real differentiation have become inadequate. No longer can comparative advantage be sustained for long through lower costs, or higher technologies. The design dimension is no longer an optional part of marketing and corporate strategy, but should be at their very core."

Product Design and Industrial Design

As previously mentioned, some studies on innovation give emphasis to 'design,' specifically 'industrial design,' as the core concept of the new product development, and in the macro-scale, the innovation process (Walsh et al., 1992; Freeman, 1982; OECD, 1992). According to Walsh et al. (1992), design is "the activity in which ideas and needs are given physical form, initially as solution concepts and then as a specific configuration or arrangement of elements, materials and components." OECD (1992) depicts the output of the design activity as "drawings aimed at defining procedures, technical specifications and operational features necessary for the development and manufacturing of new products and processes."

As the very central activity of new product development, design activity comprises several concepts. OECD (1992) describes these concepts as "initiating design"; illustrating the original invention, "analytical design"; and "the study of new combinations of existing products and components, re-arrangements of processes and designs of new equipment within the existing state of the art."

Walsh et al. (1988) mention that design can constitute a 'strategy' for market success by improving the quality of a product with incremental changes over time. Er (1997) also defines industrial / product design as a strategic process "containing that knowledge about a product from which it can be materialized and positioned in the marketplace, the answers to the basic 'why' and 'how' questions about a product."

Marketing literature suggests that 'design' is a tool to achieve competitive strategies. Porter (1980) describes the common types of competitive strategy as 'price', 'focus', and 'differentiation'. Within this framework, a competitive strategy on 'price' aims to reduce costs and convey supplier involvement in product development process and competition with lower costs. Furthermore, a company with 'focus' competitive strategy tends to address an exclusive market based on consumer demands and specialization for the market. Finally, in a competitive strategy based on 'differentiation', 'design' is a strategic tool for product positioning in the targeted market segment. 'Design' offers differentiation in features including quality, robustness, precision, ease of use, product appeal, and price, which convey competitive advantages to the product (Porter, 1980).

However, 'product design' and 'industrial design' terms are usually subject to confusion. Defining these two distinct concepts is an ongoing debate of the design literature. Although exploring the terminological distinction between two terms is not included in the aims of this study, briefly defining the difference between two concepts would be a helpful attempt for clarification.

'Industrial design' mainly refers to a 'practice' in the entire 'design' domain, while 'product design' stands for 'a combination of practices'. Thus, 'product design' should be considered not as a 'discipline', but as an 'activity' consisting of the contribution of various disciplines. A 'product design' activity appears to inevitably encompass 'industrial design' as the central practice harnessing the contribution of all other practices, for instance, engineering design, software design, interaction design, design of product graphics, and so on. The level of contribution of other practices relies on the characteristics of the product, to which the product design activity is devoted.

Walsh et al. (1992) attempt to clarify the controlling role of industrial design within a product design activity. According to them, "industrial design seeks to rectify the omissions of engineering; a conscious attempt to bring from visual order to engineering hardware where the technology does not of itself provide these features" (Walsh et al., 1992). They also emphasize the role of design function in accessing

all the specialized functions within and outside the company that includes the design function, and assembling the necessary information as input to the product design process.

Consequently, along with a variety of definitions of 'industrial design' on which the literature agrees, 'product design' refers to 'a collaborative design activity with a harnessing role of industrial design' devoted to design a particular product or a range of products.

Part 2: Building a New Definition

Design innovation, on the surface, appears to embrace two very basic explanations. The first explanation, 'innovation *in* design', refers to 'novelties introduced in the design of a particular product or artifact'. The second, 'innovation *by* design', covers 'a new product or artifact or a novelty in a product or artifact acquired by design function.'

This part eventually aims to reach to a definition of the term 'design innovation'. To achieve this, it is essential to make an in-depth analysis of the conceptual and etymological framework and a review of existing attempts to build such definition. Thus, before attempting to arrive at a definition, this part seeks to make a conceptual and etymological review of the literature for the 'design' and 'innovation' concepts that comprise the framework for 'design innovation,' and existing attempts to build a definition within this framework.

1. Design

Design, etymologically and linguistically, comprises a wide scope of meanings that make it difficult to focus on a generic definition. However, in the design literature, there are various definitions addressing to 'design' from different perspectives.

Another concern that blurs the way in building a generic definition is the wide variety of practices that 'design' discipline covers, most of which are represented in the following paragraphs. While 'design' is considered to define a category of 'innovation,' it also refers to practices that contribute to new product development activity. Furthermore, as OECD (1992) emphasizes, 'industrial design' plays a significant role in the development of products and services. Therefore, while discussing 'design innovation', it is possible to consider an integrated contribution of a variety of design practices with a central and harnessing position of 'industrial design'.

Etymological Definition of Design

The word 'design' originates from Medieval Latin of 14th Century from the word 'sign', which, in its verb form 'signare', means 'to mark out'. The word 'signare' was derived to the verb 'de+signare', which means 'to create, fashion, execute, or construct according to plan' having the synonyms 'to create, to contrive and to intend'. The verb form of the word 'design' was synchronously transferred to Middle English as 'de•sign' meaning 'to outline, indicate, mean', synonymous to the verb 'sign' (Britannica Webster's, 2002).

The first usage of the noun form of the word 'design' appears to be by 1588. Here, the word 'design', is explained as, (1) a purposeful activity, '1. A particular purpose held in view by an individual or group' or a 'deliberate purposive planning', and (2) a project or a scheme, '2. A mental project in which means to an end are laid down' or a 'deliberate undercover project or scheme'. The more contemporary explanations to

the word appear with the usage of synonymous words. 'Design', identical with the word 'plot (*in plural form*)' means 'a preliminary sketch or outline showing the main features of something to be executed'. "Another synonymous word for 'design' is 'delineation', which has the meaning of 'an underlying scheme that governs functioning, developing, or unfolding'. 'Design' is also used identical to 'pattern' or 'motif' which mean 'the arrangement of elements or details in a product or work of art'. The term design is also explained as a creative activity, 'the creative art of executing aesthetic or functional design' (Britannica Webster's, 2002).

From the etymological point of view, Oxford English Dictionary (2002) reveals the evolution of word 'design' with its usages throughout the history. The first to use the word in its noun form is Shakes in 1588 as "Thine in the dearest designe of industrie" with the meaning of '(2) purpose, aim, and intention'. At almost the same time, Hooker, in 1593, used the word as '(1) a plan or scheme conceived in the mind and intended for subsequent execution; the preliminary conception of an idea that is to be carried into effect by action; a project' in his writing, "What the lawe of God hath, either for or against our disseignes". 'Design' means '(3) the thing aimed at; the end in view; the final purpose' while Lady M. W. Montagu wrote, "Happiness is the natural design of all the world" in 1711. In 1831, Brewster used the word 'design' as "The arrangements, therefore, upon which the stability of the system depends, must have been the result of design" having the meaning '(4) contrivance in accordance with a preconceived plan; adaptation of means to ends; pre-arranged purpose". Defoe, 1719, used the word 'in a bad sense' as a '(5) crafty contrivance, hypocritical scheming' in his writing as "A...faithful...servant...without passions, sulleness, or designs". It was 17th and 18th Century, when the use of the word 'design' arose to mean 'a piece of art, a detailed project, or a creative work of art'. Junius, in 'Painting of Ancients' in 1638, used the word as "What beauty and force there is in a good and proportionable designe" having the meaning of '(6) a preliminary sketch for a picture or other work of art; the plan of a building or any part of it, or the outline of a piece of decorative work, after which the actual structure or texture is to be completed; a delineation, pattern'. The word was used in the meaning of '(7) the combination of artistic details or architectural features which go to make up a picture, statue, building, etc.; the artistic idea as executed; a piece of decorative work, an artistic device' by Evelyn in 1644 as "I was particularly desirous of seeing this palace, from the extravagance of the design". Alternatively, Ruskin, in 1854, used the word in his writing as "Design, properly so called, is human invention, consulting human capacity" with the meaning of '(8) the art of picturesque delineation and construction; original work in a graphic or plastic art' (OED, 2002).

Conceptual Definition of Design

As formerly stated, 'Design' concept has various definitions which originate from a variety of perspectives. These perspectives lead to definitions at functional and strategic levels addressing to 'design' in general, and 'product design' or 'industrial design' in particular.

The earliest recorded official use of the term 'industrial design' by the US Commissioner of Patents dates back to 1913, to distinguish the 'form' of products, as distinct from their 'function' (Lorenz, 1990). ICSID (2002) defines 'design' separately in both functional and strategic perspectives. According to ICSID (2002), 'design' operationally is "a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles." ICSID (2002) strategically define 'design' as "the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange."

OECD (1992) brings a functional perspective by defining 'design' as "*drawings aimed at defining procedures, technical specifications and operational features necessary for the development of new products and processes.*"

One of the most fundamental definitions of 'industrial design' has been made by Heskett (1980), according to whom "*...Industrial design is a process of creation, invention and definition separated from the means of production, involving an eventual synthesis of contributory and often conflicting factors into a concept of three-dimensional form, and its material reality, capable of multiple reproduction by mechanical means.*"

Marzano (2000) defines 'design' in a higher strategic level having "*a role to play in sustaining and encouraging the evolution of civilization, balancing technology, and socio-cultural values.*" According to him, 'design', "*by facilitating interaction ... makes new achievements possible, encourage the progression of values and ultimately, support in the pursue of growth, breakthrough and maturity*" (Marzano, 2000).

Porter (1980) describes 'design' as an essential strategic tool for competitive strategy. Thus, 'design' is committed to "*producing attributes with place the products apart from competing offerings within the market*" including "*enhanced quality, expressed via durability, precision, ease of operation and distinctive aesthetics and so on, at an appropriate price.*"

Walsh et al. (1992) agree on a broad definition of 'design' as "*the configuration of materials, elements and components that give a product its particular attributes of performance, appearance, ease of use, method of manufacture, and so on.*"

Buchanan (2001) defines design as "*the human power of conceiving, planning, and making products that serve human beings in the accomplishment of their individual and collective purposes.*" According to his definition, design "*is an art of invention and disposition*" with a universal scope that makes it applicable to the creation of any artifact (Buchanan, 2001).

2. Innovation

In comparison to the definition of 'design,' the definition of 'innovation' is clearer. Although word etymology brings us back to Medieval Latin, innovation has no more than a history of half a century. Some ambiguity appears when one is concerned with the categories and levels of innovation. Therefore, we outline the design innovation framework to comprise *radical and incremental innovations of products and services*.

Etymological Definition of Innovation

Etymological origins of the word '*innovation*' extends to a derivation of the Medieval Latin word '*novus*' of the 15th century, which means '*new*'. The derived Latin word '*in+novare*' broadly covers the meaning '*to make new*', which is transformed into English as '*innovate*' to mean '*to introduce something new*' (The American Heritage Dictionary, 2000; Britannica Webster's, 2002).

As maintained by Oxford English Dictionary (2002), linguistically the first to use the term '*innovation*' in history is the King Edward VI in 1548 with the meaning of '(2) *a change made in the nature or fashion of anything; something newly introduced; a novel practice, method, etc.*' in his Act 2 & 3 as "*To stave innovacions or newe rites*". The most frequent usage of the term '*innovation*' has the meaning of '(1a) *the introduction of novelties; the alteration of what is established by the introduction of new elements or forms*' as Brende, in 1553 used, '*Perdicas, whose ambitious mynde desirous of innoation, was (he*

sayde) to be preuented in time". The word 'innovation' is also used as identical to '(1b) revolution' as Stafford in 1633 used, "For the same reason of innovation, he besought them to send unto him fiue Lasts of powder with match and lead". In the Law literature, 'innovation' is used as '(3) the alteration of an obligation; the substitution of a new obligation for the old' as Bell, in 1861, describes 'innovation' as "a technical expression, signifying the exchange, with the creator's consent, of one obligation for another, so as to make the second obligation come into the first place of first..." Contemporary usages of the term 'innovation' are more likely to address the meaning '(5) the action of introducing a new product into the market; a product newly brought on the market'. Schumpeter, in his 'Business Cycles', in 1939, is first to mean 'innovation' within this framework; "Innovation is possible without anything we should identify as invention, and invention does not necessarily induce innovation" (OED, 2002).

Conceptual Definition of Innovation

Schumpeter (1934), essentially the most significant character within the innovation literature, defines product innovations as "the creation of a new good which more adequately satisfies existing and previously satisfied needs."

Freeman (1982), in one of the most significant post-Schumpeterian studies on the theory of innovation, defines 'innovation' as including "...technical, design, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product or the first commercial use of a new (or improved) process or equipment".

Contemporary marketing literature identifies innovations from the standpoint of the 'investor' in a way that is similar to that of Schumpeter. Cooper (2000) mentions that an innovation relies on the notion of commercial risk. According to him, any change of the product that is perceived by the consumer, and therefore creates risk to the brand, business, or franchise, is considered an innovation. Consequently, as Schumpeter (1939) identifies, supposed commercial risks constitute potential profits for the investor.

Utterback and Abernathy (1975) define a product innovation as "a new technology or combination of technologies introduced commercially to meet a user or market need." Even though their perspective implies limitedly a 'technological innovation', according to them, "technological innovations which may have market application, lie fallow until markets can be identified or created." They argue, "Product innovation tends to be driven or stimulated by new market needs and opportunities" (Utterback and Abernathy, 1975).

OECD (1992) brings a distinction between a 'technological innovation' and 'product innovation' due to the implementation of the technological novelty to a product or service and the marketability quality of a product or service. As per OECD (1992), "Technological innovations comprise new products and processes and significant technological changes of products and processes. An innovation has been implemented if it has been introduced on the market (product innovation)."

Leonard and Swap (1999) arrive with a multifaceted perspective to the definition of the concept. They define 'innovation' as "the embodiment, combination, and/or synthesis of knowledge in novel, relevant, valued new product, processes or services."

Sethi et al. (2001) associate 'innovation' with a "meaningful uniqueness" in new products. According to them, the degree of innovation in a new product is "the extent to which a new product provides meaningfully unique benefits."

3. Design Innovation

Attempts to Define 'Design Innovation'

As previously mentioned, both 'design' and 'innovation' studies do not include a generally agreed definition of the concept of 'design innovation.' However, certain studies, which discuss the relationship between 'design' and 'innovation,' refer to such a concept.

While discussing 'design' as a strategic tool for competitive advantage and eventually market success, Walsh et al. (1988) refer to a similar concept. They mention "*new designs enhancing product quality but involving no technical change,*" through which they discuss incremental improvements in the quality of a product or service that are less risky and expensive, short term, therefore constitute less a venture for the producer (Walsh et al. 1988).

Oakley's (1990) definition of design includes the definition of 'design innovation'. According to him, design effort is devoted to "*help turn an invention into a successful innovation – or to extend the usefulness of an existing innovation.*" He also describes this effort as a "*fine-tuning to achieve a result that suits our needs more accurately.*" At this point, Oakley (1990) exemplifies his definition as described in the Table 2. Oakley (1990) also points out that 99 percent of the new products in the market are a derivation of an existing application, thus emphasizes the importance of design effort in terms of introducing novelties by extending the usefulness of the existing innovation.

Basic Innovation	Designed Innovation
Bicycle Cassette tape system Hovercraft	BMX Bicycle Walkman stereo (etc.) Hovermower

Table 2 Example products whose market potentials have been multiplied by design (Oakley, 1990).

Another perspective that emphasizes the role of design in incrementally improving the qualities of an innovation is the concept of "robust design" (Rothwell and Gardiner, 1988). A number of identical conceptual models have been used in various studies, for which a 'robust design' (or the equivalent concept) is a design that employs an existing technology, but opens up a new user segment or a competitive advantage in the market. Rothwell and Gardiner (1988) mention the concept of 're-innovation' through which producers create "*a special type of design capable of evolving into a design family of variants which meet a variety of changing market requirements.*" This perspective also explains the 're-innovation' or the 're-design' activity as "*combining the existing with the new*" (Rothwell and Gardiner, 1988).

A Definition for 'Design Innovation'

Before focusing on a definition, determining the *context* of the concept clarifies the way to build the definition. Accordingly, within the perspective of this study, the concept of 'design innovation' constitutes a '*category of innovation,*' like technological innovation, product (radical or incremental) innovation, process innovation, and other sub-categories of innovation. Another issue that this definition seeks to clarify is the '*level of innovation*' in terms of the *novelty* in a product or service obtained through design effort. That determines whether a 'design innovation' is a radical innovation or an incremental one.

In the light of these considerations, we conclude that 'design innovations' comprise '(a) *the incremental novelties in the design of an existing product or service, or (b) radically new products or services obtained by design effort with no or minimal technical novelty.*' The 'design effort' mentioned in this definition refers to '*a design activity with a central role of 'industrial design', and contributions of a variety of design practices.*' In addition, within the framework of this definition, 'design innovation' concerns both radical and incremental innovations.

The word 'technical' in the phrase 'technical novelty' implies several meanings, and therefore needs clarification. 'Technical' for The American Heritage Dictionary (2000) means "*of, relating to, or employing the methodology of science; scientific,*" whereas 'design' is not limited to employ scientific methods, as described in ICSID's definition mentioned before, which suggests that 'design' aims "*to establish the multi-faceted qualities*" of products or services. Therefore, the 'technical novelty' mentioned here refers to '*novelty in a product or service attained by the use of sole scientific methods or practices.*'

Furthermore, this definition covers the two possible linguistic explanations of the term, which were initially mentioned. 'Design innovation', both linguistically and terminologically, embraces those two explanations. The first explanation, 'innovation in design', covers '*the incremental novelties in the design of an existing product or service obtained by design effort with no technical novelty*' fraction of the definition. On the other hand, the second explanation, 'innovation by design' stands to be identical with 'design innovation'.

The difference between 'design innovation' and ordinary product design activity seems unclear. One reason to make a distinctive definition of 'design innovation' is the 'novelty' that the output of the design activity should comprise. The degree of 'novelty' determines whether a 'design innovation' is an incremental or a radical one. It is evident that ordinary design activity does not necessarily have to encompass a novelty, in terms of a competitive advantage in the market or a meaningful benefit for user.

Part 3: Discussion & Conclusion

Conclusion & Importance of 'Design Innovation'

Although the literature does not comprise a generally agreed definition of the concept, 'design innovation', a number of studies emphasizes the importance of design in improving the quality of a product or service without technical change. According to Walsh et al. (1988), through re-design, incremental innovations are achieved with less risk, less expense and short time, therefore, less venturing the producer in terms of financial risk and market position. Rothwell and Gardiner (1988) point out the flexibility of the design of a product to meet the evolving needs of a variety of user segments. Porter (1980) identifies design effort as a sole competitive strategy, which, through differentiation and positioning, helps attain a competitive advantage in the market. Oakley (1990) emphasizes that design activity extends the usefulness of a new or existing innovation and helps the products suit user needs more accurately.

Thus, apart from routine design activity that helps transform technological innovations into product or service innovations or contributes to the incremental improvements in the quality of a product or service, 'design innovation' plays an important role in the competitive strategy of an enterprise that design and develop new products. This mostly originates from the fact that innovation *by design*, when compared to innovation driven by technological novelty, is less risky, less expensive, less time consuming and

eventually less venturing the innovator, on the other hand, more advantageous in obtaining the qualities those are perceived by the end-user (Walsh et al., 1988; Porter, 1980; Oakley, 1990).

Another concern that the emerging importance of 'design innovation' appears to elucidate is the level of technical competence needed to achieve innovation. With a corporate strategy built on 'design innovation,' companies do not need to run after highly invested technological competencies that require long-term development intervals. The increasing rate of design-driven innovation also denotes a change in the corporate insights and the structure of new product development organizations in the industry (Olson et al., 1995).

In conclusion, although the complexities and interdependency of the concepts in the design and innovation literature make it difficult to arrive at a definition, the absence of the definition of a 'design innovation' or 'innovation by design' still necessitates building one.

Discussion

An important part of the motivation to seek a definition for design innovation is that the innovation literature still falls short of highlighting the role of 'design' in innovation. Although the central role of 'design' activity has been emphasized in some studies (OECD, 1992; Freeman, 1982), the initial driver of innovation is still perceived as 'technical change.' For this reason, the innovation literature fails to provide a definition for a radical or incremental innovation achieved by design effort, instead of technical change.

Nevertheless, there is a shift of focus from a perspective emphasizing sole technical change, to an understanding that employs a variety of different perspectives and practices, especially those of social sciences and design. Schumpeter argued that innovation was no longer an activity carried out by a sole inventor, in his words, "entrepreneur," but becoming the business of trained specialists, and interdisciplinary teams. Freeman (1982) highlights the role of design in the making of a new product or equipment. More recently, OECD (1992) points out the role of design, specifically industrial design in the innovation process. According to OECD (1992), industrial design is the very core of innovation.

With reference to these, and as stated along with the definition of 'design innovation,' design innovation is attained through *'a design activity with the central role of 'industrial design' and a contribution of a variety of particular design practices.'* This makes a definition of the concept 'design innovation' meaningful. The shift of focus in innovation from technical change to a more balanced approach that includes design, and the increasing importance of user studies in innovation also make such a definition necessary.

Furthermore, such a definition attempt is also useful from the perspective of the design literature. Design innovation and routine design activity need to be separated in both methodological and practical terms. The difference between 'design innovation' and routine design activity is determined by the 'novelty' factor that 'design innovation' comprises, while ordinary design activity does not necessarily have to encompass such a novelty.

An important issue that needs clarification is the distinction between technological innovation and design innovation. As stated before, technological innovation entails a technical change or novelty, whereas design innovation brings a novelty attained through design effort with no or minimal technical novelty. The essential difference that lies behind this distinction is not the type of change but the approach taken toward innovation. This difference between two approaches can be explained in basic terms that technical change represents a 'scientific' approach, while novelties attained by design effort stands for a variety of

approaches from the Humanities to the Arts. Figure 7 represents a schematic representation of design innovation in relation to other kinds and categories of innovation.



Figure 6 A schematic representation of the categories of innovation and their cross-relations (Mutlu, 2003).

Within this framework, we can argue that design innovation plays an important role in the competitive strategy of a company. Furthermore, when compared to technological innovation, design innovation comprises several advantages from both the innovator's perspective and end-user's point of view. 'Design innovation' vis-à-vis technological innovation, remains less risky, less expensive, less time consuming from the company perspective; and more beneficial from the end-user perspective. In addition, in design innovation, new product development activity requires a lower level of technical competency to achieve innovation, which also avoids long-term development intervals. From the organizational point of view, the shift in organizations' emphasis from technological innovation to design innovation also indicates a change in the corporate insights and the structure of new product development organizations from conventional 'R&D Centers' or 'Product Development Teams' to interdisciplinary 'design teams' or 'design centers.'

In conclusion, 'design innovation' has potential to become a new mindset to understand the emerging approaches to design, their contribution to innovation, and a bridge to close the theoretical gap between the design literature and the literature on innovation and economics. Furthermore, its practical applications promise organizations to have long term benefits along with the advantage of more meaningfully and satisfactorily responding the changing consumer needs by design.



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