Influence of Product Complexity and Customer Demographics on Co-Design

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Design Science)
in The University of Michigan
2012

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To my father

Shaukat Ali

Who was my first mentor, best friend, and everything

May Allah Bless his soul million times a moment

Acknowledgements

All praise and praising is for God who makes miracles to happen. This dissertation is indeed one of them. Six years ago when I started as a doctoral student in Manufacturing Engineering, I had no idea that I will graduate in Design Science instead and that these six years will be the roller coaster ride of my life. I faced number of challenges during these years and at times came close to giving up. But few dedicated individuals helped me to keep going and finish my cherished goal of obtaining a doctorate. I would like to take opportunity and express my gratitude for their guidance and assistance. First of all I wish to thank Panos Papalambros who helped me to get transferred to the Design Science program, arranged for the financial assistance when I needed it the most, assisted me in forming the dissertation committee, and solved so many other issues that came during the course of the program. He went way out of his way to help me to go through this program. Thank you so much Panos. Special thanks are due to my advisors Richard Gonzalez and Kazuhiro Saitou for their guidance, patience, encouragement, and valuable feedback. I would also like to thank John Marshall, Anocha Aribarg, and Tim Simpson for insightful conversations that led to research questions presented in this dissertation. I am also indebted to Venkatram Ramaswamy, a globally recognized consultant on co-creation, who despite his extremely busy schedule agreed to serve on the committee and provided unique perspectives about co-creation and co-design. Thanks are also due to JoAnn Heck and Scott Slagle who helped me to obtain research data from an online panel of customers. I would also like to thank Atif for help with editing and proofreading. Finally I would like to thank my mother and sister for their encouragement and prayers for all these years.

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Abstract

Co-design is an emerging trend in new product development that results in more active customer participation in product development than conventional design processes; it connects customers, designers, and engineers throughout product design and development. This dissertation studies the influence of product complexity, frequency of product use, and customer demographics on co-design.

Three co-design surveys were conducted with an online community of customers. More than five hundred community members participated in these surveys and provided about two thousand design ideas to improve four different products. The analysis of these ideas showed that frequency of use influences the quantity of design ideas generated for that product. It was also found that product complexity (estimated by number of components and user interfaces) does not affect the novelty of design ideas generated for a product. In addition the data suggests that customers' dissatisfaction with existing products may lead them to generate novel ideas during co-design.

Results from these surveys also showed that customers' interest in co-design varies significantly with product type. For example customers are five times more interested in co-designing a house than an inkjet printer. Gender also influences co-design. Females are more interested in co-designing clothes than males whereas males are more interested in co-designing cars than females. Age also plays a role in determining customers' interest in co-design.

Finally, a five step framework (5i model) was proposed to implement co-design. These five steps were identified after reviewing latest case studies of co-design efforts for various companies like Dell, Starbucks, and Apple. In addition, the

data collected as part of this dissertation also informed the five step framework. The five steps are: invite the customers, interact with them, ideate for new products and services, implement customers' ideas and then improve the process of co-design. Using these five steps a company can initiate co-design efforts and engage customers in product design and development. It is predicted that in coming years co-design will increasingly augment conventional design processes.

CHAPTER 1

CO-DESIGN – AN INTRODUCTION

1.1 Co-creation and Co-design

In an increasingly competitive global economy, companies are motivated to continuously search for innovative products and services. Innovation has been long regarded as the source of profitable growth for companies. Customers can play a pivotal role in innovation through co-creation. Co-creation is defined as the joint creation of value by the company and the customer (Prahalad & Ramaswamy, 2004). Co-creation is a new approach for interacting with customers in various value creation activities undertaken by a company. In the early 2000s, Coimbatore Prahalad and Venkatram Ramaswamy from the University of Michigan's Ross School of Business identified the co-creation trend in industry and brought it to the attention of academia. As they write in their book, *The Future of Competition: Co-Creating Unique Value with Customers:*

> “The meaning of value and the process of value creation are rapidly shifting from a product- and firm-centric view to personalized consumer experiences. Informed, networked, empowered and active consumers are increasingly co-creating value with the firm.” (Prahalad & Ramaswamy, 2004).

According to *McKinsey Quarterly*, co-creation is one of the eight important emerging trends for businesses across the globe (Manyika et al., 2008). Co-creation may also have indirect benefits such as increasing customer engagement, loyalty and interaction with the company, which may have positive long term consequences beyond the immediate co-created outcomes.

Co-design is a special instance of co-creation (Sanders, 2008). Co-design happens when customers actively participate in the design and development process of new products. For this dissertation following definition of co-design is adopted:

> “We use co-design in a broader sense to refer to the creativity of designers and people not trained in design working together in the design development process.”(Sanders, 2008).

Co-design is different than conventional approaches to design. In conventional design customer participation is usually limited to product specification development through market surveys. They rarely participate in the initial phases of the design activity where ideas and concepts are generated by company designers. The product is given to the consumer with the company perhaps offering variants of the product to coincide with market segments. However, in co-design the user or the customer becomes an active member of the design team and participates in the design process. Therefore co-design results in user-generated designs or the designs that are realized with active participation from users. During co-design customers can participate in concept design, concept selection, and/or detailed design. The mode and intensity of participation vary depending on the product type and the design process.

Several researchers have analyzed the role of customer involvement in product design. Eric von Hippel, a professor of innovation at MIT Sloan School of Management, studied the role of lead-users in product innovation. Lead users are those customers who are at the leading edge of the marketplace. They tend to experience needs ahead of the other customers and they are able to innovate for themselves (von Hippel, 1986). Working with these users can become a source of innovation for new products for a company. Von Hippel states in his book, *Democratizing Innovation:*

> "Users of products and services both firms and individual consumers are increasingly able to innovate for themselves……….. Users that innovate can develop exactly what they want, rather than rely on manufacturers to act as their (very often imperfect) agents." (von Hippel, 2005)

This quote illustrates that firms at times cannot anticipate customers' needs accurately. As a result the solutions (products or services) provided by the firm may not be what customers want. In such cases, involving customers in the design process can lead to innovative products that customers want, desire, and perhaps more importantly, are willing to buy. In doing so, customers become active participants in the design process - usually considered to be the realm of company designers and engineers.

Along the same lines, Kaulio (1998) has identified three product development approaches: design *for* the customer, design *with* the customer, and design *by* the customer. The first approach relies on traditional market research methods, the second approach maintains a dialogue with the customer during the design process by letting them respond to various designs, whereas the third approach allows user to become the designer and this final approach is where co-design is realized. Pals et al. (2008) has used the terms *no direct user involvement, reactive user involvement*, and *active user involvement* to represent the above mentioned three approaches to product design.

Most current products are designed using the first two approaches. Usually customers play a passive role in design through surveys and focus groups. That is, they typically respond to the designs already developed by companies. However through co-design customers are able to propose designs and become active participants in the product design process. Such a co-design process has several advantages over the conventional process. The customer provides the design and the customer makes a commitment for purchasing the product. In this way no forecasting is required for the product volume. So every product made is already sold out before production. Several companies have used co-design to design successful products. Next section describes some current examples in industry illustrating the use of co-design and its principles. A brief discussion about the influence of co-design in reducing product failures and innovation is also given.

1.2 Co-design, Product Design, and Innovation

1.2.1 Co-designed Products

A number of companies—big and small—are using co-design in product development process. These companies are listed in Table 1.1. Some of these companies are supplementing conventional design activities with co-design while others co-design their entire product line. Currently, products designed using co-design mostly consists of toys, furniture, apparel, appliances, etc. A brief description of the co-design activities undertaken by these companies is given in this section.

In order to organize and compare the co-design activities undertaken by various companies, a common framework is needed. To develop such a framework, the process from conception to consumption of a co-designed product is divided into six steps: get design tool, design product concepts, submit design concepts, select design concept, execute detailed design & manufacture, and buy/sell product (see Figure 1.1 for an example with Lego). Most of the companies require that a customer submits the product design in a specific format. This format can be a CAD file or a design template. Some companies also accept hand sketches and photographs of the product to be co-designed. After obtaining the design tool (a simple CAD package or a design template), the customer designs the product. This is the major distinction between co-design and conventional design as the customer—instead of a company designer—is designing the product. Based upon the product type, customers can either submit conceptual design and left the detailed design activity for company designers or in some cases customers submit detailed design that requires minimal input from company designers.

After completing the design, customer submits it to the company such as through the company website. Hence, the Internet is one of the enabling technologies for co-design. Next concept selection takes place. Two methods have been typically used: Either other customers on the company website vote for the best design or the customer himself/herself decides to manufacture the design based upon the feedback provided by the company. During concept selection stage customers also show their commitment to buy the product. Most of the products that are currently being co-designed are simple and do not require detailed design (e.g., toys, t-shirts). However, in some cases if detailed design is required (e.g., vehicles), then company designers and engineers can undertake this step. The product is then manufactured by the company or a contract manufacturer. Once the product is manufactured, it is shipped to those customers who showed interest in buying the product. At times co-designed products are available for other customers (who did not participated in design) to buy as well.

Table 1.1: List of example companies using co-design

	Company	**Products**
1	Lego	Toys
2	Threadless	T-shirts
3	Ponoko	Furniture, household items, jewelry, miscellaneous
4	Muji	Furniture, household items
5	Elephant design	Furniture, home appliances, fashion items, miscellaneous
6	Local Motors	Vehicles

Lego (http://www.lego.com)

Lego is a leading toy manufacturer with a customer base of more than 400 million. It mass-produces toys that are designed by the customers (Hara, 2007). To help customers co-create Lego toys, the company has created software called Lego Digital Designer. Customers design Lego products using this software and submit their designs to the company. Lego then selects the outstanding designs and markets them. Lego shares the profits with the customer and also prints the customer name and picture on the Lego box (Hara, 2007). In this example of co-design, the customer designs the products but the company makes the final decision about manufacturing a particular design. This can be contrasted with the next example of co-design where voting is used for concept selection.

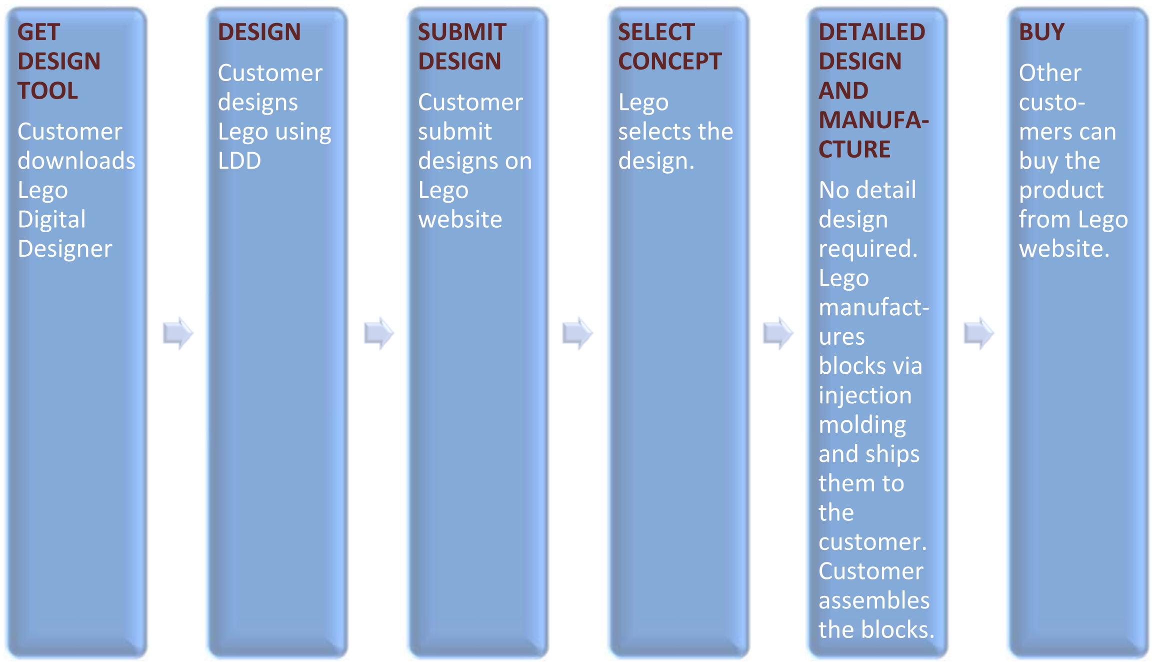

Figure 1.1: Co-design at Lego

Threadless (http://www.threadless.com)

Threadless has used designs submitted by its customers to build up a successful business. On its website, Threadless asks customers to submit T-shirt designs. The community of Threadless customers then votes for the best designs. The designs that are voted best are printed on t-shirts that are available for purchase online or through a bricks and mortar Threadless store in Chicago. Threadless pays fees to the customers whose designs are printed on the T-shirts. (Manyika et al., 2008). It is conjectured that some of these customers may be designers by profession in other fields and they use Threadless as an avenue to express their creativity and design clothing that they want to wear. In this way Threadless is co-designing T-shirts where customers design the shirts and Threadless markets them. Here voting is used for concept selection.

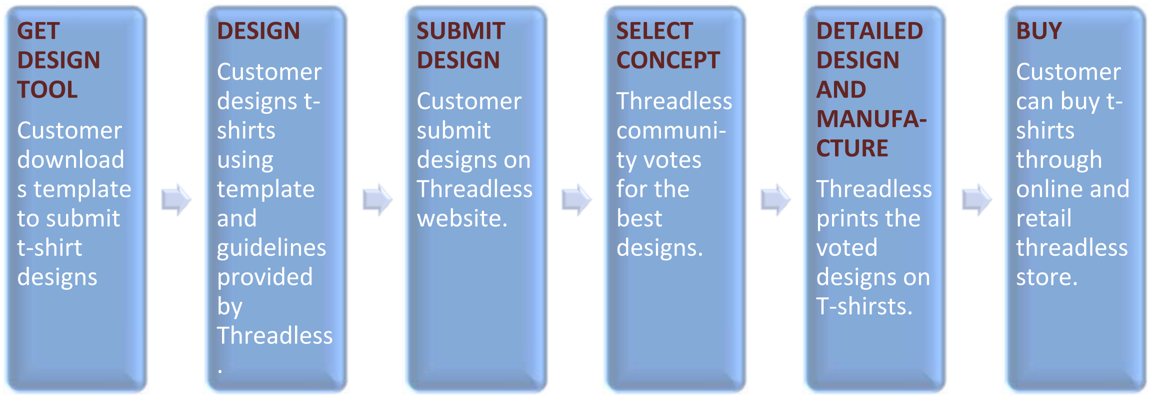

Figure 1.2: Co-design at Threadless

Cameseteria- a Brazilian T-shirt company is co-designing T-shirts in a similar way as Threadless. To date Brazilian customers have co-designed more than 25,000 T-shirts on Cameseteria website. Customers can post their designs on the website and they can also vote for the best designs, which are then produced by Cameseteria. Through co-design, Threadless and Cameseteria has reduced the cost and risk involved in launching new apparel. On the cost side, co-design eliminates the expense of hiring professional designers and through customer voting it reduces the risk of launching those products that customers are not interested in buying (Ramaswamy and Goulliart, 2010).

Ponoko (http://www.ponoko.com)

Ponoko is an online co-design company. On Ponoko's website customers can submit designs for various products like lamps, jewelry, furniture etc. Ponoko manufactures the products (or use contract manufacturers) according to the designs submitted by customers. The customer can sell the product at Ponoko website to other customers. One limitation on designs is that they have to be manufactured using laser cutting process. Even with this limitation hundreds of unique products are designed by the customers and are available for sale through Ponoko's website. In the Ponoko example, customers make the final decision about manufacturing the product. It is different than the previous two examples given where in one case the company made the final call and in the other case voting was used for concept selection.

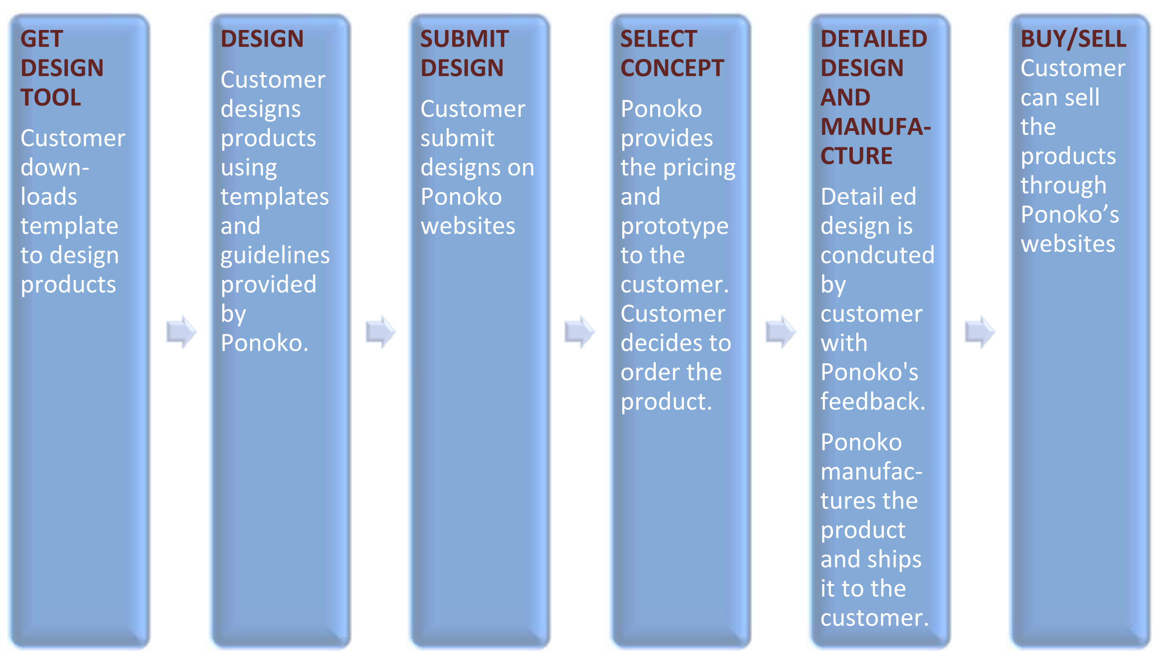

Figure 1.3: Co-design at Ponoko

Muji (http://www.muji.com)

Some of the most successful products sold by Muji, a Japanese retailer, are designed by Muji customers. Muji customers submit product ideas on its website. Muji customers also shortlist the ideas submitted on the website through voting. Company designers conduct the detailed design for the product ideas shortlisted by the customers. Those products are then manufactured and marketed by Muji. Products co-created by Muji's customers tend to outperform other Muji products designed using conventional design processes (Ogawa & Piller, 2006). For example a co-designed bean bag sofa generated sales of 1,344 million Yen as compared to 24 million Yen of average annual sales in this product category. (Ogawa & Piller, 2005). A combination of voting and company designers' opinion is used for concept selection for Muji.

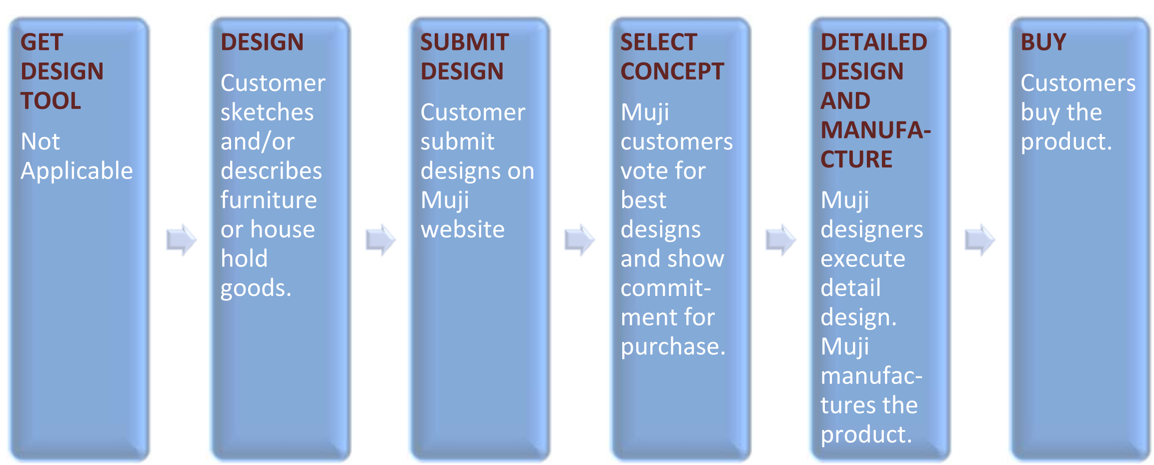

Figure 1.4: Co-design at Muji

Elephant Design (http://www.elephant-design.com)

Elephant Design -- a Japanese design consulting firm -- claims that the user can order anything they want by submitting a design idea on their website (Elephant Design, 2008). The design process starts with a user submitting a product idea on the website. Website users can view all the submitted ideas and they vote for the best ideas. If enough users vote for a product design and they are ready to purchase the design at a given price, then Elephant-Design contacts a manufacturer to make that product. The detailed design phase is either conducted by Elephant-Design designers or the contract manufacturer's designers. A compact electric cooker has been designed using this process. Like Threadless, voting by customers is the primary tool for concept selection at Elephant design.

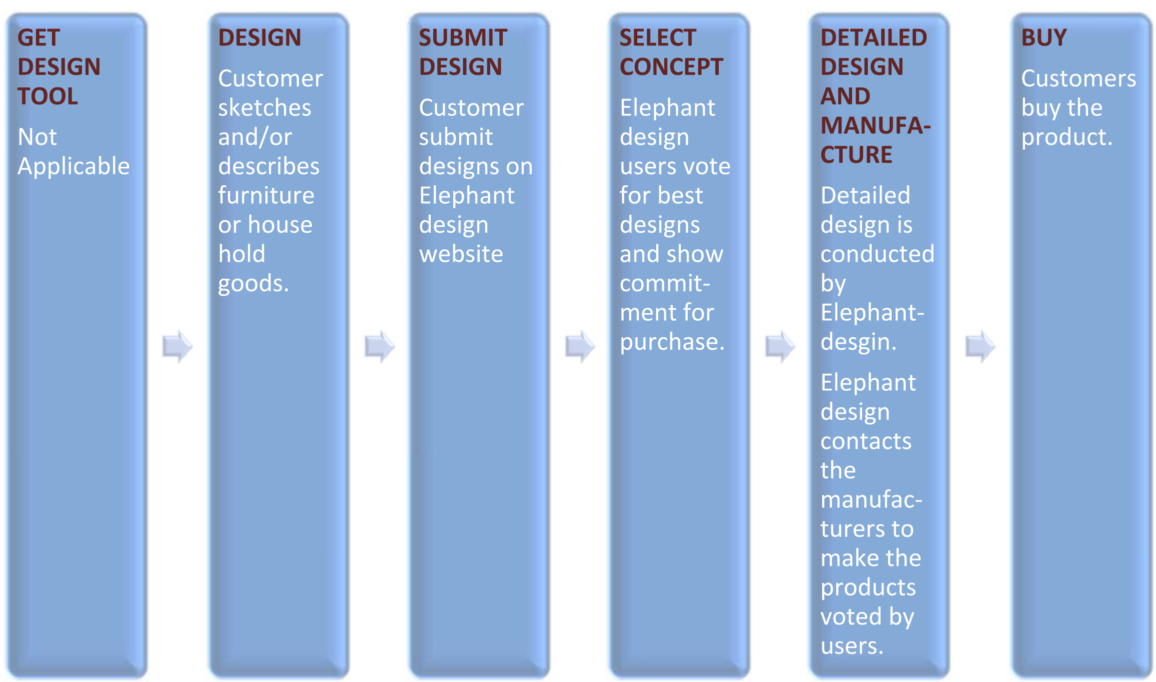

Figure 1.5: Co-design at Elephant Design

Local Motors (http://www.local-motors.com)

Local-motors is applying co-design to automotive design. On Local Motors' website customers (most of them are freelance automotive designers) can submit their sketches for exterior design of a car. The site's community then votes to select a design for production. To date only one design has been selected for production named Rally Fighter. Even though the exterior design was co-designed, most of the components for this car were selected off the shelf. Local-Motors engineers and machinists conduct the detailed design and fit the exterior design to a common chassis. The design is then transferred to a network of suppliers that provides sub-assemblies to local factories. The car is then assembled in small build centers where customers can participate in the assembly process.

Defense Advanced Research Projects Agency (DARPA) has also initiated a program named vehicleforge.mil. The purpose of the program is to develop a collaborative environment that will allow co-design of complex electro-mechanical systems.

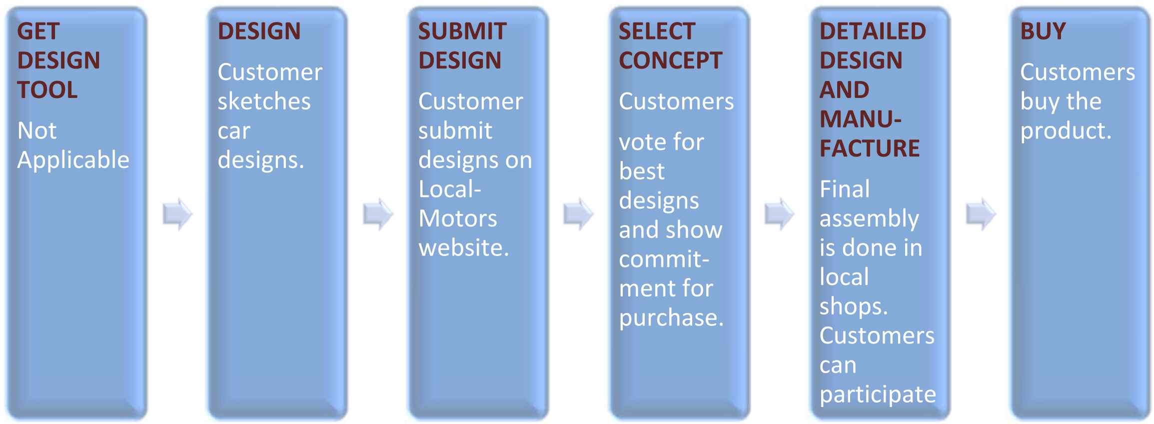

Figure 1.6: Co-design at Local Motors

Co-design has also been found helpful in eco- design and in designing low cost products for developing countries. For example, Bhalla (2011) has described that how Phillips Design co-designed a simple cooking stove to reduce CO emissions and improve fuel efficiency. Phillips Design involved local NGOs and used insights from actual users to develop this simple cooking stove that has won several design awards. Bhalla (2011) also suggests using co-design for a similar design project aimed to design a $300 house for the world's poor. He recommends involving people who will live in those houses in the design process. Similarly Thrift (2006) argues that customers can influence companies through co-design imposing their values on the design process. For example, customers can ask for sustainable products through co-design.

This section presented several examples of co-design as it currently exists in the marketplace. Most of these examples can be conceptualized as providing the infrastructure for individuals to manufacture and sell their designs. For example, an individual with an idea for a t-shirt can submit the idea and make use of an elaborate infrastructure to bring the idea to market. There is no need for an elaborate business plan. Potential customers vote on the idea, manufacturing is handled through the infrastructure and sales are sometimes secured prior to manufacture. Admittedly, these existing examples of co-design are somewhat limiting. One wonders what co-design would look like for well-established companies such as Ford Motor Co or Wilson Sporting Goods. Some newer examples of co-design have a somewhat different structure than depicted in say Figure 1.1, such as the smart-phone landscape with Apple's iOS and Google's Android. This dissertation hopes to address these more general concerns of co-design motivated by the successful examples provided in this section.

1.2.2 Role of Co-design in reducing Product Failures

Cooper and Kleinschmidt (1987) have reported that about 35% of the new products failed to meet financial goals. Similarly, Ogawa and Piller (2006) have mentioned that more than 50% of new products fail to meet financial expectations. This implies that companies may in part be often wrong in predicting what customers really want, at what price, etc. Any tool that can help companies perform better at predicting customers wants, desires, and purchase behavior will help reduce product failure rates. As Ogawa and Piller (2006) write:

> "The manufacturer's nirvana is to develop and produce exactly what its customers want and when they want it and to do this with no risk of overstocks or inventory." (Ogawa and Piller, 2006).

Co-design provides one answer to this problem. Using a design process similar to Elephant-Design, companies can solicit customers' suggestions about future product offerings. The Internet has facilitated the communication required between companies and their customers. Companies can also judge customers' willingness to buy at given price and predict the volume to produce. In this way the design process has been initiated by the customer and customers may show a greater commitment to buy the products once designed.

1.2.3 Co-design and Innovation

As stated earlier in the chapter that companies are on a continuous search for innovative products and services. Through co-design, customers can bring their unique experiences and play a pivotal role in innovation. Examples of products designed on Elephant Design, Muji, and Ponoko websites demonstrate that customers were able to design unique and novel products through co-design. However an important question is what type of innovation happens in co-design?

A review of the literature shows two classification methods for innovation. One is based on the 'degree' of innovation (Reid & Brentani, 2004) and the other is based on the 'source' of innovation (Verganti, 2008). According to Reid and Brentani (2004) there are two types of innovation based on the degree of newness: incremental and radical. Incremental innovation happens when a new product is designed using existing technologies targeted towards existing markets, whereas radical (or discontinuous) innovation disrupts current technologies and markets and introduces “really new” products. Another classification of innovation is described by Verganti (2008). According to Verganti there are three types of innovation based upon the source of the innovation.

1. Market pull
2. Technology push
3. Design driven

Market pull innovation happens when either a designer observes user needs, analyzes them and proposes a solution to meet user needs. Or users themselves propose a solution to their unmet needs– as it happens in co-design. However, according to Verganti (2008) such innovation is only incremental and it cannot result in radical innovation. As he states, “Customers hardly help in understating possible radical changes in product meanings as they are immersed in a sociocultural context that lead them to interpretations that are in line with what is happening today.” (Verganti, 2008). According to Verganti (2008), radical innovation happens through technology push or is driven by design. Technology push innovation occurs when a technology developed in R&D lab is used to solve exiting or latent needs of customers. Similarly design innovation occurs when 'new meanings' are given to existing products by a company (Verganti, 2008). For example, with the advent of semiconductor technology, mechanical watches were replaced with Quartz watches. So this represents a case of technology push innovation as a new technology ‘semiconductors’ changed the design of watches. On the other hand, Swatch – a Swiss watch company introduced colorful inexpensive Swiss watches that were meant to be worn as fashion items. Swatch did not introduce a new technology but they transformed the meaning of the watch from a utility item to a 'fashion item.' Users may be unable to foresee design and technological innovation, so co-design may result only in incremental innovation. User involvement in product design can only result in incremental market pull innovations. Other types of innovations are outside the realm of user involvement in product design. Thus co-design provides an avenue to involve customers in the design process and facilitates market pull incremental innovation.

1.3 Dissertation Layout

The remaining chapters of the dissertation are as follows:

Chapter 2 summarizes the literature review about co-design research, identifies the research gaps, and then presents the goals and research questions for the dissertation.

Chapter 3 describes a design experiment conducted through online surveys to study the influence of product complexity and frequency of use on co-design. Customers' ideas generated during this experiment were analyzed for novelty and feasibility.

Chapter 4 discusses the influence of customer demographics on co-design and shows that how customers' interest in co-design varies with product type and product features.

Chapter 5 delineates a five step framework to implement co-design within a firm. These five steps were identified using recent case studies about co-design and drawing insights from design thinking literature.

Chapter 6 concludes the dissertation by summarizing key findings and mapping the direction for future work in co-design.

CHAPTER 2

LITERATURE REVIEW AND RESEARCH OBJECTIVES

2.1 Literature Review

Several researchers have studied customers' participation in the design process and have discussed various issues related to customer involvement in the design process. Research is this area has tended not to be conducted in one particular domain. Multiple research areas interact with co-design, for example lead user method, mass customization, innovation, and engineering design.

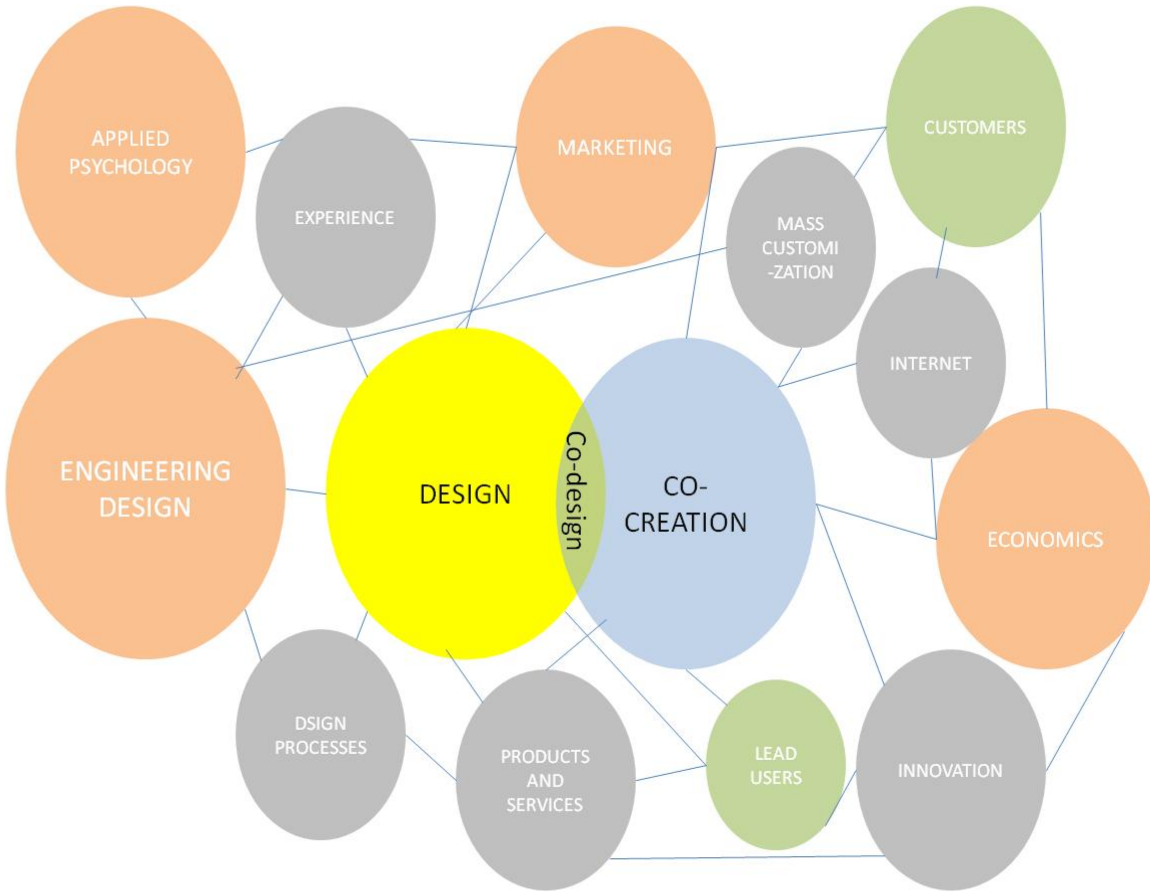

Figure 2.1: Co-design and various disciplines

Figure 2.1 depicts the interaction between co-design and various disciplines. As discussed in the last chapter co-design is a special instance of co-creation. This is shown by the two circles at the center of the figure. Those disciplines that are related to co-creation and design influence the research in co-design and are shown by large orange circles in the figure. For example research in marketing studies the interaction between customers and companies. Similarly, research in product design is also important for co-design as it studies the role of various members of a design team and their influence on product design. At the same time research in applied psychology provides methods to study the ideation process used in co-design. Small blue circles represents various processes (mass customization), constituents (customers, lead users), and modalities (internet). There are numerous interactions between all the entities given in the figure as depicted by various lines. Some of these interactions are being studied and others remain unexplored. For example, the relationship between mass customization and engineering design has been studied in greater depth over the past two decades. This chapter presents a brief discussion of research in these areas as related to co-design, relationship between co-design and customization, and experiments that are used for co-design research. The goal of Chapter 2 is to develop an organizing structure that summarizes the themes and results of previous research and points to the future research opportunities.

2.1.1 Three Methods for Customer Involvement in Product Design

Three methods for customer involvement in product design mentioned in the literature are:

1. Lead user
2. Crowdsourcing
3. Single customer co-design

Lead user method is perhaps the oldest method to involve customers in product design process. It was introduced by Eric von Hippel in the late eighties (von Hippel, 1986). Lead users are those customers who are at leading edge of the marketplace. They tend to experience needs ahead of the other customers and they are able innovate for themselves (von Hippel, 1986). Lead user method relies on direct interaction between lead users and product development teams. This method is applied to specialized and rather complex products (for example surgical drapes or sporting equipment). Von Hippel et. al (1999) studied the role of lead users in innovation at 3M. They concluded that lead users helped companies to find innovations that companies alone could not have found. Frank, Von Hippel, & Schreier (2006) analyzed the innovations by users in kite surfing. The found that 10-40% users have modified products for their use and these modifications can become a source of innovation for next generation of products. They also found that those users that are 'ahead of trend' developed more innovative modifications as compared to other users. Similarly, von Hippel & Thomke (2002) have reported case studies about innovation by customers in business to business settings (GE plastics and BBA).

A salient feature of lead user method is that it is used to improve already existing products. Lead user method relies on the prior use of the product. The user, in order to innovate, must use a product and then modifies the product to meet his/her specific needs. These modifications then become the source of innovation for the next generation of products. If lead users are not using a product then there are slim chances that they will be able to innovate. Lead user method does not include all the customers in the design process. Most of the studies conducted for lead user method first identifies the lead users and then involve them in the product design process. Another limitation for lead user method found in the literature is that it has studied a relatively few types of products. Lead user method application to more common products like cars, cell phones, etc. is absent from literature. Sanders (2008) argues that lead user method may not be able to predict the actual needs of vast majority of customers who are finally going to use the products. So lead user method limits the scope of co-design by involving only a fraction of customers.

Crowdsourcing, on the other hand, is a recent phenomenon as its working has been facilitated by the Internet. Crowdsourcing is defined as “the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production (when the job is performed collaboratively), but is also often undertaken by sole individuals” (Brabham, 2008). Companies use crowdsourcing for various activities like designing advertisements, solving R&D problems, and designing new products (Crowdsourcing, 2009). The internet has played an important role in involving customers in innovation process through crowdsourcing. Most of the products that are designed using crowdsourcing are simple like clothing, furniture, jewelry etc. Products co-designed on Threadless, Elephant Design, and Muji websites are prime examples of crowdsourcing. In contrast to the lead user method, crowdsourcing is used for two types of products: to design products within an existing category and to design products that do not exist.

The third method for involving in product design is single user co-design. Co-design activities of Lego and Ponoko fall into this category. Only one user is involved in the design of a product. The user provides the product design in the form of sketches or CAD files to the company and based upon the feedback (feasibility, cost, timing, etc.) received from the company the user decides to order the product. The company then manufactures the product and ships it to the user. At times, this product is available for other customers to buy through the company website. Sometimes this approach is considered akin to mass customization (Piller et al., 2005). A clarification of relationship between mass customization and co-design is therefore discussed in the next section. Also given are some open research questions mentioned in mass customization literature. These questions formed the research objectives for this dissertation.

2.1.2 Co-design vs. Mass customization and Personalization

Co-design is different from mass customization and personalization. Co-design happens when customers are involved in the design phase of a product. This contrasts with mass customization, which is defined as, "developing, producing, marketing and delivering affordable goods and services with enough variety and customization that nearly everyone finds exactly what they want." (Salvador & Piller, 2009). It follows from this definition that mass customization focuses on creating a variety of products so a customer while shopping for a product is able to find the product that meets his/her requirement. There is no mention of customers' involvement in product design. Von Hippel (2003) has aptly captured this difference as he writes, "Mass customization approach does not address the first problem, learning how to design novel custom goods efficiently."

Closely related to mass customization is product personalization. Product personalization is “a process that defines or changes the appearance or functionality of a product to increase its personal relevance to an individual” (Blom & Monk, 2003). Whereas in mass customization the market size is one or few, in personalization the market size is essentially one (Kumar, 2007). A good example of personalization is printing one’s name on a product or choosing an aesthetic cover for a cell phone. Blom & Monk (2003) studied cell phone personalization and investigated the disposition to personalize and effects of personalization. Personalization effects included improvement of aesthetics, feeling of ownership, feeling of control, etc. The public health literature has used personalization to increase adherence to treatment. For example, personalized diets have better adherence and personalized medical information shows better recall and comprehension. (Campbell, et al. 1994; Kreuter, M.W., Glassman, B, & Strecher, V.J., 1999).

In personalization customers are not involved in product design activities. However, there exists a small overlap among mass customization, personalization, and co-design. A possible way to represent the relationship between co-design, mass customization, and personalization is depicted in Figure 2.2. It shows that personalization is a subset of mass customization, whereas co-design overlaps with mass customization but can be unique. In some cases co-design activity can result in personalization. For example, a customer co-designing a t-shirt just for himself/herself and prints his/her name on it. In this way co-design also resulted in personalization. This overlap between co-design and personalization is shown by the shaded area in the Figure 2.2.

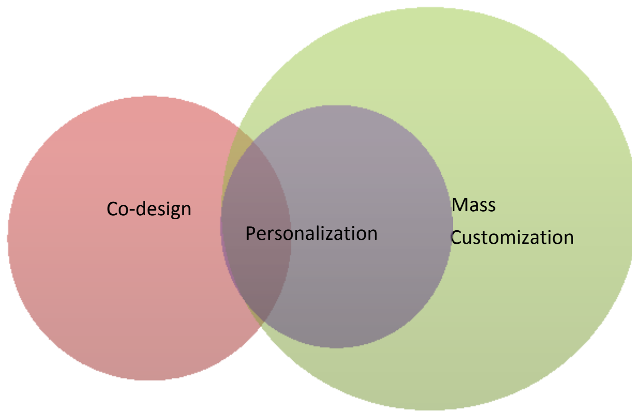

Figure 2.2: Relationship between co-design, personalization, and mass customization

Similarly sometimes customers can co-design options for mass customization. For example, if customers dictate what type of options will be available for mass customization during the design phase of a product then customers are co-designing customization. Some researchers have described various types of customization and have stated that true customization requires user input during the design phase. While analyzing the mass customization efforts of various vehicle manufacturers, Alford et al. (2000) described three types of mass customization: core customization, optional customization, and form customization. Core customization happens when a customer is involved in the design phase of a product and dictates the design changes (similar to co-design concept). Collaborative customization is another term used to represent core customization (Gilmore & Pine, 1997). Optional customization happens during the manufacturing phase as it allows customers to dictate the assembly of a product based upon the options they choose. However, a customer cannot change the design of the product through optional customization. In form customization, a customer can only add or delete options available at the point of sale. For example, at a car dealer a customer can choose from various types of warranties available for a vehicle. Some researchers have studied the limitations of customization. Pine, Victor, & Boynton (1993) analyzed failed customization activities by various companies and concluded that not all products lend themselves to customization. Similarly Zipkin (2001) reported that not everything can be mass customized and he suggests that companies should be cautious about mass customization as it requires flexible manufacturing and logistics system and at times customers are not ready to pay extra for mass customized products. So far, mass customization has been limited to apparel, sporting goods, publishing, houses, etc. This observation also provides an interesting area for co-design research. Can all the products be co-designed or like mass customization there are limits to co-design?

2.1.3 Experiments for Customer Involvement in Product Design

Two types of research methodologies have been used by researchers for studying customer involvement in the product design: case studies and design experiments with students and/or actual customers. Case studies with companies provide real world data to analyze the role of customers in co-design however they are time consuming and there is little experimental control over the process. Researchers have to follow the design teams for several months and at times several years to gain meaningful insights. Design experiments, on the other hand, tend to be quick to perform (they are usually a semester long), and they can provide good experimental control. For example, design experiments with mechanical engineering students were used to study the influence of communication method on design outcome (Zhang & Jikeala 2009). They found that during a design project on-line communication is at least as productive as face-to-face communication. Similarly, Yang (2009) has used design experiments with students to study the influence of quality of sketches on the design output. However, the data obtained by experiments may not accurately reflect the corporate design environment. Consensual Assessment Technique (CAT) (Amabile, 1982) was used in most cases to rank the user ideas for novelty and creativity. Overall, there is the usual tradeoff between field and lab studies. The former offers external validity but little control; the latter offers internal validity and the ability to isolate casual mechanism but tends to lack realism. The tradeoff depends on how one weighs abstract models with casual fidelity from more realistic models that many not yield causal statements.

In order to study the user involvement in service design an experiment was conducted to enhance the text messaging service (Kristenssen et. al., 2002). Students and company experts generated ideas to enhance the text messaging service in Sweden. The Consensual Assessment Technique was used to evaluate the ideas generated during the experiment. The researchers found that the ideas generated by users were more innovative than the ideas generated by service developers. The authors suggested that other metrics like producibility should be studied and also if designers and users are allowed to interact during the experiment then the outcomes should be studied.

Along the same lines, Piller and Walcher (2006) studied the role of ‘Toolkits for Idea Competition (TIC)’ in user innovation. TICs are used to invite users to generate ideas for products and services. The researchers found that customers are more sensitive to the need aspects of design, whereas company experts are more sensitive to solution aspects of the problem. They also reported that integration of co-design and conventional design requires culture change within a company.

Similarly in an online experiment, customers were invited to participate in the design of the Audi infotainment system. 1662 customers participated in the experiment and 219 ideas were generated for the design of the infotainment system (Fuller & Matzler, 2007). In another example, Buur and Matthews (2008) reported an experiment for redesign of waste water treatment facility that included the customers(technicians) in the design activity. During the course of the study technicians generated ideas that help their activities. For example, they proposed the design of a display system that moves it out of the central control room and place it next to water treatment unit. However, the engineers from the company were resistant to the ideas. The ideas generated by the customers required multiple departments to work together and it required organizational change at the manufacturer.

Mass customization research has also relied on design experiments with students. For example, Randall et al. (2007) have experimented with customization on the Dell laptop website. They allowed students to either specify design parameters for the computer or to express their needs and then software used those needs to select design parameters. It was found that as compared to expert users, novice users were able to customize computer by inputting their needs instead of design parameters.

In order to differentiate between customer and designer perceptions of products, an interesting experiment was conducted by Chamorro-Koc, Popovic, and Emmison (2008). They compared the visual representation of a product by designers and customers. They reported that users and designers represented the same product differently. Specifically, designer's representation did not describe the experience of using the product, whereas the user representation described the experience of using the product. This finding provides insight about how users and designers approach the same problem from different perspectives. For this reason co-design can help to bridge the gap between users and designers in product design.

2.2 Gaps and Challenges in Co-Design Research

A number of questions related to co-design are still unanswered in the literature. These questions belong to both a strategic level (for example, which products to co-design) and to an operational level (e.g., how to co-design a particular product). Can all products be co-designed or are there some types of products that lend themselves to co-design and others that do not? Is co-design always better than conventional design or there are specific products that are more suited for co-design than conventional design? Boutin (2006) aptly describes this dilemma in an article about co-design:

> "Most companies' products are a lot more complicated than T-shirts and lamps, and require deeper domain expertise to design them. I've got some great ideas for the Corvette, but not a clue how to whip up a CAD file to send Chevrolet's engineers."(Boutin, 2006).

Some of the questions posed for future research in the above research papers are: (1) identifying success factors, drivers, and enablers for co-design (Piller et al. 2005), (2) to what extent a company wants to substitute conventional market research and product evaluation measures by customer participation and evaluating user ideas on multiple dimensions other than innovation (Kristenssen et al., 2002), (3) to study the interaction between users and designers during co-design (Kristenssen et al., 2002), and (4) how co-design will influence design education and future of design (Sanders & Stappers, 2008). Using the insights gained from co-design examples mentioned in Chapter 1 and future research areas proposed in co-design and mass-customization literature, the following questions were finalized for the dissertation.

2.2.1 Research Objectives and Questions

This dissertation addressed the following questions:

1. What influences do product type and complexity have on co-design?

2. What products do customers want to co-design? How do they want to participate in co-design process? How do customer demographics relate to interest in co-design?

3. What steps should a company should take to implement co-design?

Question 1 is addressed in Chapter 3 which describes a design experiment conducted through online surveys to study the influence of product complexity and frequency of use on co-design. Chapter 4 discusses the influence of customer demographics and product type on co-design and shows that how customers' interest in co-design varies with product type and product features. In order to address Question 3, a five step framework to implement co-design within a firm is described in Chapter 5.

CHAPTER 3

INFLUENCE OF PRODUCT COMPLEXITY AND FREQUENCY OF USE ON CO-DESIGN

In order to study the influence of product type on co-design a design experiment was conducted through online surveys. Survey participants (survey participants were actual customers, so the term “customer” is used to refer them from now onwards) were asked to provide design ideas about both complex and simple products. This chapter describes the procedure, results, and analysis for this experiment.

3.1 Method

As discussed in Section 2.1.3 design experiments with students, customers, and designers have been widely used to study various factors affecting the design activity. Similarly, in order to study the influence of product complexity and frequency of use on co-design a simple design experiment was conducted with a group of customers available through an online forum. The independent variables for this experiment were product complexity and frequency of use. The dependent variables were quantity, novelty, and feasibility of design ideas generated by the customers. Customer responses from the survey were used to test hypotheses for these experiments.

3.1.1 Selection and Classification of Products

The first task of the experiment was to select a group of products with which a typical US customer is familiar and at the same time the complexity of these products can be varied. Four components of a car were selected for the study. These components were: cup holder, instrument panel, wiper system, and fuel door & cap. These components will be treated as standalone products for this study and will be referred as products. There were two reasons to select the components of a car. First, the author works for an automotive OEM and has good knowledge about the conventional design process used for these components. Second, the group of online customers used for this study was accessed through an automotive OEM. So posing a design task related to automotive design made data collection and analysis convenient. These four products were divided into four groups based upon the complexity and frequency of use as shown in Table 3.1.

Table 3.1 Four types of products

	Simple product	**Complex product**
High frequency of use	Cup holder	Instrument Panel
Low frequency of use	Fuel door and cap	Wiper system

Complex products have more subassemblies and interfaces with users than simple products. For example, a cup holder usually consists of two cavities and a cover for those cavities, whereas an instrument panel can have a number of gauges, controls, vents, and storage compartments, etc. In addition to product complexity frequency of use was also an independent variable.

As discussed in Chapter 2 that one of the reasons for customers to bring unique ideas for co-design are the unique experiences that every customer has with a given product. So the duration and type of customer experiences with the product might shape the outcome of a co-design experiment. For instance, if a customer has little or no experience with product use, then the likelihood of him/her generating design ideas about the product will be low. In order to validate this aspect of co-design, frequency of use was included as an independent variable in the design experiment. Again, products were divided into two groups based upon frequency of use: high frequency of use and low frequency of use. High frequency of use products are those products that customers use on daily basis, whereas low frequency of use products are those products that customers use on a weekly or monthly basis.

3.1.2 Participants

An online pool of customers was used for the design study. The descriptive statistics of this pool is as shown in Table 3.2. In total 2159 customers are member of this pool. Male and female ratio is about fifty percent. The pool is divided into five age groups (generations) as shown in Table 3.2. These age groups are: Millennial-Young (18-25), Millennial-Old (26-32), Generation X (33-45), Boomers-Young (46-54), and Boomers-Old (55 and up).The pool is slightly biased towards the three middle generations of customers.

Table 3.2: Statistics of subjects participated in surveys

Total subjects	2159
Subjects participated in survey 1	552
Subjects participated in survey 2	299
Subjects participated in survey 3	264
Percent Female	48%
Age Groups	
Millennial-Young (18-23)	11%
Millennial-Old (23-32)	27%
Generation X (33-44)	27%
Boomers-Young (45-54)	17%
Boomers-Old (55-64)	18%

Since this pool was accessed through a consultancy firm and an OEM, therefore some guidelines about survey design imposed by them were followed. There was a limitation about the number of questions that could be asked of these customers. In a given survey only seven questions could be asked and five of those questions were required to be quantitative and the remaining two could be qualitative questions. Due to this limitation the customers were divided into two groups. Each group was given a survey with five quantitative and two qualitative questions. Qualitative questions were used to conduct the design experiment. In total three surveys were conducted. These surveys are given in the Appendix. Survey 1 was used to gain customers' feedback about co-design (discussed in the next chapter) and to run a pilot design experiment. Surveys 2 and 3 were used to conduct the design experiment.

3.1.3 Procedure

Quantitative questions in the surveys were used to obtain customers' input about the categorization of products shown in Table 3.1. The two qualitative questions were used to present a design task to the customers. The design tasks given to the customers of the first group were:

1. Suppose you are given a chance to design the cupholder for the next model of your car. How would you design the cupholder. Please number your design ideas as you type them.
2. Now suppose you are given a chance to design the wiper system for the next model of your car. How would you design the wiper system. Please number your design ideas as you type them.

And the design tasks given to the second group were:

1. Suppose you are given a chance to design the fuel door and cap for the next model of your car. How would you design the fuel door and cap. Please number your design ideas as you type them.
2. Suppose you are given a chance to design the instrument panel (dash board) for the next model of your car. How would you design the instrument panel. Please number your design ideas as you type them.

The surveys were posted on the online forum where customers can access them and provide their responses. Customers were allowed a week to fill these surveys.

3.1.4 Hypotheses

The hypotheses for this experiment were developed as follows. It is conjectured that as complex products have more interfaces with which customers interact, customers will be able to generate more design ideas about complex products as compared to simple products. Along the same lines, it was presumed that in case of high frequency of use products, customer will interact on daily basis and this interaction may lead customers to develop more novel design ideas for high frequency of use products as compared to low frequency of use products. Also it is assumed that novel ideas in general will be less feasible, as new manufacturing processes and technologies may be required to implement these ideas. The following hypotheses were tested using the data collected from the customers.

H1 Customers will generate the highest number of design ideas about complex high frequency of use products.

H2 Customers will generate the most feasible ideas for simple high frequency of use products.

H3 Customers will generate most innovative ideas about complex high frequency of use products.

For this study idea feasibility and innovation are rated separately. However there may be an inverse relationship between the two. It is predicted that innovative ideas proposed by the customers may not be feasible to implement with current technology. This leads to an additional hypothesis that ideas rated high on innovation may be rated low on feasibility and vice versa.

3.2 Results

The survey was posted to 2159 customers divided into two groups. 299 customers from group one responded to the survey, whereas 264 customers from group two responded to the survey. Average response rate was 26%. Even though the response rate is low but it is no different than the response rate to the other surveys that are regularly conducted on this site.

Customer responses to questions four and five of the survey were used to confirm the classification of products and customers responses to questions six and seven were used to test the hypotheses presented in the last section.

3.2.1 Product Complexity and Frequency of Use

In order to confirm the categorization of products as shown in Table 3.1, customers were asked to rate the four products for complexity of design and frequency of use. Table 3.3 shows percentages of customers that responded to five choices given to rank the products from simple to complex. This table shows that 78% of customers responded that cup holder is a simple or somewhat simple product to design whereas 18.34% customers hold the same opinion about wiper system. Similarly, only 6.67% of customers responded that instrument panel is a simple product to design and 55.30% of customers rate fuel door as a simple product to design. Thus, based upon customer's responses we verified that in customers' opinion instrument panel is the most complex product to design whereas the cup holder is simplest. Similarly, the wiper system is more complex to design than the fuel door and cap, which is simple. In summary, customer's responses confirm the categorization of these four products into four groups as proposed in the study so we feel comfortable proceeding with the analyses of the data using the *a priori* classification.

Table 3.3: Customers' rating of product complexity

	Cup Holder	Wiper System	Fuel door & Cap	Instrument Panel
Very simple	37.68%	6.71%	15.35%	2.86%
Somewhat simple	40.33%	11.63%	39.95%	3.9%
Neither simple nor complex	13.75%	22.86%	26.86%	9.99%
Somewhat complex	7.71%	53.15%	16.27%	40.86%
Very complex	0.53%	5.66%	1.56%	42.41%

Table 3.4 shows customers' responses about the frequency of use for the four given products. 58.84% customers use cup holder on daily basis, 9.52% customers use wiper system on daily basis, 84.39% customers use instrument panel on daily basis, whereas only 0.89% customers use fuel door and cap on daily basis. So it can be stated that customers report interacting with cup holder and instrument panel more frequently than wiper system and fuel door and cap.

Table 3.4: Customers' rating of frequency of use

	Cup Holder	**Wiper System**	**Fuel door & Cap**	**Instrument Panel**
Several times a day	37.65%	3.74%	0.17%	76.38%
Once a day	21.19%	5.78%	0.72%	8.01%
Several times a week	23.65%	29.17%	15.22%	8.09%
Once a week	5.83%	20.71%	48.75%	3.42%
Several times a month	6.23%	27.19%	30.81%	1.24%
Once a month	2.42%	6.57%	3.45%	1.24%
Less than once a month	3.05%	6.87%	0.91%	1.64%

3.2.2 Extraction of Design Ideas

The design ideas were submitted by customers in verbal format. Although it was specifically mentioned in the instructions given to the customers to number the ideas but some customers numbered the ideas and others did not. So the first step of the data analysis was to extract distinct design ideas from the verbal input received from customers. Figure 3.1 shows one customer's response about redesign of cup holder and wiper system. Table 3.5 shows the two design ideas that were extracted from this customer's response.

Suppose you are given a chance to design the fuel door and cap for the next model of your car. How would you design the fuel door and cap. 1. I would keep it the same but make it so that once you're done refueling and the cap is on that the fuel door would close itself automatically. 2. Allow to open/close fuel door from keychain. Convenient if you're walking in to pay the cashier and want to lock your car while you're gone but don't want to use the keys again just to open the door to begin refueling. Suppose you are given a chance to design the instrument panel (dash board) for the next model of your car. How would you design the instrument panel. 1. Make voice activation standard in every car so you don't have to drive around dis	tracted turning knobs or touch screening. I think most dashes are fine but the materials used make a difference in determining that trashiness/cheapness of the car.

Figure 3.1: Verbal input as received from customer

Table 3.5 Extraction of design ideas

Customer ID	**Fuel door &cap ideas**
23695	1. Fuel door cap closes automatically
	2. Allow fuel door to open/close from key fob

Some customers described the design process instead of design ideas for a given product. Their ideas were about how to design a wiper system, for example, rather than what to design for the wiper system. Design ideas for such customers were not used in the analysis.

Design ideas submitted by the customers were about both form and function of the product. Some customers provided ideas about a new function that a product should perform (e.g. heated cup holder), while other customers provided ideas about the form of the product (e.g. colored wipers). Few customers provided ideas related to both form and function (e.g. analog and digital gauges).

One limitation of the study is that these design ideas are not complete 'designs' for the product. The design team needs to further refine these ideas subjected to manufacturing and technological constraints. Another important limitation of this study is that majority of customers have provided ideas about a functional requirement without mentioning the details that how this requirement will be implemented in the product. Two reasons can be attributed for this limitation. First, during the experiment, customers were only able to submit verbal input and there was no mean available to them for submitting visual (sketches, photographs etc.) input. Therefore, customers might have only expressed functions and did not opt to describe how these functions should be accomplished by the product. Second, may be due to limited knowledge, customers were not able to describe how to transform their functional requirements into useable products. For example, customers may not know what material or heating method to use for a heated cup holder in a vehicle. For this study ideas about function are also treated as design ideas and these limitations should be addressed in future studies.

3.2.3 Ratings of Design Ideas

Once design ideas were extracted and counted they were rated for novelty (low to high: 1-7) and feasibility (low to high: 1-7) by the author. A sample of rating is shown in Table 3.6. After that Consensual Assessment Technique (CAT) (Amabile, 1982) was used to compare the author's rating with engineers working at an auto OEM. CAT relies on subjective evaluation of judges about creativity. Most of the studies in literature about product design have relied on CAT to evaluate the product or service ideas submitted for creativity. CAT is a general measure of creativity but has been successfully used to measure product innovativeness also (Piller & Walcher, 2006). This technique is based upon the observation that there is no consistent definition of creativity but a person tends to judge creativity using a common criterion. Thus, an idea or a product is as creative as a person rates it. Evaluators are asked to use their own subjective rating of creativity to evaluate the ideas. Three practicing engineers with experience in automotive component design were used as the judges for the current study. Judges were asked to rate each idea on a scale of 1- 7 (low – high) for novelty and feasibility. The inter-judge correlations and Cronbach Alpha for these ratings are shown in Table 3.7. Author's correlation with one engineer is high as compared to two other engineers. Cronbach Alpha is in acceptable range for similar type of experiments. However, correlation between the author and all engineers should have been higher and future work should investigate the reasons for low correlation between these ratings.

Table 3.6 Rating of design ideas

ID	Fuel door &cap ideas	Quantity	Novelty	Feasibility
23695	Fuel door cap closes automatically	1	4	4
	Allow fuel door to open/close from key fob	1	3	4
	Total	**2**	**7**	**8**
	Average		**3.5**	**4**

.

Table 3.7 Correlations and Cronbach Alphas for idea ratings

	Novelty	Feasibility
Engineer 1 - Correlations	0.71	0.62
Engineer 2- Correlations	0.46	0.27
Engineer 3 - Correlations	0.28	0.42
Cronbach Alpha	0.69	0.67

Table 3.8 summarizes the results for all the ideas collected for this experiment. As can be inferred from Table 3.8, customers generated the highest number of ideas about the cup holder and instrument panel, whereas, most novel ideas were generated for fuel door and cap. The feasibility of ideas was about the same regardless of the product type. Further statistical analyses are given in the next section.

Table 3.8 Averages and S.D. for product quantity, novelty, and feasibility

		Quantity	Novelty	Feasibility
Cup Holder	Mean	3	2.80	3.20
	S.D.	1.20	0.61	0.42
Wiper System	Mean	2	2.96	3.16
	S.D.	1.26	0.81	0.60
Fuel Door and Cap	Mean	2	3.25	3.28
	S.D.	1.12	0.91	0.77
Instrument Panel	Mean	3	2.71	3.34
	S.D.	1.7	0.86	0.61

3.2.4 Statistical Analysis

Pair-wise tests were used for inter group comparisons and t-tests were used for comparing means for intra group products. The results for these comparisons are shown in Table 3.9. Means and standard errors for quantity, novelty, and feasibility of ideas are plotted in Figures 3.2, 3.3, and 3.4.

Table 3.9 Comparison of products for quantity, novelty, and feasibility (α=0.05)

	Quantity (P value)	**Novelty (P value)**	**Feasibility (P value)**
t- test: paired two samples			
Cup Holder vs. Wiper System	**0.000**	**0.002**	0.377
Fuel Door vs. Instrument Panel	**0.000**	**0.000**	0.304
t-test: two samples equal variance			
Cup Holder vs. Fuel Door	**0.003**	**0.000**	0.188
Cup Holder vs. Instrument Panel	0.738	0.184	**0.008**
Wiper System vs. Fuel Door	0.900	**0.000**	0.085
Wiper System vs. Instrument Panel	**0.001**	**0.002**	**0.030**

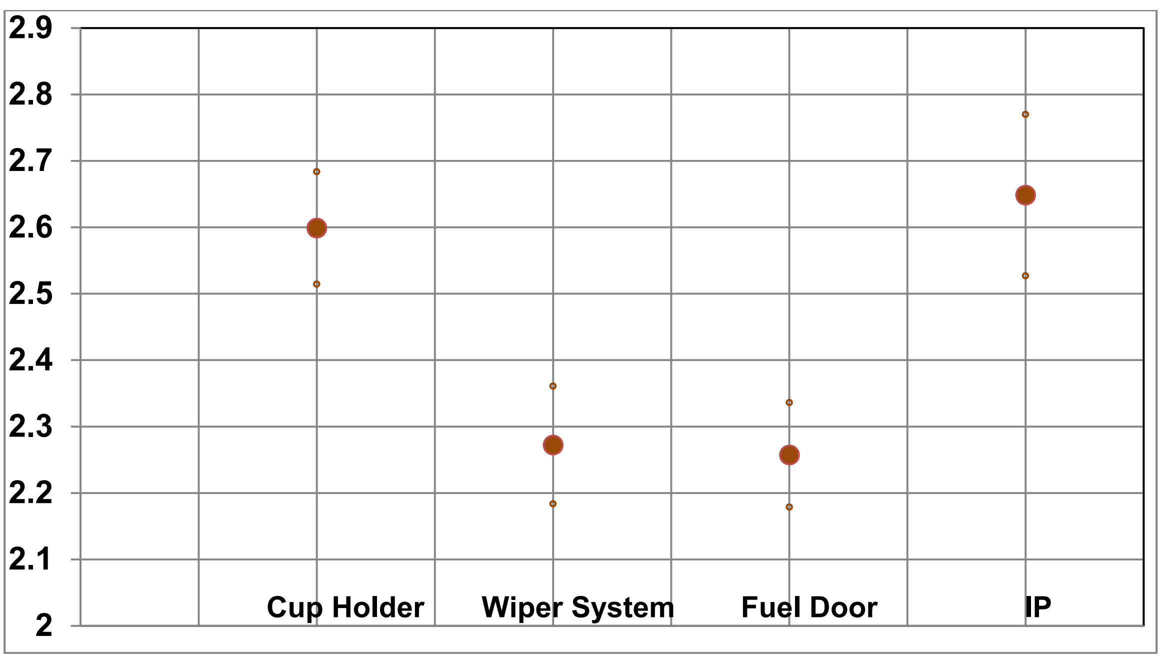

Figure 3.2 Mean and standard errors for Quantity of Ideas

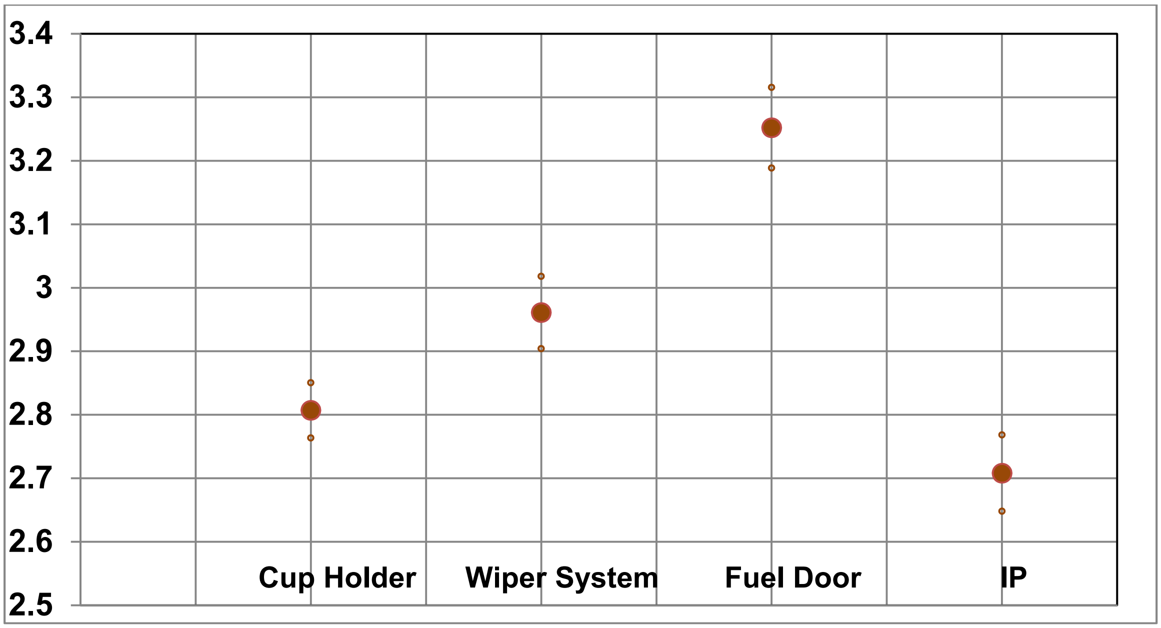

Figure 3.3 Mean and standard errors for Novelty of Ideas

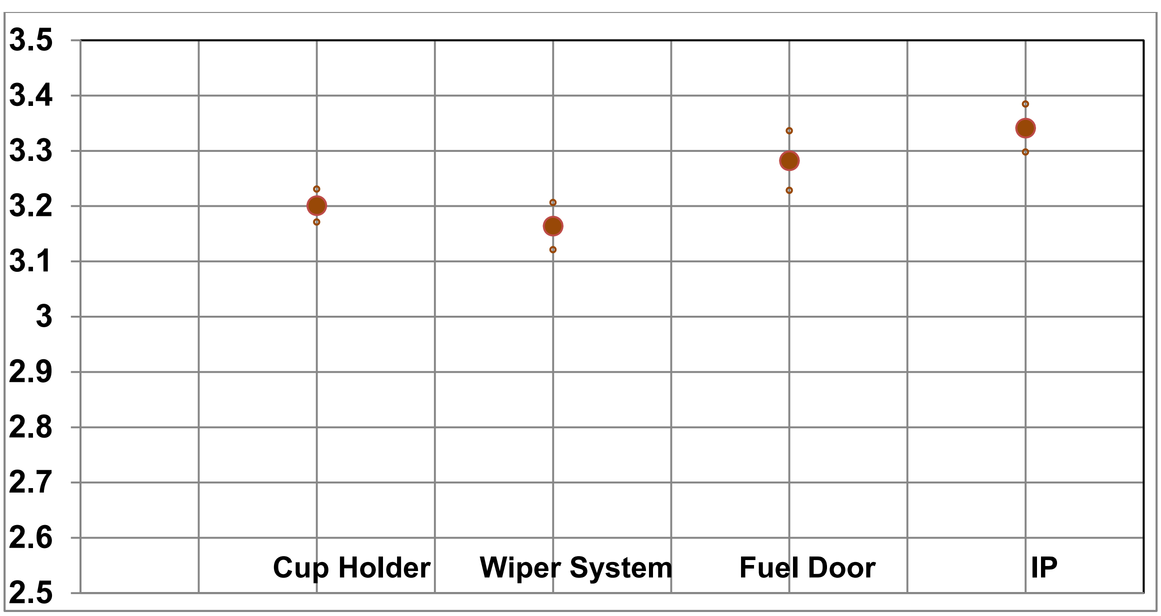

Figure 3.4 Mean and standard errors for Feasibility of Ideas

3.2.5 Evaluation of Hypothesis

H1 stated that customers will generate the highest number of design ideas about complex high frequency of use products. This product was the instrument panel. It can be seen from the Table 3.8 that instrument panel ideas are higher as compared to wiper system and fuel door. But they are not significantly different than the cupholder. So H1 is not completely supported by the data. Similarly, H2 stated that customers will generate most feasible ideas for simple high frequency of use products. However, the data shows that the ideas for instrument panel have the highest feasibility. H3 stated that customers will generate most innovative ideas about complex high frequency of use products. Whereas data shows that most novel ideas are generated for simple low frequency of use product i.e. fuel door and cap. Thus, H3 is not supported by the data.

Even though the product type influenced the outcome of co-design, it cannot be assumed that customers will generate more ideas about complex products as compared to simple products. Similarly, high frequency of use does not lead customers to generate more novel ideas. On the other hand, it is observed that more ideas are generated for high frequency of use products as compared low frequency of use products. Customers generated more novel ideas about low frequency of use products as compared to high frequency of use products.

There are two possible explanations for the fuel door and cap being rated highest for novelty of ideas. First, the dissatisfaction of customers about the current design of the product may have served as the trigger for novel ideas for future improvements. Tom Peters (2011) stated that dissatisfied customers can be an asset for a company. Dissatisfied customers can provide ideas that can help to improve a product through innovative solutions. It is conjectured that instead of product complexity and frequency of use, customer dissatisfaction may lead to innovative ideas. This finding is discussed further in the next section. Second, the fuel door and cap may have received less design resources from a company as compared to instrument panel and cup holders. An OEM may spend more time and engineering resources to design instrument panel as it is a highly visible and frequently used component for customers. Whereas, fuel door being a less frequently used component, may have received comparatively less design resources. This may have caused customer dissatisfaction which in turn lead customers to propose innovative ideas to improve the fuel door and cap.

3.2.6 Analysis of Novelty

As shown in Table 3.7 the novelty of the ideas submitted by the customers during co-design differ by product type. In order to further analyze the dependency of novelty of ideas on the product type, the most novel ideas generated by the customers for each product type were evaluated. Ideas that received five or higher rating for novelty for each product type are listed in Table 3.10. Also given are the percentages of these ideas for each product. Again, fuel door and cap has the highest percentage of novel ideas as compared to the other products. Instrument panel has 5% of ideas with novelty rating of five and higher, wiper system has 5%, and cup holder has only 1% of ideas that rated high on novelty scale.

Table 3.10 Percentage of novel ideas and most novel ideas

	% of Novel Ideas	Novel Ideas (verbatim customer inputs)
Cup Holder	1.50%	• Cup holders should have a tight mode that hold the drink to allow for opening the cap with one hand.
Wiper System	5.2%	• Additional wipers to clean the pesky corners of the windshield • Additional wipers to clean the bugs with smearing them over the windshield. • Should be able to readjust at the touch of button to reach different areas of window
Fuel Door and Cap	9.3%	• Design a sliding fuel door • the door should be hidden • Auto close when the car is turned on fuel door and cap closes. • Ability to open from either side of the car. • Can be reached from either side of the car • Make one that shut like Grlosch bottle cap. • Hands-off design, will require redesign of filling mechanism • Make the door and cap automatic. • A pass through cap/flap lock from inside the car. • Automatically hook to the gas pump and fill the car.
Instrument Panel	5.2%	• Display turns to diagnostics when car is in park. • Downloadable driving history form the IP. • Program a speed limit and have voice message when I am over the speed limit • Personalize instrument panel with colors and displays the driver like • OEM to publish new gauge designs for the display that customer would install.

This method of ranking the products by the percentage of novel ideas provides better distinction between product types as compared to the average novelty of all the ideas. These ideas are originating from the experience of the customers with the use of the product. Those products that are meeting or exceeding customer's expectations are not triggering the experiences that lead to novel ideas, whereas those products that trigger disturbing experiences may lead to novel ideas.

This leads to a new insight about customers' participation in the design process. In order for customers to generated novel ideas about a product, they first should have some experiences with that product where the product fails to meet the latent needs or it causes a problem in customers' life. These 'unwanted' or 'uncomfortable' experiences then lead to novels ideas during co-design activity. For example, some customers may pull the car on the wrong side of the gas pump and thus they want to have fuel door on both sides of the car. Similarly, some customers forget to open the fuel door from inside the car and they want a button on the key fob to open the door while standing next to the gas pump. Similarly, agonizing experience of a customer to open the can with one hand, while driving with the other hand, led to the idea of designing a 'hold' feature in the cupholder to assist in can opening. Perhaps dissatisfied customers are the best source of novel ideas during co-design. Sometimes dissatisfied customers are 'blessings in disguise' for companies that want to use their input to improve the products.

3.2.7 Role of Gender and Generation in Co-design

Since the gender and generation data about the survey participants was available, Ordinary Linear Regression (OLR) was used to study the influence of gender and generation on co-design ideas. The gender was coded as 1(female) and 2 (male) and the linear predictor of age (generation) was coded 1 (millennial-young), 2(millennial-old), 3(generation x), 4(boomers-young), and 5(boomers-old). The 4-level product category was coded with three dummy codes using fuel door and cap as the reference category. The results of the OLR are shown in Table 3.11. It can be seen that only generation is significant for idea quantity with older generations generating more ideas than younger generations. One possible explanation for this phenomenon can be that older generations have more driving experience than younger generations and this experience led them to generate more ideas.

Table 3.11: Results of Ordinary Linear Regression (OLS) for four products (α=0.05)

	Quantity		**Novelty**		**Feasibility**	
	β	**Sig**	**B**	**Sig**	**β**	**Sig**
Gender	.061	.084	.046	.188	-.031	.384
Generation	.079	**.024**	-.007	.849	.005	.879
Cupholder	.112	.009	-.225	.000	-.043	.317
Wiper System	.011	.801	-.144	.001	-.072	.094
Instrument Panel	.125	.004	-.277	.000	.054	.208

3.3 Conclusions and Limitations

In conclusion, the ideas generated by customers during co-design activity vary by product type. Based upon the qualitative analysis of most novel ideas submitted by the customers, it is conjectured that the ‘dissatisfaction’ with a product may lead to customers experiences that triggers novel ideas during the co-design. This result need to be replicated and verified with further design experiments, including better inter-rater reliability.

What does this conclusion means for companies mulling to use co-design? Maybe companies can first measure the satisfaction of customers with their products or various features of the products. Based upon this prescreening they can select those products for co-design activities that rank low on satisfaction. Another approach can be to design prototypes that lead to customer dissatisfaction. Then let customers redesign those prototypes to improve customer experience with them. The in- depth study of this paradoxical approach (in order to satisfy the customers, first dissatisfy them during co-design) can be an interesting topic for future research. Of course, such a recommendation must be approached with care so as not to lose the customer at the initial dissatisfaction stage.

There are three main limitations of this study that can be addressed in future research. First, only one product was used for each of the four possible combinations of the independent variables (complexity and frequency of use). In future studies, more than one product for each of the combinations should be used. This can help to better understand the interactions between independent and dependent variables. A second limitation of the study was the scant description of design ideas submitted by customers. Most of the customers provided ideas about the desired functions of the products. In future studies, customers can be asked to provide sketches and more details about the ideas they have submitted. Obtaining detailed input from customers will help deepen the understanding of customers' approach to co-design. A third limitation is the analysis of the knowledge gap that exists with customers for co-design. It is assumed that a minimum level of knowledge is required by the customer to proceed with the co-design of a product. This knowledge will help the customer to transform the 'needs' into 'solutions' or to link 'form' and 'function' of a product. As the product complexity grows the knowledge required for design will also grow. As some point for a given product customer may lack the knowledge to design solutions for his/her needs. This lack of knowledge will preclude customer from generating design concepts for the desired functions. Separating customer responses in desired functions and design concepts will help to analyze the influence of knowledge gap on co-design.

CHAPTER 4

CUSTOMER DEMOGRAPHICS AND CO-DESIGN

Customers’ participation in designing products and services is much deeper during co-design than conventional design. Therefore conventional design processes should be adapted to account for various factors that can affect customers’ participation in co-design. For example, as shown in Chapter 3, customers’ interest and design input varies significantly for different components of a car. Similarly it will be interesting to know whether customers are equally interested to participate in co-design of all the products they own or are they more interested in one product as compared to the other? For example, given a chance to co-design, will a customer prefer to co-design a house or a digital camera? Also, assuming customers want to co-design, how do they want to participate in co-design? What is the right medium to contact customers for co-design? Online, offline or a hybrid of the two. Similarly, what mode will customers prefer to submit their design ideas to the design team? Verbal, visual, or a combination of both? These and few more related questions were posted to the same pool of customers that participated in the design study discussed in the last chapter. Customers' responses are presented and analyzed in the following pages. Insights gained from these responses were used to propose a model for co-design in the next chapter.

4.1 Procedure

Surveys are extensively used in market research to gain customer feedback. They are usually the first tool researchers use to find out customers' perception about products and services. Therefore to gain customer's insights about various dimensions of co-design, three surveys were conducted from November to December 2010 with an online pool of customers sampled throughout the US. These are the same participants and surveys as reported in the previous chapter. Customers' responses to qualitative questions posed in the surveys were discussed in the last chapter. Customers' responses to quantitative questions are discussed in the next section.

4.2 Results and Discussion

Six quantitative questions were asked of the customers. The average response rate was 26 %. In depth description and discussion of the customer responses follows.

4.2.1 Co-design and Product Type

The first question asked the customers to indicate their interest in participating in the design process of ten different products. The question posed in the survey was: Please indicate your interest in participating in the design of the following products: House, car, computer, cell phone, clothes, house hold furniture, shoes, digital camera, home appliances, sporting goods, inkjet printer. This list of products was not exhaustive but it represented the products that are commonly used by a typical customer. Also interest in co-design can be measured by customer segments and product type but only product type is considered here. Figure 4.1 shows the responses from the customers. The first thing to note is that the interest of customer to participate in co-design varies with the product type. For example, an average customer is five times more interested in the design of a house than an inkjet printer.

Also it can be observed from the figure that four distinct categories of products emerge from customer responses. The first category consists of house and car with about 50% of customers showing interest in co-design. The second category consists of cell phone and computer with about 30% of customers interested in co-design. Clothes, shoes, household furniture, digital camera, and home appliances fall in the third category, where about 20% of customers are interested in design. The last category consists of sporting goods and inkjet printer.

From these results it may be conjectured that customers prefer to participate in co-design of those products with which they interact more than those products with which they interact less. For instance, most of the customers use cell phones more often than an inkjet printer, so they are more interested in co-design of a cell phone than a printer. However, it was discussed in Chapter 3 that high frequency of interaction may not necessarily lead to novelty of ideas during co-design.

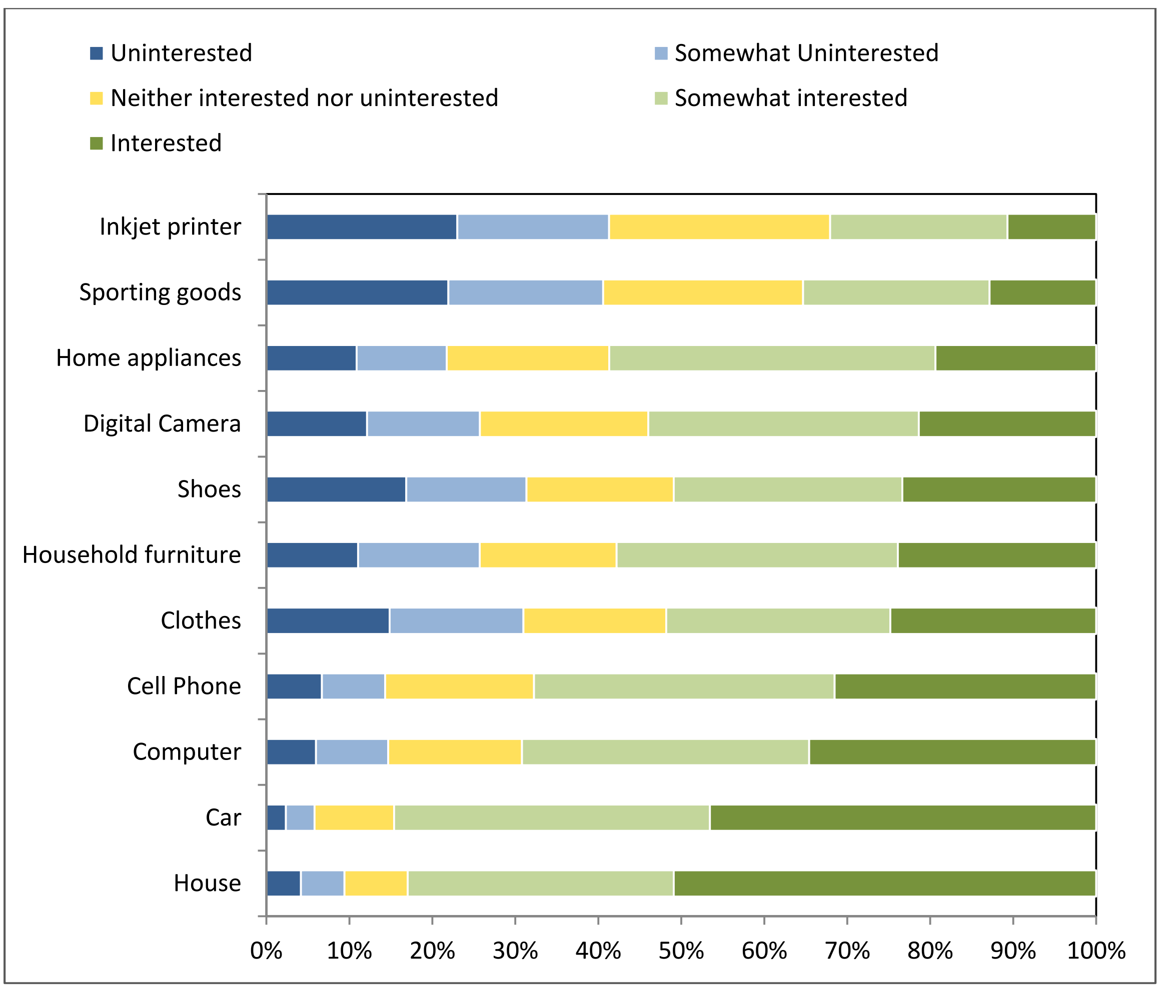

Figure 4.1: Customer interest in co-design of various products.

Breaking down the results by gender reveals some interesting trends. There are some products where females are more interested in co-design than men and vice versa. Then there are products where gender does not influence customer's interest in co-design. Figure 4.2 shows the percentage of customers interested in co-design by product type and gender. The products on the x-axis are arranged from low to high interest in co-design as responded by female respondents. The largest gap in interest between genders is in co-design of clothes. About 20% of females are interested in clothes design whereas only 6% of males are interested in co-designing clothes. The same trend appears for shoes. Nevertheless, males are much more interested in designing cars than females. The same pattern appears for computer. The third category of products is where male and female interest is approximately equal like digital camera. Chi-square significance values are shown in Table 4.1. It can be seen that gender is significant in determining the interest in co-design of seven out of eleven products. Based upon these data it can be assumed that gender influences customer's decision to participate in co-design.

Apart from gender, generation (age group) of customers also plays a critical role in determining their interest in co-design of products. The breakdown of customers' interest in co-design by generation is shown in Figure 4.3. The abbreviations used for generations are Millennial-Young (my), Millennial-Old (mo), Generation X (x), Boomers-Young (by), and Boomers-Old (bo). Overall one trend that is obvious from Figure 4.3 is that three generations (generation x, young- boomers, old millennial) are more interested in co-design than the other two generations (young millennial and old-boomers). So the interest in co-design may first develop with age and then later declines with age (these are cross-section rather than longitudinal data so such trend inferences must be made cautiously). Nevertheless there are some exceptions to this trend. For example, Young- millennials are as interested in co-design of clothes and shoes as other generations. But their interest in co-design in other eight products is less than in the other generations. Chi square significance values only points to one product that is influenced by generation. (Table 4.1).

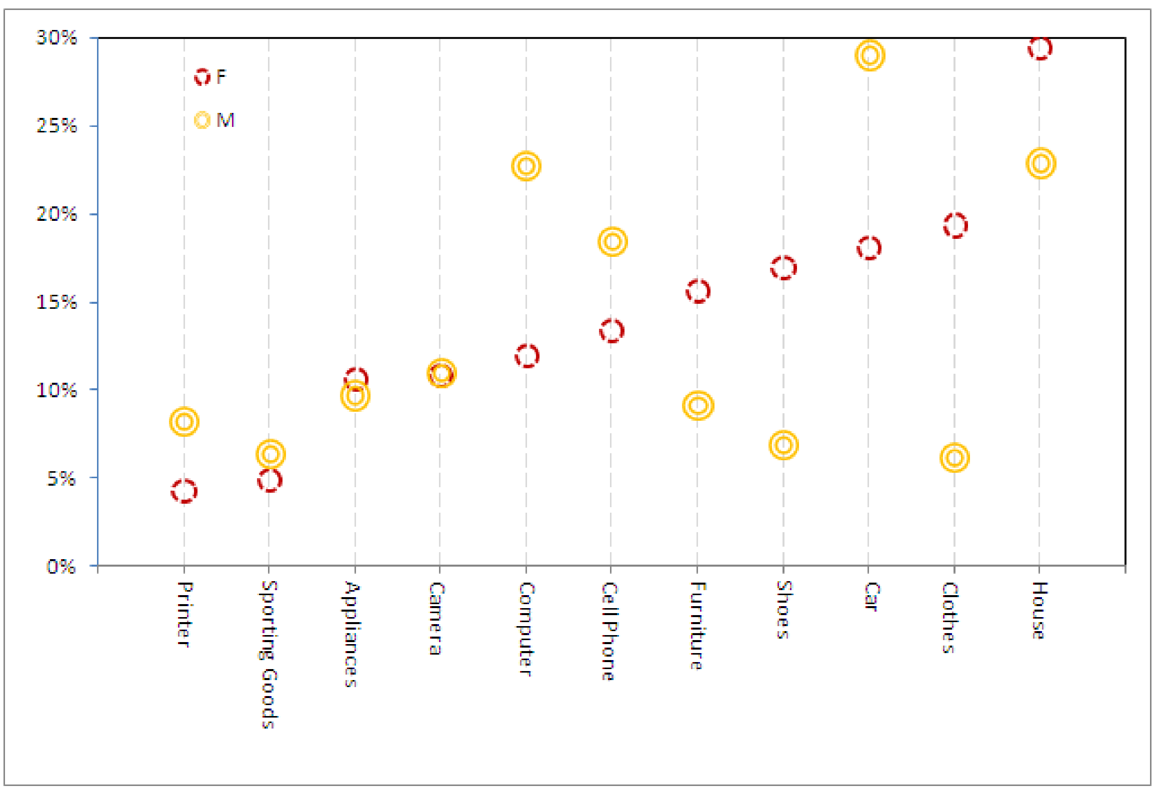

Figure 4.2: % customer interested in co-design by product type and gender

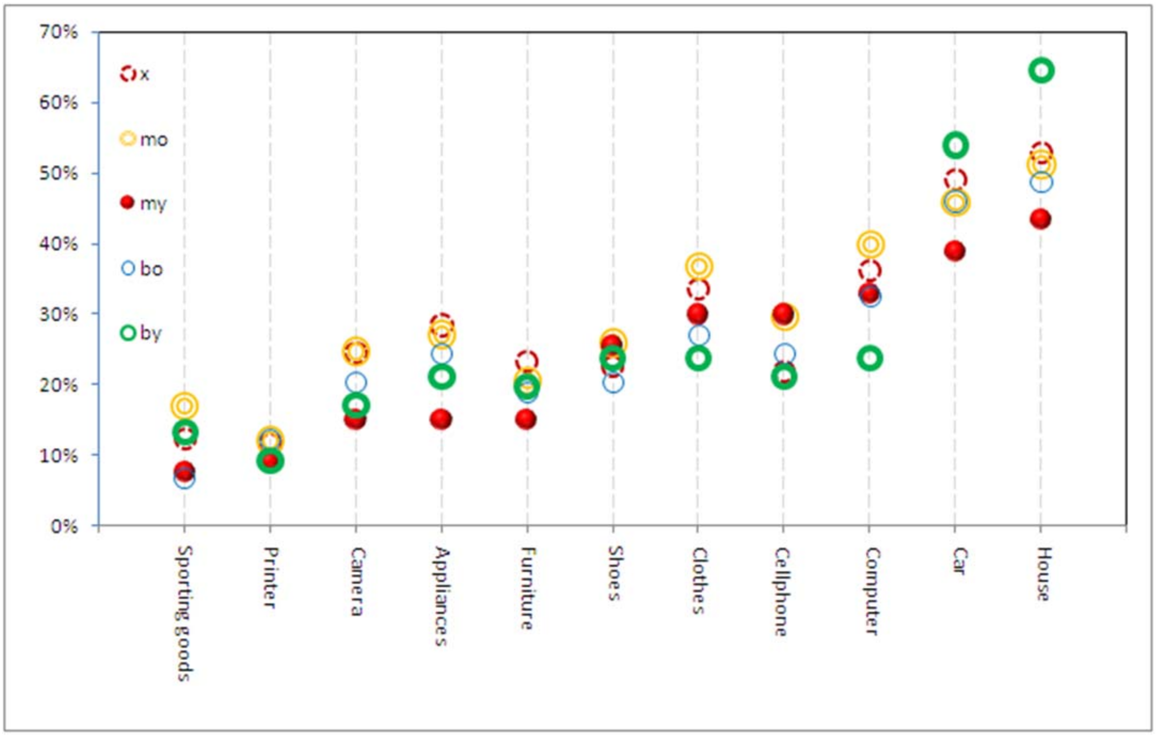

Figure 4.3: % customer interested in co-design by product type and generation.

Table 4.1: Chi Square values for customers' interest in co-design.

Product	**Chi Square (Gender)**	**Chi Square (Generation)**
House	0.053	0.124
Car	**0.000**	0.875
Cell Phone	**0.009**	0.324
Computer	**0.000**	0.568
Household furniture	**0.000**	0.090
Home appliances	0.435	0.958
Clothes	**0.000**	**0.042**
Shoes	**0.000**	0.089
Digital camera	0.335	0.216
Sporting goods	**0.000**	0.954
Printer	0.675	0.954

4.2.2 Co-design and Product Features

Products usually consist of a number of components and features. There are some components that customers are more familiar with than the others. For instance, in the case of a car customers are more familiar with a steering wheel than the engine controller. It is possible that the interest in co-design may also vary with the component type of a product. In Section 4.2.1 data showed that 50% of customers are interested in co-design of a car. But does this interest vary by the components and features of a car? In order to answer this question following survey question was posed to the participants:

> If you had the opportunity to participate in the design of a car, how interested in designing each of the following aspects would you be? (list of components as shown in Figure 4.4)

The response to this question is shown in Figure 4.4.

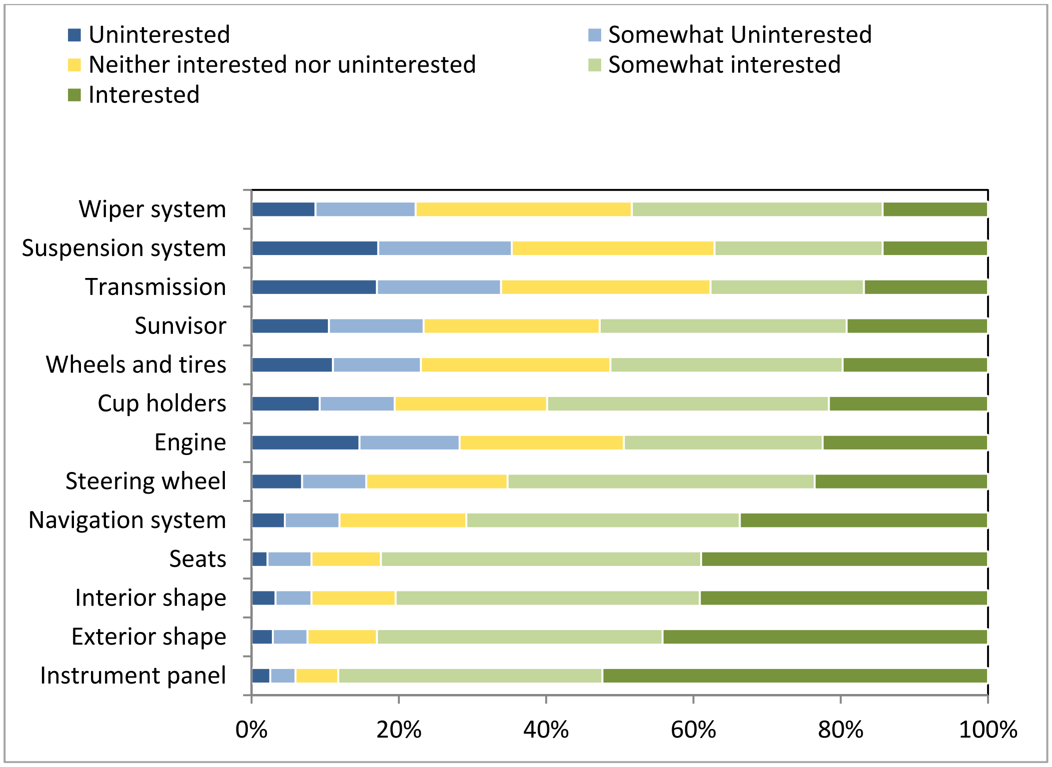

Figure 4.4: Customer interest in co-design by product features

It is noteworthy that the interest in co-design varies significantly with product features. Even though wiper system and instrument panel are both components of a car, customers are approximately five times more interested in the design of instrument panel than wiper system.

It can also be inferred from the figure that there are two distinct groups of features emerging from customers' responses. More than 30% of customers are interested in the cluster consisting of instrument panel, exterior shape, interior shape, seats and navigations system. Only 20% or fewer customers are interested in co-design of rest of the components. What does this means for co-design of cars? Maybe a car company has to focus its co-design activities to only on those components in which a majority of customers are interested in co-design. Or the company can form various groups of customers working with various design teams working on specific components. For instance, only those customers who showed interest in co-design of transmission could work on the design of transmission.

Dissecting the data (Figure 4.5) by gender shows that except for cup holders, males more interested in design of all the components of a car than females. Nevertheless the degree of interest varies by component type. For examples, males are four times more interested than females in designing transmission, whereas, females are less than half a percentage point behind the males in showing interest in co-design of instrument panels.

Generation also determines the percentage of customers who are interested in the design of various components of a car (Figure 4.6). For example, all five generations are about equally interested in design of the exterior shape, whereas Young Millennials lag far behind than other generations in the design of seats. Apart from the navigation system and interior shape, Young Millennials are less interested in co-design of various components of car than other generations. Maybe Young Millennials can relate better to navigation system because of its similarities with other gadgets they use so they are more interested in its design as compared to the other components. Chi-square significance values for product features are shown in Table 4.2. It can be seen that gender is significant in determining the interest in co-design of six out of thirteen features. Age was not a significant predictor for any feature.

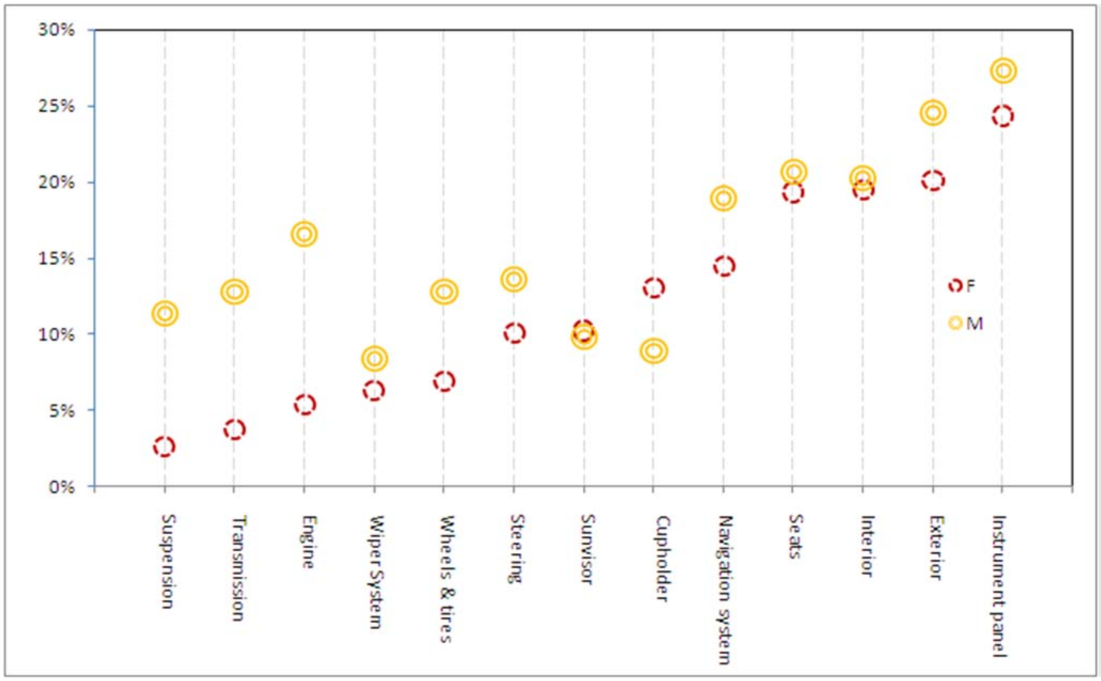

Figure 4.5: % customer interested in co-design by product features and gender.

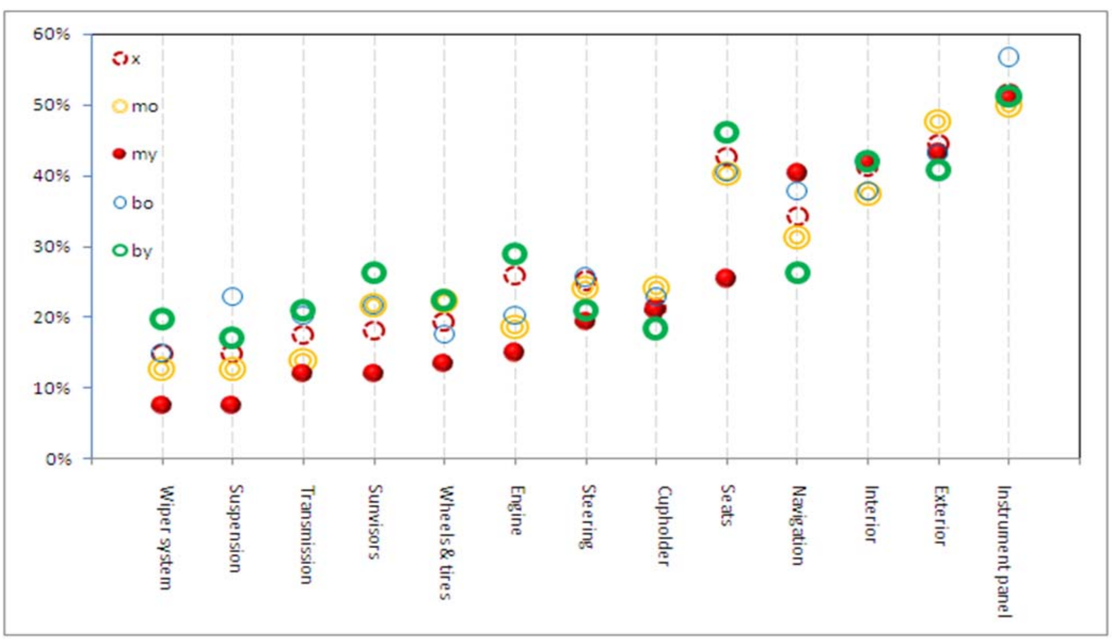

Figure 4.6: % customer interested in co-design by product features & generation.

Table 4.2: Chi-square significance values for product features

Product feature	Chi Square (Gender)	Chi Square (Generation)
Exterior shape	0.102	0.534
Interior shape	0.717	0.915
Seats	0.169	0.055
Wheels and tires	**0.000**	0.600
Instrument panel	0.196	0.245
Navigation system	0.128	0.234
Steering wheel	0.082	0.685
Suspension system	**0.000**	0.454
Engine	**0.000**	0.454
Transmission	**0.000**	0.825
Cupholders	**0.000**	0.921
Sunvisors	**0.022**	0.423
Wiper system	0.060	0.059

4.2.3 Awareness of Co-design and Related Terms

There are various terms used in the literature to describe customer involvement in product design. Some of them are co-creation, co-design, open innovation, open sourcing, and crowdsourcing. Are customers more familiar with one or the other term? This may influence the way companies want to name their co-design initiative. One question in the survey tried to find out customer awareness of various terms related to customer involvement in the design process. The survey question was:

> Are you aware of the following terms: Open innovation, opensourcing, crowdsourcing, co-creation, and co-design.

Customer responses to this question are shown in Figure 4.7.

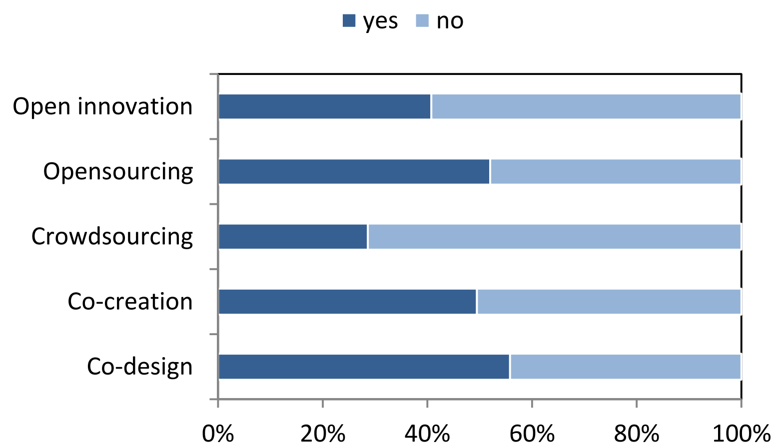

Figure 4.7: Awareness of co-design terms.

More than half of the customers responded that they are familiar with the terms co-creation and open sourcing. However, for most of the survey respondents crowdsourcing is rather unfamiliar term. Maybe this finding reflects that crowdsourcing is a rather recent term as compared to the other four terms. This may explain the unfamiliarity of this term among the customers. Another noteworthy observation is that customers are aware of co-design term more than co-creation, whereas co-creation is much broader in meaning and application than co-design. Cuts of survey pool by gender and generation are shown in Tables 4.3 and 4.4 respectively. One interesting observations is that male respondents report being twice as familiar with crowdsourcing as females. Companies may have to use multiple terms while involving customers in design efforts of products and services or companies may have to explain terms clearly at onset of co-design efforts. However, based upon survey responses co-design is the most recognized term by customers of the terms given in the survey.

Table 4.3: Awareness of co-design terms by gender.

	Female	Male	P-value (Chi Square)
Open Innovation	40.15%	64.31%	0.044
Open Sourcing	40.15%	64.31%	0.000
Crowdsourcing	19.33%	38.29%	0.000
Co-creation	48.33%	51.67%	0.438
Co-design	53.53%	59.48%	0.164

Table 4.4: Awareness of co-design terms by generation

	Young Millennial	Old Millennial	Generation X	Young Boomers	Old Boomers	P-value (Chi Square)
Open Innovation	43.28%	45.18%	41.29%	42.11%	28.38%	0.181
Open Sourcing	35.82%	57.83%	52.26%	57.89%	48.65%	0.03
Crowdsourcing	25.37%	30.72%	35.48%	25.00%	17.57%	0.058
Co-creation	49.25%	59.04%	50.97%	38.16%	40.54%	0.015
Co-design	53.73%	67.47%	56.77%	52.63%	37.84%	0.001

4.2.4 Idea Submission by Customers

Most of the participation of customers in co-design results from idea submission. These ideas are then transformed into products and services. So ideas generated by customers form the basis of co-design. One measure of customer's interest in co-design can be whether they have submitted design ideas to any company or not. Therefore the following question was posed to the online forum of customers:

> Have you ever submitted a design improvement suggestion to any company?

79% customers responded in the negative to the above questions. This is stark contrast with the response to question one. In question one more than 50% customers showed interest in designing some products but only 20% of these customers have submitted ideas to other companies. A number of reasons can be attributed to this response. Maybe there is no channel for the customers to provide the ideas to company. Even if customers want to submit the ideas there is no website or forum where they can post the ideas. The gap between customer willingness to participate in co-design (response to questions one) and actual customers submitting ideas is worthwhile for further investigations. The removal of barriers that prevent customers to submit ideas will enhance co-design and more customers will submit ideas on the web sites.

Table 4.5 shows the responses by gender and generation. The division of responses shows some very interesting statistics. One thing becomes obvious --

males are more active in ideas submission than females. 27% males have submitted ideas and only 15% females have submitted design improvement ideas. Reasons for this gap between female and male participation in ideas submission is unknown.

Table 4.5: Idea Submission by Gender and Generation

	% Submitted Ideas
P-value (Chi Square) 0.001	
Female	14.87%
Male	26.77%
P-value (Chi Square) 0.050	
Young Millennial	13.43%
Old Millennial	16.87%
Generation X	20.65%
Young Boomers	27.63%
Old Boomers	29.73%

Young Millennials are again lagging behind other generations in submitting ideas. However, it is interesting to note that Old Boomers are leading in idea submission. Even though Old Boomers showed less interest in co-design of various products (response to questions one), they are very active in idea submission. This may be because of their age they have had more opportunities to submit ideas and therefore they are leading other generations in this regard.

4.2.5 Idea Submission Medium

Design ideas can be described in a number of ways. Sketches, verbal explanations, prototypes, photographs, all are but some ways in which a design idea can be submitted. As co-design involves a larger number of customers in the design process it is anticipated that multiple means of ideas submission should be provided to the customers. The following question inquired about the customers' preferred method of idea submission:

> If you are invited to participate in the design process of a product how would you like to submit your ideas.
>
> a. Design ideas described verbally
> b. Sketches of design ideas
> c. Computer drawings
> d. Digital photographs

The responses by the customers are shown in .Figure 4.8.

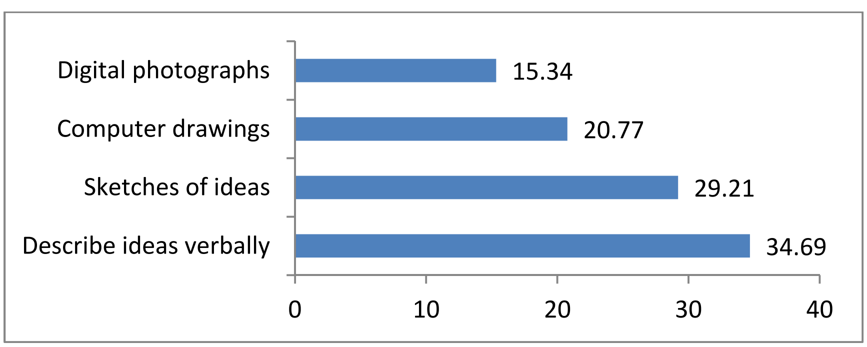

Figure 4.8: Idea submission medium.

More than 30% of the customers prefer to submit the ideas verbally, 29% of customers want to submit their ideas through sketches, and a combined 35% of customers want to use computer drawings and digital photographs to submit the ideas. So again customers are divided into three groups. One group wants to rely on verbal input, other on visual input through sketches, and the last group wants to use digital means to submit the ideas. Also the medium of idea submission can influence the type of input received from the customers. For example, if customers can only submit verbal input, then they may not be able to describe the design concepts for the product being co-designed and may limit their input to desired functions of the product (as the majority of customers did in the study described in Chapter 3). Therefore, it is suggested to provide customers a choice of multiple mediums to submit their ideas both verbally and visually.

Cuts of the survey pool by gender shows that females in general do not prefer a particular method as compared to the males (Table 4.6). Describing ideas verbally is first choice of idea submission methodology by females and males. Digital photographs ranks lowest on their menu.

Table 4.6: Idea submission medium by gender.

	Female	Male	P-value (Chi Square)
Digital Photographs	16.79%	13.06%	0.222
Computer drawings	20.36%	20.52%	0.968
Sketches of Ideas	26.43%	32.46%	0.121
Describe ideas verbally	36.43%	33.96%	0.545

Cuts of the survey pool by generation show some interesting statistics. 33% of Old Boomers want to submit ideas through sketches. Similarly, Young-Millennials first choice of idea submission is through sketches. Verbal submission is the number one choice for the remaining three generations.

Table 4.7: Idea submission by generation.

	Millennial Young	**Millennial Old**	**Generation X**	**Boomers Young**	**Boomers Old**	**P-value (Chi Square)**
Digital Photographs	8.70%	15.85%	18.18%	13.16%	14.29%	0.459
Computer drawings	20.29%	24.59%	20.28%	21.05%	10.39%	0.150
Sketches of Ideas	37.68%	25.14%	27.97%	30.265	33.77%	0.313
Describe ideas verbally	33.33%	34.43%	33.57%	35.53%	13.16%	0.793

4.2.6 Interaction Medium

Last question asked customers to indicate their preferred method of interaction with the design team during the co-design process. The question in the survey was:

> If you are invited to participate in the design process, which of the following ways of interaction with the design team would you prefer:
>
> a. Working one-to-one with the design team at the company design studio
> b. Working online with the design team

c. Teleconference with the design team

d. Working with other customers on a web based forum

The summary of customer responses is shown in the Figure 4.9:

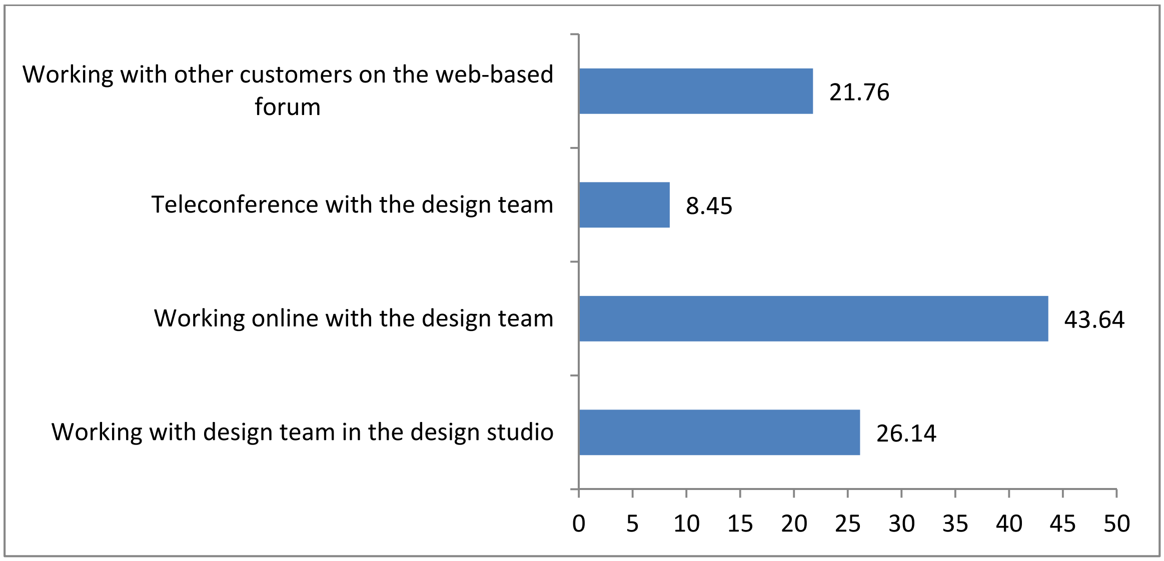

Figure 4.9: Customers preferred interaction methodology.

Online working with the design team is by far the preferred method by more than 40% of the customers, whereas only 5% of customers want to work through a teleconference with the design team. Working with the design team in the design studio and interacting with other customer through online forum was equally preferred. It can be stated that a forum where customers can interact with the design team and other customers while participating in the design activity of new products will satisfy about 60% of customers. Since computers with Internet access are ubiquitous and co-design requires a large number of customers to participate in the design process, online web forum may be the most costeffective solution to engage a large percentage of customers in the design process.

Table 4.8 shows the interaction medium preference by gender. No significant difference is noted between females and males. Online interaction with the design team is still the preferred method by both genders. Table 4.9 shows the interaction medium preference by generation.

Table 4.8: Interaction medium by gender.

	Female	**Male**	**P-value (Chi Square)**
Web Forum	23.93%	20.15%	0.098
Tele Conference	6.79%	10.45%	0.295
Online	45.71%	41.79%	0.442
Design Studio	23.57%	27.61%	0.468

For Young Millennial, the most preferred method of interaction is to work with the design team in the design studio. Online interaction with the design studio is the third preferred method. This response by Young Millennial is surprising. One would assume that Young Millennials are most familiar with the Internet and they would prefer online interaction over all other methods.

Table 4.9: Interaction medium by generation.

	Millennial Young	Millennial Old	Generation X	Boomers Young	Boomers Old	P-Value (Chi-Square)
Web Forum	31.88%	20.22%	23.08%	23.68%	14.29%	0.060
Tele Conference	7.25%	4.37%	11.19%	7.89%	15.58%	0.062
Online	26.09%	47.54%	50.35%	39.47%	42.86%	**0.018**
Design Studio	34.78%	27.87%	15.38%	28.95%	27.27%	**0.031**

4.3 Conclusions and Implications

In summary following conclusions can be drawn from this chapter:

1. Customer's interest in co-design varies by product type. For example, customers are more interested in designing a house than designing a digital camera.
2. Gender and generation of a customer influence the interest in co-design for certain products. Younger customers are more interested in designing sporting goods than older customers. Females are more interested in designing clothes than males, and males are more interested in designing cars and computers.

3. In a given product, customer interest in co-designing various components varies. Customers are more interested in designing the exterior shape of a car than transmission.
4. Customer would like to interact with design team online for design of the products.
5. Most customers want to describe their design ideas verbally.
6. Crowdsourcing is the least know term related to co-design.
7. Only 20% of customers have submitted design ideas to a company.

This survey was designed mostly to provide descriptive statistics about various characteristics of co-design and examine some relations with two demographic variables (gender and age). There were no specific hypotheses to test from this descriptive survey. However, the insights from the survey are used to present a five step model for implementing co-design in the next chapter. In this sense, the survey was useful in advancing our knowledge in the development of a new model. We now turn to the description of the new model in the next chapter.

CHAPTER 5

IMPLEMENTING CO-DESIGN THROUGH ENGAGEMENT PLATFORMS

5.1 Introduction

Several companies have launched co-design initiatives and have invited customers to participate in the design process. Few such examples were discussed in Chapter 1. Surveys conducted for this dissertation have shown that more than fifty percent of customers are interested in co-design. How a company that is not practicing co-design should go about involving customers in the design process? There is no step by step guideline yet available for starting a co-design effort. However, using few recent case studies on co-design mentioned in the book *Power of Co-creation* (Ramaswamy and Gouillart, 2010) drawing insights from the literature on Design Thinking, and results from surveys discussed in Chapter 4 a five step methodology to initiate co-design is proposed in this chapter.

5.1.1 Design Thinking

In recent years Design Thinking has emerged as a process to design products, services, and solve business problems. IDEO (a leading design consulting firm) uses Design Thinking to solve various problems for its clients. Tim Brown (2008) has described Design Thinking as the discipline that converts people needs into market opportunity. He writes:

> "Simply put, it is a discipline that uses designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity."(Brown, 2008)

It is important to note that the designer is playing a central role in Design Thinking. It is the designer and his perceptions that create value. He further describes how a design project goes through three phases as follows:

> "Design projects must ultimately pass through three spaces ….. .We label these "inspiration." For the circumstances (be they a problem, an opportunity, or both) Motivate the search for solutions; "ideation," for the process of generating, developing, and testing ideas that may lead to solutions; and "implementation," for the charting of a path to market." (Brown, 2008)

Figure 5.1 captures the essence of Design Thinking and the three spaces that a project goes through (3i model). With designer (or design team) at the center, the discovery of problems, generation of ideas and implementing of feasible solutions happen. The process is iterative and a design project may go back and forth between these three phases before the final product or service is produced

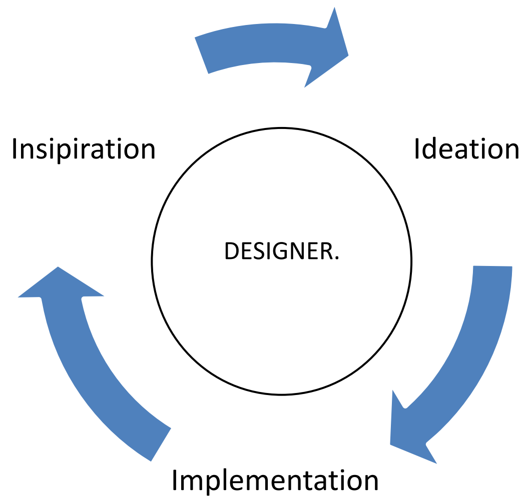

Figure 5.1: Three spaces for a design project and role of designer. (Brown, 2008)

This notion of designer being central to the design process is not new. Jones (1979) while describing his views about design process wrote in the first issue of Design Issues journal :

> "The design process, or strategy, can be expressed as a program or sequence of proposed techniques, each likely to generate the answer to a question and enabling the next question to be posed. Thus the design process is the designer's way of discovering what he knows, and what he does not know, about this new thing that he has promised to invent, and to integrate into the world as it is."(Jones, 1979)

Thus in conventional design, the designer plays a central role in interpreting customer's needs, generating ideas and converting those ideas into products and services. In contrast to conventional design process, customers are at the center of co-design. So any process for co-design should start by inviting customers to participate in the design process.

5.2 Five Steps for Implementing Co-Design

Involving customers and making them an integral part of the design team is crucial for any co-design activity. Inviting customers and then interacting with them is fundamental to co-design. It is suggested that first step of inspiration as mentioned above should be replaced with invitation and interaction with the customers. Customers will bring their unique experiences with them, and inspirations for design will be drawn from these experiences. The next step is to interact with customers to find their interest in co-design. As discussed in Chapter 4 customers' interest in co-design varies by product type and by product features. Gender and customer age also influence their willingness to participate in co-design. Therefore, an active interaction with customers to find their interests in co-design should happen before ideation can take place. After customers are onboard and their interests identified, the next step is to ideate about products and services that customers want to design. These ideas can be small incremental improvements to the existing offerings of a company or they can lead to novel products and services (incremental or radical innovation, as discussed in Chapter 1). Implementation of ideas is the next step. The last and ongoing step of co-design will be to improve and 'co-design' the process of co-design.

Engagement platforms (Ramaswamy and Gouillart, 2010) can facilitate these five steps.

Those companies that have already launched co-design efforts have build engagement platforms to invite, interact, and ideate with customers. These engagement platforms can take many forms -- live meetings, web sites, and even physical stores (Ramaswamy and Guolliart, 2010). Engagement platforms are the locus where customers and designers come together for co-design. Figure 5.2 shows the five step process (5i model) for co-design and the central role of customers in this process.

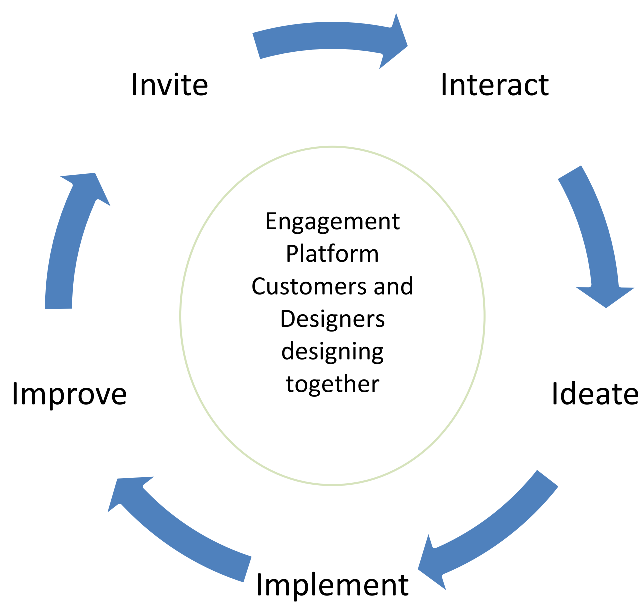

Figure 5.2: Five steps for implementing co-design through engagement platforms (5i model for co-design)

Use of engagement platforms is not limited to co-design. They can and are being used for marketing, experimenting with new product offerings, or gaining insights into customer behaviors (Ramaswamy and Gouillart, 2010). Five examples of companies that have designed engagement platforms for co-design and have involved customers in the design of products and services are discussed next. These examples are used to depict the implementation of each of the steps of 5i model.

5.2.1 Invite

The first step in a co-design initiative is to invite customers to participate in the design process. Surveys in Chapter 4 have shown that more than fifty percent of customers are interested in design of products and they are aware of the phenomenon of co-creation and co-design. So in order to include customers in the design process companies must set up channels through which customers can participate in the design process. Customers will bring their unique experiences and inspiration for product improvement ideas to the design team. Design teams on their own may not be able to imagine those ideas that surface from unique experiences of the customers.

Several companies have started to invite customers to participate in the design process on experimental basis. Example such as Audi has been briefly described in Chapter 2. However, some companies are now regularly using co-design.

Ramaswamy and Gouillart (2010) have described in detail that how one company, Dell, launched its initiative to invite customers to the design process.

Dell launched two initiatives to invite customers and have a transparent dialogue with them about Dell's products and services. In July 2006 Dell launched Direct2Dell blog to listen to complaints of customers. Then in February 2007, Dell launched IdeaStorm website (Figure 5.3). The purpose of IdeaStrom was to invite customers to participate in the design process of Dell products. In the first year of its launch 8859 ideas were submitted by customers and of these 20 ideas were implemented. To date 15498 ideas have been submitted on this website and more than 400 ideas have been implemented. Some of the ideas that were implemented included removing trial software from computers. Also using ideas from IdeaStorm Dell launched computers with lighted keyboards, longer battery life, and extra security features. Michael Dell (CEO of Dell) explains the reason behind launching IdeasStorm as follows:

> "I'm sure there's a lot of things that I can't even imagine, but our customers can imagine. A company this size is not going to be about a couple of people coming up with ideas. It's going to be about millions of people and harnessing the power of those ideas." (Ramaswamy and Guolliart, 2010)

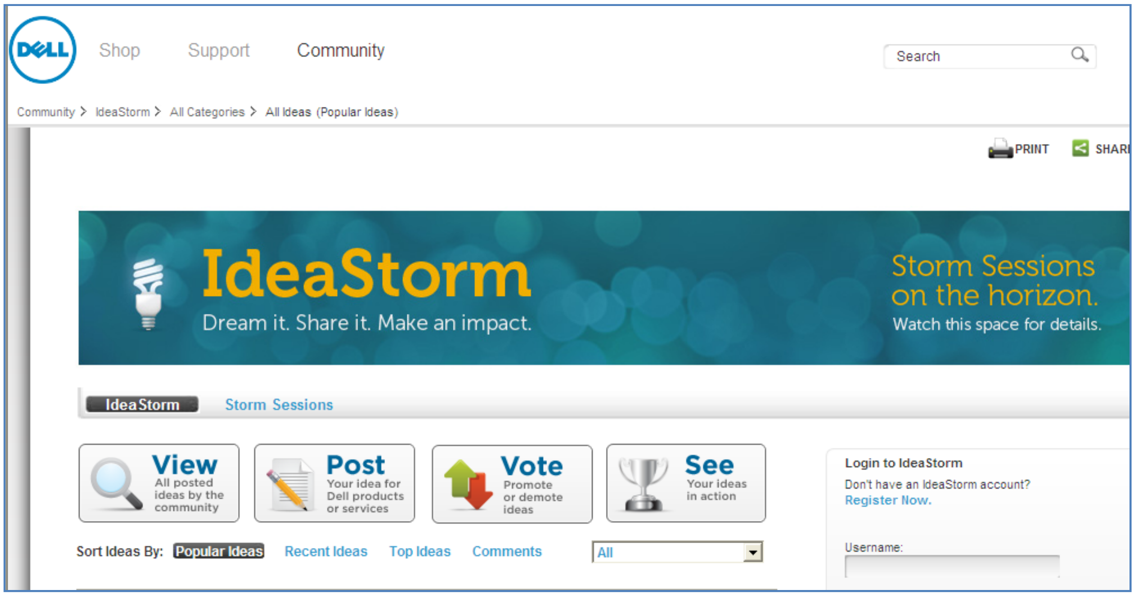

Figure 5.3: Dell's IdeaStorm home page for submitting ideas.

One key advantage of invitation is that large numbers of customers will participate in the design process. This in turn will increase the diversity and quantity of ideas generated and thus increasing the probability of design success. In summary, to start co-design first customers should be invited. A company's website is the most obvious starting point to invite customers. These websites can be converted into engagement platforms where customers and company designers co-design products and services.

5.2.2 Interact

Customers' interest in co-design varies significantly with product types and features. So companies should interact with customers to find out their interests and then co-design those products or services that customers are interested in.

For example, old boomers are not interested in design of sporting goods and young millennials are not interested in co-designing houses. Therefore interaction with customers will lead to formation of customer groups or communities for co-design around particular products and services. This will maximize the effectiveness of co-design initiatives by the company.

Interaction lets customers share their past experiences and future expectations. Interaction can be with company or with other customers that are present on the website. As was shown in the survey that customers want to interact with both company designers and other customers during co-design. Even though most companies regularly interact with customer through focus groups but interaction for co-design can lead to better products as this interaction is live and proactive. Club Tourism – a leading tourism company in Japan have formed customer interest groups to co-design tours. (Ramaswamy and Gouillart, 2010).

Club Tourism uses the simplest form of engagement platform- a live meeting with customers for co-designing tours. Club Tourism is a division of Japan's second largest tourism company with seven million members. Club Tourism employees interact with its customers to generate ideas about new tours or modifying existing tours. Club Tourism customers who participate in co-design belong to various theme clubs that are formed around common interests like – tea drinking.

Customers from this club along with Club Tourism employees design trips that focus around tea drinking. Then after the tour customers share their experiences and photographs that helps future co-design activities. This interaction with other customers and company employees is much deeper than filling a survey at the end of trip (which is the usual practice at other tour companies).

5.2.4 Ideate

Customer generated ideas are the backbone of co-design efforts. So once the customers are onboard the company's engagement platform the next step is to generate ideas about improving company's products and services. Ideas can be for minor improvement to existing products and services of a company or they can lead to breakthrough new products and services. Starbucks launched its engagement platform and asked customers to provide ideas to improve customer experience in Starbucks coffee shops.

Starbucks was facing competition and the customer experience in coffee stores was deteriorating. In order to reverse this trend Starbuck launched it engagement platform for involving customers in design and other activities at Starbucks. MyStarbcuksIdea.com became Starbucks initiative in co-design. MyStarbucksIdea invited customers with the following message (Ramaswamy and Goulliart, 2010):

> "Welcome to MyStarbucksIdea.com. This is your invitation to help us transform the future of Starbucks with your ideas—and build upon our history of co-creating the Starbucks Experience together…So, pull up a comfortable chair and participate in My Starbucks Idea. We're here, we're engaged, and we're taking it seriously."

On this website anyone can provide ideas to improve the customer experience Within a month of launch of the website, several ideas were posted on the website. One popular idea posted was to embed regular customer order in the Starbucks card. Another interesting idea posted on Starbucks website was to use ice cubes made out of coffee so that coffee is not diluted by the ice cubes. Similarly a solution called 'splash sticks' originated from the customers in Japan. These stick acts as a stopper to plug the hole in the lid and prevent the sloshing of coffee.

Starbucks also provided feedback to customers through 'Idea Partners' on this website. These Idea Partners were specially trained employees who respond to customer ideas and at same time take promising ideas to the internal teams at Starbucks. By 2008 there were 50 idea partners responding to customer ideas. Starbucks want customers to have a seat at the table when product decision are made (Ramaswamy and Gouillart, 2010). In the first year alone more than 65,000 ideas were posted by customers and 658,000 votes were casted. By 2009 fifty ideas were selected for implementation. The sheer number of ideas and use of Idea Partners show that how serious Starbucks is about co-design of Starbucks experience and how much emphasis is put on the ideation phase.

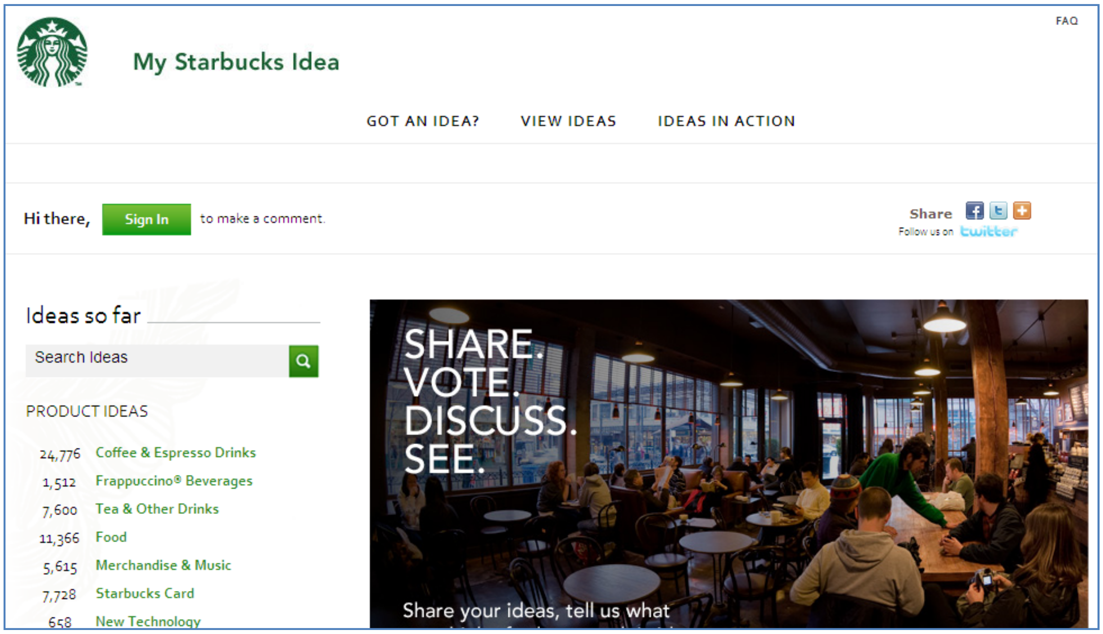

Figure 5.4: My Starbucks Idea home page showing the categorization of ideas.

5.2.5 Implement

After the ideation phase the next and most important phase of co-design is implementation. It is the phase where ideas generated by customers are converted into products and services that customers want to have. Customers generally lack resources to implement ideas on their own. That is why they interact with companies so that they can realize their ideas with the help of companies.

This is what makes co-design a win-win situation for everyone involved in the process. Generally two methods are being used for ideas selection for implementation: Customer voting or expert rating of ideas. It is quite possible that some of the ideas may not be implemented. For these ideas companies should provide transparent feedback to customers and at the same time research into ways to make those ideas a reality sometime in future.

Through implementation phase, company shows their dedication to co-design efforts. If customer ideas don't proceed beyond ideation phase, customers may start to think that a company is not serious about co-design. Implementing customers' ideas will lead customers to come back for further participation in co-design efforts. Through implementation value is co-created for both customers and company.

During the implementation phase customers can remain engaged with the companies providing important feedback as the products and services advance from prototypes to market launch. At the same time customers can also co-design marketing campaigns with the company. Lego a pioneer in co-design have involved customers through multiple channels and have converted several customer ideas into products and services.

Lego has been a leader in co-design and its co-design initiatives are repeatedly cited in the literature. Lego has implemented co-design on multiple facets. Lego Factory has already been discussed in Chapter 1. Another co-design initiative by Lego is the Mindstorm product. Mindstorm allows customers to create robots using Lego blocks. Users can write computer code for their robots. Interestingly, about half of the Mindstorm customers are adults. Lego invited users to take part in the programming of Mindstorm's user interface. In 2006 Lego launched Mindstorms 2.0 NXT that was co-designed with Lego users. For the launch Lego selected users and asked them to write about their experiences about NXT. It set up a message board to allow users to share their experiences and pictures of Lego Mindstorms they created. Lego not only implemented user ideas but also involved them in marketing the new products.

5.2.6 Improve

The final step in implementing co-design through engagement platforms is to improve the process of co-design through ‘co-design’. As discussed above that co-design takes place on engagement platforms so enhancing customer experience on engagement platforms can enhance the co-design of products and services. Engagement platforms for co-design should also be co-designed. Improving the co-design experience will increase customer participation in co-design process. It can attract new customers to participate in the co-design process. Thus more diverse and novel ideas will be generated to improve the products and services.

The ‘co-design’ of engagement platforms can follow the same steps that were just discussed about the co-design process. So the steps of invite, interact, ideate, and implement can also be applied to engagement platforms as these steps are applied to the design of products and services. Customers can be invited to participate in co-design of engagement platforms. Maybe all or maybe a fraction of customers will be interested in the co-design of engagement platforms. After customers are onboard for co-design of engagement platforms, interaction with them will lead to insights about customers' experiences on engagement platforms. Ideas can be generated to improve the engagement platforms. This improvement effort can take many forms. It may lead to enhancement of the web interface with customers or design of new engagement platforms. Some customers may also like to interact with company designers through physical engagement platforms instead of virtual engagement platforms. An example of Apple's effort to improve its co-design platform as described by Ramaswamy and Gouillart (2010) is discussed next.

When Apple launched iPhone in 2007 it opened its software for developers to write applications for iPhone. Apple provided its internal Software Development Kit (SDK) to developers and enthusiasts at no cost. This led to thousands of applications that are developed by independent developers for the iPhone and are available for download through online Apps store. Through this initiative Apple has opened up its internal product design process for co-design. The same concept was extended with the launch of iPad and Apple let developers to use SDK to write applications for iPad.

However Apple went one step further in co-design. Apple brought the software developers though live meetings and a dedicated website to share their insights about using SDK to write applications for Apple products. In order to enhance the experience of these software developers Apple ask them to share their development experience with Apple software engineers and other developers who are using the SDK. Thus Apple first opened the SDK platform for co-design of the iPhone applications and then it interacted with developers to learn and enhance their experiences with SDK.

More and more companies are augmenting their conventional design processes with co-design. These steps can help companies to launce co-design initiatives as they make customers an integral part of the design effort. This will enhance everyone's experience involved in conceiving and consuming the products and services and at the same time reduce the risk of expensive market failures.

5.3 Comparison between the Chapter 1 framework and the 5i Model

A framework in Chapter 1 was introduced to compare the co-design activities of various companies. It was developed by extracting common steps from conception to consumption of a co-designed product. Those steps were: get design tool, design product concepts, submit design concepts, select design concept, execute detailed design & manufacture, and buy/sell product. It will be apt to compare and contrast that framework with the 5i model.

5i model borrowed its inspiration from 3i model of Design Thinking and is strategic in nature, whereas the framework in Chapter 1 focuses on operational details of the co-design process. Since for any business activity both strategy and operation are important, so these two models complement each other as shown in Figure 5.5. The first three steps of the framework fall under ideation and the remaining three steps are related to implementation stage. However, invite, interact, and improve are additional steps that broaden the scope of the overall model. Another important distinction between the two is that the framework was developed using a customer's perspective for co-design and it relied on case studies of existing successful companies using co-design, whereas the 5i model was developed from a company's perspective and it relied on the survey data.

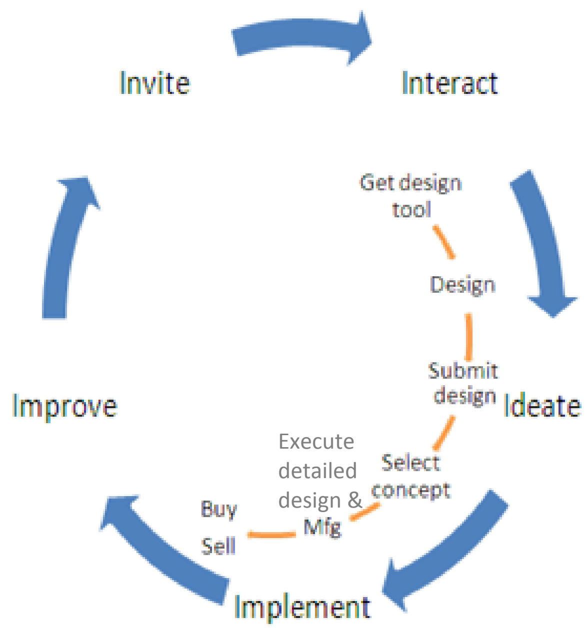

Figure 5.5: Mapping between Chapter 1 framework and 5i model.

Table 5.1 compares the examples from Chapter 1 and Chapter 5 using 5i model. The dots in the table indicate that a particular step is being carried out by the company in a given row. It can be seen from the table that customers are involved in the ideation phase of all the companies. Those companies that are only involved in co-design do not extend an explicit invitation to customers to participate in co-design activities. However, established companies that are augmenting their conventional design activities with co-design extend an invitation to their customers. Similarly, the last step of improve is missing from most companies, which creates an important opportunity to enhance the co-design experience. Few companies are improving the process of co-design through co-design.

Table 5.1: 5i model applied to co-design activities of companies

	Company	**Invite**	**Interact**	**Ideate**	**Implement**	**Improve**
1	Lego	●	●	●	●	●
2	Threadless		●	●	●	
3	Ponoko		●	●	●	
4	Muji	●	●	●	●	
5	Elephant design		●	●	●	
6	Local Motors		●	●	●	
7	Starbucks	●	●	●	●	
8	Club-tourism	●	●	●	●	
9	Dell	●	●	●	●	
10	Apple	●	●	●	●	●

In summary, the 5i model and the Chapter 1 framework captures different aspects of the same phenomenon. One is strategic in nature and the other focuses on operational steps. A company planning to initiate co-design activity may find both of them helpful, and Figure 5.5 suggests a useful integration.

CHAPTER 6

CONCLUSIONS AND FUTURE WORK

6.1 Summary

This dissertation investigated the influence of product complexity, frequency of use, and customer demographics on co-design. Co-design, an emerging trend, is changing the conventional design processes as it is replacing them with design processes that make a customer an active contributor to the design team. This co-operation between customers and companies has resulted in some successful product designs. Nevertheless, it was found that co-design is still limited to simple products.

In order to study the influence of product complexity on co-design three online surveys were conducted. The results of these surveys indicated that the frequency of interaction with a product influences the quantity of design ideas generated for that product. In addition it was found that product complexity does not affect the novelty of design ideas generated for a product. However one limitation of this study was that majority of customers provided ideas about functional requirements of the product. They did not provide the design concepts to implement these requirements. These surveys also showed that customers' interest in co-design varies with product type and product features.

Using the insights gain from the surveys and literature a five step framework was proposed that can be used to implement co-design within a firm. These five steps were identified after reviewing latest case studies of co-design efforts for various companies like Dell, Starbucks, and Apple. In addition, the data collected as part of this dissertation also informed the five step framework. The five steps are: invite the customers, interact with them, ideate for new products and services, implement customers' ideas and then improve the process of co-design. It is predicted that in coming years co-design will increasingly augment conventional design processes. Overall, the dissertation offers both strategic and operational models, supported by case study, surveys, and literature review.

6.2. Contributions

This dissertation made following three contributions to the study of co-design

1. Studied the influence of product complexity on co-design.

The first contribution of the research was to study the influence of product complexity on the outcome of co-design activity. It was found that the ideas generated by customers during co-design varied by product type and product frequency of use. Customers generated more design ideas about high frequency of use products than low frequency of use products. However, the complexity of the product did not play a significant role in either novelty or quantity of ideas generated by the customers. This can help companies select products that they want to co-design as it shows that co-design may be more successful on some products than other products.

2. **Studied the influence of customer demographics and product type on co-design.**

The second contribution was a study of the influence of product type and customer demographics on co-design. Through online surveys, it was found that customer's interest in co-design varies by product type. For example, customers are more interested in designing a house than designing a digital camera. Gender and generation of a customer also influence customer's interest in co-design. For instance, younger customers are more interested in designing sporting goods than older customers. Similarly, females are more interested in designing clothes than males.

3. **Presented the 5i model for co-design.**

The third contribution was to develop the 5i model of co-design. 5i model provides a starting point for any company that is pondering on launching a co-design effort and is looking for a starting point. Using these five steps companies can launch their first co-design effort and later on improve their efforts as they gain experience of implementing designs designed by the customers.

6.3 Future Work

Will co-design replace conventional design in near future? Will it augment conventional design activity? Tim Brown (2009) provides a possible answer:

> "For the moment, the greatest opportunity lies in the middle space between the twentieth century idea that companies created new products and customers passively consumed them and the futuristic vision in which consumers will design everything they need for themselves." (Brown, 2009)

As most companies try to augment conventional design activities with co-design, a number of research questions and areas about co-design remain unexplored. Some of these questions are:

1. What is the correlation between customer dissatisfaction and the novelty of design ideas generated during co-design?
2. How customer's knowledge gap precludes the transformation of customer's needs into design concepts during co-design? One way to study this is to run a similar experiment as described in Chapter 3 with

professional designers. Then compare their approach with customers' approach to co-design. This would help to identify customers' knowledge gap and its influence on co-design.

3. How to best combine co-design and conventional design activities in a large corporation? What are the implications of co-design on designers working in a company?
4. Customers usually generate a large number of ideas on co-design websites like MyStarbucksIdea.com. However very few ideas are actually implemented. What are the reasons for this phenomenon?
5. Is there a more reliable and repeatable method to rate design ideas generated by customers in a co-design process than CAT?
6. How does the method of interaction between customers and designers influence co-design? If online co-design efforts are supported with direct interaction between customers and designers, will it enhance co-design?
7. How does co-design impact the business model and what are its implications on manufacturing, supply chain, and inventory management for a given company?

Investigations pursuing these questions will help to define the future of customers' involvement in the design process through co-design. The present dissertation is an initial attempt at addressing very important developments in an emerging method to engage the customer in the design of new products.

APPENDIX

CO-DESIGN SURVEYS

I am a student of University of Michigan and employee of an automotive OEM. I am conducting research to gauge customer's interest in participating in the design process of new vehicles. In this regard, you are invited to participate in a series of three surveys. Your responses from these surveys and demographic information about you will be used anonymously to draw insights about customer participation in the design process. Participation in these surveys is complete voluntary.

Survey 1

1. Please indicate your interest in participating in the design of following products:

	Uninterested	Somewhat Uninterested	Neither interested nor uninterested	Somewhat interested	Interested
House					
Car					
Cell Phone					
Computer					
Household furniture					
Home 1appliances					
Clothes					
Shoes					
Digital Camera					
Inkjet printer					
Sporting goods					

2. Apart from the products listed above are there any other products that you want to design for yourself? If yes please list them. Note: These products can be existing in the market or they may not be available in the market.

3. If given a chance to participate in the design of a car, what aspects of the car are you interested in designing.

	Uninterested	Somewhat Uninterested	Neither interested nor uninterested	Somewhat interested	Interested
Exterior shape					
Interior shape					
Seats					
Wheels and tires					
Instrument panel (dashboard)					
Navigation system					
Steering wheel					
Suspension system					
Engine					
Transmission					
Cup holders					
Sunvisor					
Wiper system					

4. Suppose you are given a chance to design the sunvisor for the next model of your car. How would you design the sunvisor. Please number your design ideas as you type them.

5. Are you aware of the following terms:

	Yes	No
Co-design		
Co-creation		
Crowdsourcing		
Opensourcing		
Open innovation		

6. Have you ever submitted a design improvement suggestion to any company

	Yes	No

Survey 2

1. How often do you use the following on your car:

	Several times a day	Once a day	Several times a week	Once a week	Several times a month	Once a month
Cupholder						
Wiper system						
Instrument panel						
Fuel door and cap						
Sunvisor						

2. How complex it will be to design following components.

	Very simple	Somewhat simple	Neither simple nor complex	Somewhat complex	Very complex
Cupholder					
Wiper system					
Instrument panel					
Fuel door and cap					
Sunvisor					

3. If you are invited to participate in the design process, what is your preferred method for submitting you ideas:

    a. Design ideas described verbally
    b. Sketches of design ideas
    c. Computer drawings
    d. Digital photographs

4. If you are invited to participate in the design process, which of the following ways of interaction with the design team would you prefer:
    a. Working one-to-one with the design team at the company design studio
    b. Working online with the design team
    c. Teleconference with the design team
    d. Working with other customers on a web based forum

5. If given a chance to participate in the design of a car, what aspects of the car are you interested in designing.

	Uninterested	Somewhat Uninterested	Neither interested nor uninterested	Somewhat interested	Interested
Instrument panel (dashboard)					
Cupholder					
Wiper system					
Fuel door and cap					
Sunvisor					

6. Suppose you are given a chance to design the cupholder for the next model of your car. How would you design the cupholder. Please number your design ideas as you type them.

7. Now suppose you are given a chance to design the wiper system for the next model of your car. How would you design the wiper system. Please number your design ideas as you type them.

Survey 3

1. How often do you use the following on your car:

	Several times a day	Once a day	Several times a week	Once a week	Several times a month	Once a month
Cupholder						
Wiper system						
Instrument panel						
Fuel door and cap						
Sunvisor						

2. How complex it will be to design following components.

	Very simple	Somewhat simple	Neither simple nor complex	Somewhat complex	Very complex
Cupholder					
Wiper system					
Instrument panel					
Fuel door and cap					
Sunvisor					

3. If you are invited to participate in the design process, what is your preferred method for submitting you ideas:

    a. Design ideas described verbally
    b. Sketches of design ideas
    c. Computer drawings
    d. Digital photographs

4. If you are invited to participate in the design process, which of the following ways of interaction with the design team would you prefer:
    a. Working one-to-one with the design team at the company design studio
    b. Working online with the design team
    c. Teleconference with the design team
    d. Working with other customers on a web based forum

5. If given a chance to participate in the design of a car, what aspects of the car are you interested in designing.

	Uninterested	Somewhat Uninterested	Neither interested nor uninterested	Somewh at intereste d	Interested
Instrument panel (dashboard)					
Cupholder					
Wiper system					
Fuel door and cap					
Sunvisor					

6. Suppose you are given a chance to design the fuel door and cap for the next model of your car. How would you design the fuel door and cap. Please number your design ideas as you type them.

7. Suppose you are given a chance to design the instrument panel (dash board) for the next model of your car. How would you design the instrument panel. Please number your design ideas as you type them.

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