Design-oriented New Product Development Strategy in Chinese Small and Medium Enterprises

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Abstract

China is in economic transition, from the resource consuming “made in China” to an aspirational “designed in China”. Chinese Small and Medium Enterprises (SMEs), have made significant contributions to society and the national economy, their influence determines the success of this economic transition. On the other hand, design-oriented New Product Development (NPD) strategies are generally recognised as beneficial for company survival, but are mostly applied in large companies. Evidence of testing design-oriented NPD strategy in Chinese SMEs is sparse. This research therefore, attempts to introduce design-oriented NPD strategy to Chinese SMEs, and investigates how design-oriented NPD strategy performs in Chinese SMEs.

This research adopts a qualitative approach with three stages: the first utilises a scoping study to understand the feasibility of this research, and synthesise knowledge from the literature to construct a customised NPD process model with “design-oriented” aspects; the second stage focuses on using an experimental method to conduct a parallel implementation: two NPD projects follow different NPD approaches, the “conventional” NPD process of SMEs and the introduced “design-oriented” NPD process; the third stage carried out mainly by observation, set out to investigate the changes brought about by the NPD process.

Empirical data from three NPD projects is collected and analysed. Evidence from the parallel NPD projects demonstrates that the introduced “design-oriented” NPD strategy gains internal confidence but is costly when compare with the “conventional” approach (funds and time). Although the new product from the “design-oriented” team of the experiment performed less well from a sales perspective, a continuous observation on their follow-up NPD project, the investigation of the changes, discloses that the NPD behaviour of the investigated company is changed, all participants reach consensus regarding the merits of the design-oriented NPD. It concludes that the design-oriented NPD strategy in Chinese SMEs are implementable and beneficial.

This research is a single case study, and a qualitative investigation of implementation of the design-oriented NPD strategy in one selected Chinese SME. It requires a wider adoption of the design-oriented NPD strategy in companies across different industries, and to investigate a larger sample of NPD projects, to gather quantitative confirmation.

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Publications

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Abbreviations

BIDC	Beijing Industrial Design Centre
CAD	Computer aided design
CIDA	China industrial design association
DDF	Dragon design foundation
GD	Graphic Design(er)
GDP	Gross domestic production
HEV	Huoyun Electric Vehicle Co., Ltd
ID	Industrial design(er)
JZY	JinZhongYi Furniture Co. Ltd.
LED	Light-emitting diode
NPD	New product development
NPS	New product success
ODM	Original design manufacturer
OEM	Original equipment manufacturer
PDP	Product development process
PM	Project manager
SMEs	Small and medium enterprises
SOEs	State-owned Enterprises
UST	USbright Technology Co., Ltd.
“IG”	“Inner Glow”, a product name of the selected company
“UP”	“Ultimate Power”, a product name of the selected company
“SP”	“Smart Power”, a product name of the selected company
“IE”	“Infinity Energy”, a product name of the selected company
“SE”	“Smart Energy”, a product name of the selected company

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Chapter 1. Introduction

The growing Chinese economy is in the process of economic transition. From the environment consuming “made in China” to a more sustainable “designed in China”. Chinese SMEs, with their high weight of contribution to society and the national economy, to a large extent determine the success of the aspirational “designed in China” economic transition.

1.1 Chinese Economy

China (Mainland China, excluding Taiwan, Hong Kong and Macau) is one of the largest emerging markets of the world. It still keeps growing rapidly with approximately 8% annual increase in GDP (Gross Domestic Product). As an emerging economy, it continuously narrows the income gap with developed countries and is more open to the world by being a by-product of globalization (Vercueil, 2012). In 2013, China total exports at about 2,210 billion dollars, account for over 12% of overall global exports and ranked as the largest exporter in the world. In recent decades, alongside with the development of the internet, e-commerce has been welcome. Chinese companies have had a remarkable record, the biggest Chinese e-commerce platform provider Alibaba achieved 1.1 trillion yuan (170 billion dollars) on sales in 2012, this number

takes about 2% of total GDP of China in the same year and it exceeded the sales combination of eBay and Amazon (The Economist, 2013), and the sales is predicted keep growing rapidly.

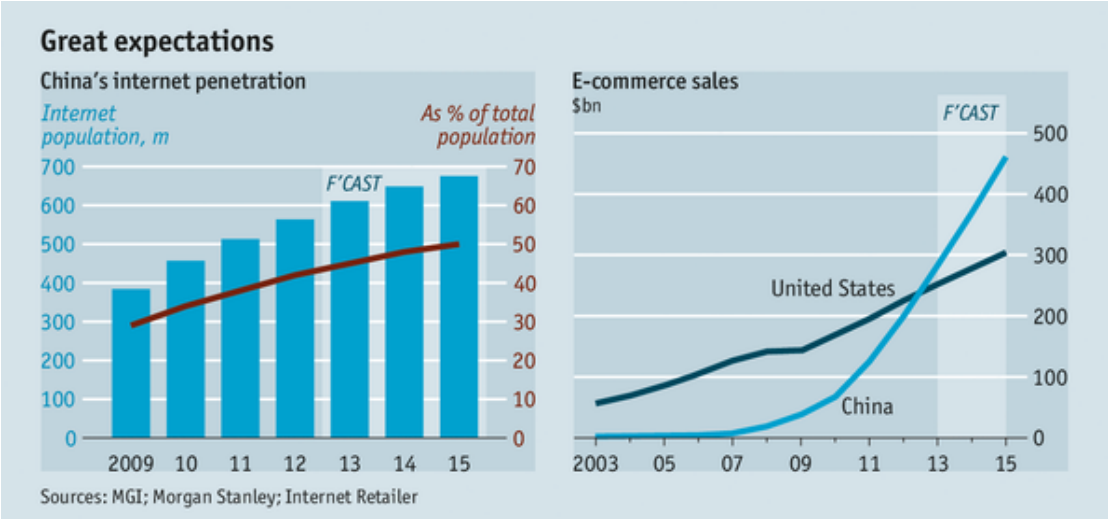

Figure 1. Great expectations (The Economist, 2013)

Figure 1 indicates that the number of internet population which will keep growing in the future years, from 300 million to about half of the population in 2015. And the sales of Chinese e-commerce owing to the growth of internet population and maturity will goes beyond the US in 2012, and foreseeably, to have a market scale with close to 500 billion dollars in 2015. Those numbers confirm a fact that China has ever increasing impact on the world economy with a large scale of consumers.

The Chinese central government gradually recognised the rapid economic

development as a by-product of globalization (factory of the world) is seriously impact on the environment and limits the national creativity (CCTV, 2012). In 2010, twelve ministries of the central government launched a guidance for promoting industrial design development (Miit.gov.cn, 2014). Design was then formally given the task of transferring the Chinese economy from “made in China” to “designed in China”.

1.2 Chinese SMEs

Small and Medium Enterprises (SMEs) have different definitions owing to the differences in various countries. The EU defined it as enterprises with fewer than 250 persons and within 50 million euro annual turnover, or within 43 million euro annual balance sheet (Ec.europa.eu, 2003), while the US saw it as different in industry, ownerships, revenue and number of employees (Sba.gov, 2012). Following the definition of SMEs in the USA, Chinese SMEs were defined based on the differences of industries, there are three main characters: annual revenue, number of employees, and total assets (Appendix 1). Chinese SMEs are low in revenue, have less number of employees, and the value of total assets is relatively low.

However, Chinese SMEs have significant impacts on the Chinese economy. The total amount of Chinese SMEs represents 99% of companies in China,

provide 80% of total jobs and contribute over 60% GDP, but have only 3.7 years' average life (People.com.cn, 2012). In the process of "designed in China" economy transition, Chinese SMEs are playing a more important role than large companies, and to a large extent, determinative on the success of the "designed in China" economy transition.

1.3 Thesis Structure

Chapter 1 gives the background of this research. It restates the growth of Chinese economy and highlights this research to focus on Chinese SMEs.

Chapter 2 starts from discovering a phenomenon of counterfeiting in Chinese SMEs, focuses on reviewing literatures in relation to NPD and design, to understanding the current state of the art for NPD strategies and models, approaches in Chinese SMEs, and discovers opportunities of improving the current status of Chinese SMEs by combing design and NPD.

Chapter 3 starts by a statement of the research objective and questions, qualitative approaches are selected and follows build, implement, reflect three steps to answer the three research questions.

Chapter 4 provides the detailed process of answering the first question. It

starts by a scoping study to confirm the feasibility of conducting further research, and displays the process of generating the instrument: the conceptual designer-led NPD process model.

Chapter 5 is the representation of the detailed implementation process. It includes, preparation of the implementation, parallel implementation and post implementation. The preparation process includes company selection, optimised the proposed NPD process model with practitioners, confirmation of the role of the researcher, and a metrics tool is also generated with practitioners to score the processes. In the parallel implementation process, two NPD projects are conducted in parallel, but following different NPD process models. One follows the proposed model and the other uses their existing approach for making further comparison. In the post implementation process, results from the metrics tool is discussed as evidence of subjective/internal evaluation and the six months' sales data of two outcomes is collected as evidence of objective/external evaluation.

Chapter 6 displays the very detailed process of their continuous NPD project, to understand their changes after introducing the design-oriented NPD strategy. It appears their approach of team assembling is changed, and the NPD project progresses in review loops. They start to develop new product by

using external resources and the top manager pays more attention to the NPD project.

Chapter 7 revisits their changes at different steps of this research, and summarised the main characteristics of design-oriented NPD that discovered by their evolved NPD process in Chapter 6. Advantages and disadvantages of this type of design-oriented NPD in Chinese SMEs are summarised.

Chapter 8 concludes this research by giving answers to each research question, and claims the contribution of this research mainly on the discovery of the way of applying design-oriented NPD in Chinese manufacturing SMEs. Limitations and suggestions are given in the end.

Chapter 2. Literature Review

This chapter starts by understanding the counterfeiting phenomenon in Chinese SMEs. And move to review firstly, industrial design aspects; it contains industrial design development in China and design process models. Secondly, NPD associated aspects. It covers NPD process models, NPD success factors or NPS (New Product Success) Factors, and NPD strategy in Chinese SMEs. Last but not least, the existing types of the design-oriented NPD strategy. It helps to understand what the current combination of design and NPD is, and why Chinese SMEs do not follow those existing design-oriented NPDs.

2.1 Counterfeiting behaviour

China is the world's largest counterfeit goods producer and these counterfeit goods account for about 1% to 1.5% of China's GDP, and about 15-20 per cent of all Chinese brands are victims of counterfeits, and only about 8% of all counterfeit goods are sized each year (Asia Business Council, 2005). In the US, about 40% of product recalls were import from China (Clifton and Ahmad, 2009), Figure 2 shows two phones, one is counterfeit iPhone 5 produced by a Chinese manufacturer and the other is genuine iPhone5 launched in October in 2012 by Apple. It is hard to distinguish the genuine one by only appearance.

But the counterfeit product costs less than 8 per cent of a genuine iPhone5 (91.com, 2013).

Figure 2. Fake iPhone 5 and genuine iPhone 5 (91.com, 2013)

The country of origin label “Made in China” to some extend still has “cheap and junky” image (Wang, 2008). Some companies have goods that are manufactured in China but avoid using the “Made in China” label, such as Apple, they replaced it by “Designed by Apple in California, Assembled in China”.

Although China has become the second largest economy body of the world and growing quickly, the quantity of population determines that the average income and social security is still at developing level. Consequently, materialism is a main stream. There are two reasons that increase the society materialization and fear of poverty. The first is historical, the economic reforms; Open and Reform policy of China in 1979 led to rapid economic growth. While in 1978, the state owned enterprises dominated almost 80% of industrial value

added, there are only 140,000 individuals involved in the private economy (Qin, 2008). The employment policies for works previously almost characterized by strict bureaucratic control, a monopoly on labour allocation through lifetime employment policies and severe restrictions on labour mobility (Knight & Yueh, 2004). However, in the over three decades, the demise of lifelong jobs in the push towards a market economy has resulted in the materialization of a competitive labour market in China (Gao & Smyth, 2010). Meanwhile, people's aspirations for stability have increased. The other is about the fact that millions of people lost their job at the end of last century, known as lay off. It was an employment change between 1998 and 2002 in China; the official figures indicated that there were over 26 million workers laid off from state owned enterprises (Armitage, 2003). Most economists suggest that the unemployment rate is around 15 per cent and 25 per cent in northeast while the official figure is only 3 to 4 per cent (Roberts et al., 2002).

These factors pushed people aspiring for stability. A monetary approach is a visible way for maintaining their life and survival. Thus, a number of corporation owners turn to appreciate short-term monetary benefits. Consequently, a considerable amount of products has been produced without careful considerations of quality and design, but on price competition and marketing efforts. Some critical academic researchers have cast doubt on the reality and genuineness of Chinese values (Chen and Dai, 2002). A significant

number of contradictions and paradoxes emerged against positive Chinese values, such as short-term opportunism, corruption, counterfeiting and other unethical business practices (Millington et al., 2005; Gao et al., 2010).

Things which are popular, from consumer products to cultural activities that will be duplicated with little or slight modification, this activity is locally called ‘shanzhai’, which is an indigenous phrase describing counterfeiting or imitating behaviour (Si, 2009). An article in China Daily (2009) frequently praises ‘shanzhai’ as ‘a culture that bears the imprint of grassroots innovation and the wisdom of the common people’. Chinese authorities have remained relatively silent towards issues of these kinds of plagiarism and Intellectual property rights (IPR) violation. Wilcox et al. (2009) found that consumers are trend to be more likely to purchase counterfeit brands while genuine goods remain high price and unaffordable for them. These counterfeits are suitable for impoverished masses and have a positive function in terms of softening tensions between the haves and the have-nots (Ang et al., 2001).

Chinese values are considered derived from Confucian ethos (Hofstede, 1991), high on power distance and long-term orientation, and low on individualism (Hofstede, 2003). Confucian values application in economic development and entrepreneurial development were considered beneficial. Kahn (1979) associated Confucian cultural values such as dedication, motivation,

responsibility, education, sense of commitment, organizational identity and loyalty, to the rapid growth of economies for example Japan, Korea, Taiwan and Hong Kong. ‘Shanzhai’ is considered as an approach to innovation, and similarly as a precedent in Japan (Cox, 2007). Masayuki Kurokawa, former chairman of Japan Industrial Designers’ Association, stated that Japan had a similar situation like nowadays China before World War II, European companies even denied Japanese to take photos of their products because of the potential of being copied (CCTV, 2012). Shiro Aoki, Executive Director and Chief Operating Officer of Japan Institute of Design Promotion, thought imitation was foundational for learning advanced things (ibid). Historically, the Country of Origin started in 1887, by the Merchandise Marks Act 1887. It is used to stop foreign manufacturers falsely claiming that their goods are British-made and selling them in Britain and Europe (Crosby, 2014). It was initiated as protectionism against Germany who introduced “Rye and Iron” tariffs (SIEPR, 2002), but successfully distinguished British-made goods from comparatively “low quality and junky” Germany made ones during that time (CCTV, 2012).

2.1.1 Institutional Environment

The impacts of institutional environment to counterfeit behaviour cannot be ignored. Davis and North (1971) stated that the institutional environment is a

set of fundamental political, social and legal ground rules that builds the basis for production, trade and distribution. The type of ground rules such as rules governing elections, property rights, and the right of contract that builds up the economic environment. Yeung (2002) claimed it is political economic structures and dominant organizational and cultural practices. Henisz and Delios (2002) proposed institutional environment includes political institutions, economic institutions and sociocultural institutions. Political institution is related to national structure of policymaking, regulation and adjudication; economic institutions are the structure of the national factor markets and the terms of access to international factors of production; and sociocultural institutions related to informal norms. In practical Chinese SMEs activities, Peng et al. (2008) found that institutions govern societal transactions in politics (e.g., corruption, transparency), law (e.g., economic liberalization, regulatory regime), and society (e.g., ethical norms, attitudes toward entrepreneurship). In terms of funding, Chinese SMEs adopt terms like collective enterprise, joint venture, and small individual firms to gain fiscal benefits and legitimacy (Malik, 1997). They mainly rely on joint ventures and alliances in order to access financial resources and technologies (Peng, 2002), but they lack of access to the formal financial market and leave to resort to informal and underground financial institutions to obtain loans (Wang and Yao, 2002). Alternatively, for saving costs, they rely much on municipal and local authorities to get access to community resources, such as land and properties (Siu et al., 2006). Siu (2001)

argues that, under the influence of indigenous relationships, Chinese SMEs use personal contacts and networks to broaden their distribution channels and new business development. Yamakawa et al. (2008) summarized that the SMEs in emerging economies are under weak institutional context, lack financial support, have low levels of legitimacy and face higher constraints. An increase in government R&D budget can push the firm to expand its own R&D activities (Hu, 2001).

According to Wang and Yao (2002), the institutional environment of Chinese SMEs determined the difficulties for them to get access to the formal financial market. Most Chinese SMEs hard to obtain affluent financial support, the limited funds result that they cannot make considerable investment on learning or behave as large firm's design-oriented NPD strategy, and this is also a reasonable explanation of why the SMEs continuously counterfeiting. Lack of market regulation execution is the main cause for "shanzhai" (counterfeiting or imitating) phenomenon, and the official to some extent see this as a learning process (China Daily, 2009). There are obvious merits that SMEs can gain by using 'copy-cat' approach to make "shanzhai" products. Firstly, avoiding market uncertainty; a product that is selected to copy is welcomed and proofed by the market. Secondly, saving time and development cost; copying others save a large amount of money and efforts on doing market research and jumped all the process from prototyping to mass production. However,

counterfeiting is not sustainable: only duplicate the appearance of a product, key technology cannot be learnt, this leads a poor quality and performance of the product, and can only be sold with low profit as “knockoffs”; have no warranty or standard certificates, only target to those have-nots (Ang et al., 2001). It is unethical and illegal, and limits the company expansion to international market, and harms the company’s innovativeness.

2.1.2 National Design Promotion

For overcoming counterfeiting behaviour and promoting design, 12 ministries include the Ministry of Industry and Information Technology, Ministry of Education, Ministry of Science and Technology, Ministry of Finance, Ministry of Human Resource and Social Security, Ministry of Commerce, State Administration of Taxation, National Bureau of Statistics, State Intellectual Property Office, Securities Regulatory Commission and Banking Regulatory Commission, launched a guidance for promoting industrial design development together (Miit.gov.cn, 2014). These ministries cover almost all relevant areas for companies that aspire to implement good designs. Design was formally raised to national level and considered as a weapon for winning from international competitions, also a vital tool for upgrading the national economy from the resource consuming “made in China” to “designed in China”. With the increasing social recognition and attention to industrial design, there

are several private organizations and government-directed association work for building platforms for nominating and awarding designers with remarkable achievements, and organizing shows for companies to represent their well-designed objects to the public with the purpose of meeting buyers.

The first official organization in China working to promote industrial design was the China Industrial Design Association (CIDA). It was founded in 1979, initiated by design enthusiasts, entrepreneurs and people who work in art and design discipline. The aim of CIDA is to promote the development of industrial design in China, enhance the competitiveness of domestic products and therefore assist the national economic growth. The main task is to organise professional research and develop strategies for industrial design development. Also hand in suggestions and advices to government management departments to produce policies for promoting industrial design. Moreover, CIDA is responsible for validating industrial design organizations and qualification authentication; to assist design education deployment, research and verification; develop industrial design consultancy agent services; organise design competitions and award organizations and persons that produce outstanding work in design practise, education, research and management (CIDA, 2013). CIDA has a similar function to the Design Council in the UK and Industrial Design Society of America in the US. However, CIDA carries more government work and is involved in policy making and rights to

assess private design firms.

There is another organization founded in 2010 called Dragon Design Foundation (DDF). It is the first design foundation in China with the tenet to support the growth of design talents, promote the design industry development. Several awards have been administrated by DDF: the DDF Award, China Top Ten Youth in Design Industry Award, China Design Award, Dragon Star Award. With exception of the China Design Award, the other awards commend and fund individuals who make outstanding contribution to the design industry. Moreover, DDF organizes design activities among professionals such as China Design Festival, China Design Forum. DDF commits itself to building a platform that is willing to serve the design industry comprehensively: from information exchange, talent development to investment and corporate finance advice (DDF, 2013).

Numerous awards have been founded by different organizations, such as the China/Chinese Design Award started in 2006, funded by DDF (2013). The Red Start Design Award (2013) which was initiated in 2006, sponsored by the Beijing Industrial Design Centre (BIDC); and China Excellent Industrial Design (CEID Award) which is started in 2012, founded by Ministry of Industry and Information Technology of China (CEID, 2013). These awards are similar as world-renowned awards, for example, IF award and Red-dot Award in

Germany, and IDEA Award in the US. The winning products of these awards are presented in shows, and promoted by the Media and showcased online on the official award websites. The China/Chinese Design Awards tend to attract product with Chinese identity, Red Star Award more like IF design award and Red-dot design Award, it is for participants in a wider range of products. The CEID Award is similar to the Red Star Award, but operated directly by the Chinese government. All these organizations and awards are built for accelerating industrial design development and rewarding excellent designs.

2.2 Industrial Design

The term ‘industrial design’ that is used interchangeably with ‘product design’ involves both engineering and aesthetic design (Ekberg, 2005), but with more emphasis on users’ consideration (Roozenburg & Eekels, 1995). Industrial design is linked to the manufacturing sector, the needs of consumers, and also takes into account business matters (Keinonen, 2006). In a New Product Development context, the term “design” is closely related to industrial design practice which is to create things or develop concepts that will benefit both users and manufacturers (IDSA, 2010). It seems industrial design is to describe the activity that trained designers to utilize their talents to generate solutions that will benefit both users and manufacturers.

2.2.1 Industrial Design in China

In 1984, the first Industrial Design course is introduced by Guanzhong Liu at the Central Academy of Craft Art (In 28th September 2005, The Central Academy of Craft Art is merged into Tsinghua University, and named "The Academy of Arts & Design of Tsinghua University"). The first design consultancy is established in 1985 (CCTV, 2012). The short history of industrial design determines the immature and imbalanced character. In 2012, while there are more than 100 thousand design consultancies in China, Liu (ibid) indicates that most of these Chinese entrepreneurs and designers go abroad for inspiration, is actually for hunting targets to duplicate; they have overlooked their own life. Coincidentally, "Milan International Furniture Fair", with over 200 thousands square metres, has never had a Chinese company permitted to participate, on the other hand, China is the biggest country for producing and exporting furniture (ibid). Carlo Guglielmi (President of COSMIT) argues that copy, duplication is Chinese design in most people's mind. Meanwhile Alberto Alessi (CEO of Alessi) points out that there was a chasm in Chinese design: for almost 50 years, China is out of design (ibid). Chen et al. (2010) discovers the 4 phases of industrial design development in China, and analysed it from a historical perspective:

Table 1. Development pattern, Embryonic Phase (Chen et al, 2010).

Development Strategy	Sectorial Scope of Industrial Design	Industrial Design at Firm Level	Industrial Design Education and Research	Government Design Policy	Design Discourse
Uniformed planned economy mechanism. Primary specialization in heavy industry. (From independence to the end of the 1970s)	Small-scale, low-tech industries. E.g. crafts and household goods.	N/A	The major or individual course is created in Light Industry Institute or Academy of Art and Craft.	N/A	N/A

In the 1970s, there were no design companies, government and people have limited awareness of what industrial design is (Table 1). In 1980s, the China Industrial Design Association was established and design courses were imported from developed countries (Table 2).

Table 2. Development pattern, Introduction Phase (Chen et al, 2010).

Development Strategy	Sectorial Scope of Industrial Design	Industrial Design at Firm Level	Industrial Design Education and Research	Government Design Policy	Design Discourse
Transfer from planned economy to market economy. Export promotion. Seller's market in domestic consumption. (Decade of the 1980s)	Large-scale, investment driven industries. E.g. endurable consumer goods, such as televisions, refrigerators.	Industrial Design as a means of imitation and beautify appearance. Small-scale industrial design firm	Teachers who sent abroad for further study came back and students who were enrolled after reform and opening up stayed at school as a teacher. Complete education system of ID was established	ID is recognized as a development tool, and CIDA is established, but there is no clear policy about how to use it.	Article written by educators dealing with ID as a separate discipline appear in related journals. Design is an image of modernization, especially as a cultural phenomenon.

The notion of design was blurry until the 1990s (Table 3), industrial design was

gradually considered as a bridge to market. During that time, the market was not as competitive as nowadays, so design was not considered as important as marketing and development.

Table 3. Development pattern, Adjustment Phase (Chen et al, 2010).

Development Strategy	Sectorial Scope of Industrial Design	Industrial Design at Firm Level	Industrial Design Education and Research	Government Design Policy	Design Discourse
Planned market economy. Export promotion and investment driven economic growth model. Buyer's market in domestic consumption. (Decade of the 1990s)	Investment driven standard technology industries. E.g. household appliances and most consumer goods.	In-house ID teams ID as a tool of systematic product differentiation and adaptation on the basis of product modification.	Postgraduate ID course. Study programmes get a strong theoretical input. Localization of ID education starts. Education discuss in the nationwide.	Design groups in Government Ministry are established. The recognition of ID as the bridge to the market.	Applied articles are published in related magazines. Book on ID are published.

In the beginning of 2000s, large companies started to embed design as strategy for winning from market competition. Many more design consultancies appeared, ways of promotion design developed by both private organizations and government. Design was considered as weapon for wining from international competitions and as a vital tool for upgrading economy from "made in China" to "designed in China" (Table 4).

Table 4. Development pattern, Take-off Phase (Chen et al, 2010).

Development Strategy	Sectorial Scope of Industrial Design	Industrial Design at Firm Level	Industrial Design Education and Research	Government Design Policy	Design Discourse
Market economy. Export promotion and investment driven economic growth model. Global strategy Diversified buyer's market in domestic consumption. (Decade of the 2000s)	New product development is practiced in all major ranches of industries.	Specialized ID departments. ID is recognized as part of corporate strategy. Product innovation and independent brands.	Doctoral course. Most teachers have postgraduate degree. Specialization occurs within design like transportation design. Differentiated equipped institutions.	ID is recognized as part of national competitive strategy. ID as an element of innovation is part of industrial culture. Chinese Industrial Design Excellence Award.	International discussion. Form cultural advocacy to institutional improvement and commercial practice.

2.2.2 Design Process

Design process as a generic process where designers modify either the tentative or current design or the requirements and specifications based on information available (Braha and Reich, 2003). It starts from some abstract specifications and ends with the description of a product. Design process follows cycles of mutual adjustment between specifications and solutions (Hatchuel & Weil, 2009). Liu (1996) found that experienced designers do not just synthesize solutions but also invent design issues that capture important aspects of given problems during conceptual design process. Bousbaci (2008) states that design should be broken into steps, such as understanding, collecting, analysing, developing, assessing and solution final testing. French

(1985) proposed a design process model start from needs, and then moves to defining the problem analysing and obtaining feedback (figure 3).

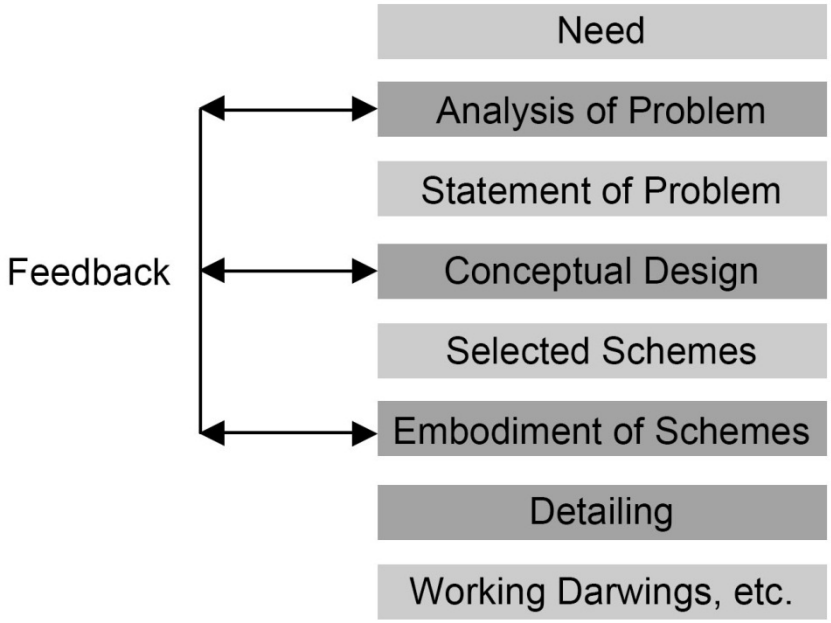

Figure 3. French's (1985) design process model

By providing conceptual design, and selection process, then moving to embodiment design of selected schemes, detailing it and ending with working drawings. Jones (1992) simplified the design process to a three phase model, analyse, synthesize and evaluation. Dominick et al. (2000) use all design terms to define their design process model, starting from planning, to conceptual design, and embodiment design, end with detailed design. A model proposed by Ulrich and Eppinger (2003), includes six phases, planning, concept development, system level design, detail design, testing & refinement and finally production ramp-up (Figure 4).

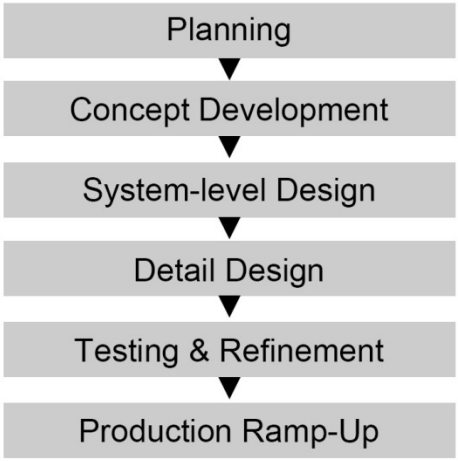

Figure 4. Ulrich & Eppinger's (2003) design process model

The production process was embedded in their model, while other researchers mentioned ending with detailed design, working drawings or evaluation (Dominick et al., 2000; French, 1985; Boekholt, 1985). Another model that mentions ending with production was produced by Pugh (1991), and named the total design activity model (Figure 5). It starts from the market, and moves to specification, concept design, detailed design, and manufacture, and end with sale. However, he mentioned that concept design and detail design are main design activities. There are similarities in different type of design process models; these can be synthesized as ideation, concept design, detailed design and evaluation.

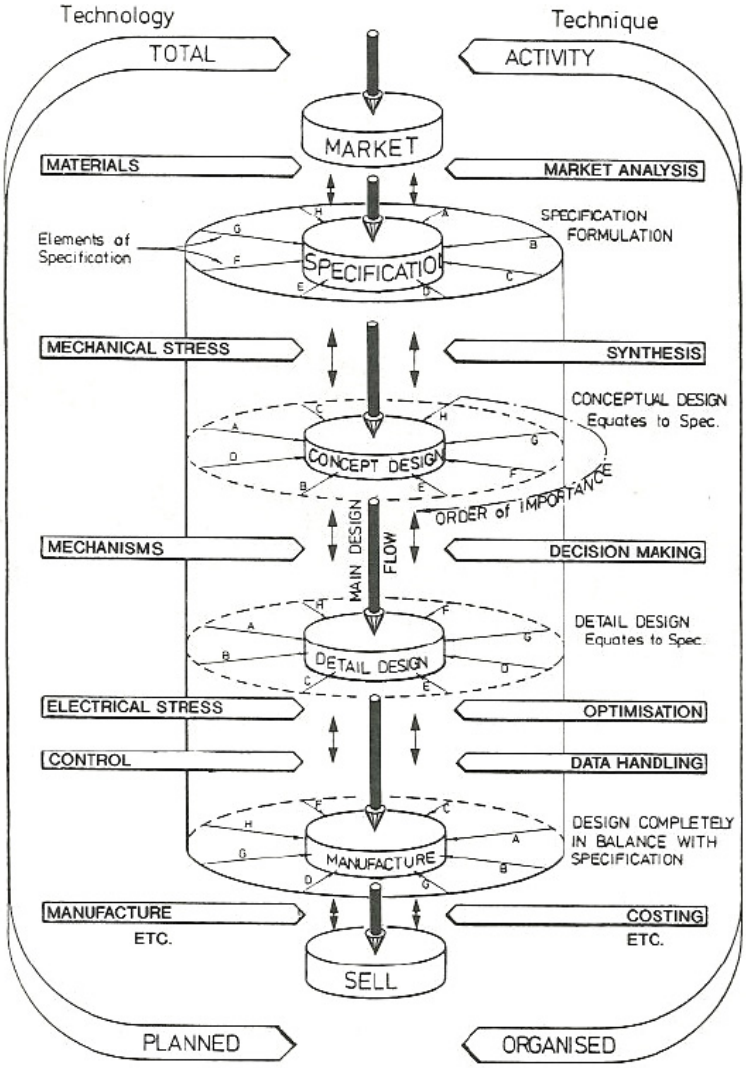

Figure 5. Model of the Total Design activity (Pugh, 1991)

Chinese universities suggest a design process model with eight steps (Cheng, 2006): Preparation, market research, targeting, conceptual design, rendering, design drawings, prototyping, and evaluation. Preparation, market research, targeting are all related to have an idea, can therefore be sorted into ideation; rendering is about to communicate an idea, and same to the purpose of conceptual design; design drawing is one task of detailed design; prototyping

runs like a test before production, and is vital for the quality of produced product, therefore, the process can be simplified into five phases: ideation, conceptual design, detailed design, prototyping and evaluation.

2.3 New Product Development

New product development (NPD) is considered to be important for a firm's growth and survival (Drucker, 1985). It aims to produce product that is sold by an enterprise to its customer (Ulrich and Eppinger, 2003), which provides a set of benefits offered for exchange and can be tangible (that is, something physical you can touch) or a device that provides a service which enhances human experience (Cagan and Vogel, 2002). New Product Development is the entire process of bringing a new product to market, companies typically see new product development as the first stage in generating and commercializing new products within the overall strategic process of product life cycle management used to maintain or grow their market share. The task of New Product Development is to create, define and select superior products by integrating and coordinating tasks, improving the company's competitive advantage (Paashuis, 1997). It is a set of activities beginning with the perception of an opportunity and ending with the production, sale and delivery of a product (Ulrich and Eppinger, 2003).

Disciplinary background plays an important role as to how the New Product

Development is understood. For example, staff in marketing, management and R&D domains refers to “innovation” (Rothwell, 1974); those from the sphere of engineering use the term “design” and those from a “design” background may prefer to see New Product Development as a specific stage in the process of developing new products. The above reflects the interdisciplinary nature of New Product Development (Hart, 1995). To avoid confusion, the term “New Product Development” in this research context is used to describe the economic interest-motivated activity that companies spend effort and resources in order to achieve a mass produced “New Product” which has tangible parts (tangible object, package), and/or intangible parts (experience/service) that accompany it.

2.3.1 New Product Development process model

A Product Development Process is the sequence of steps or activities which an enterprise employs to conceive, design and commercialize a product (Ulrich & Eppinger, 2003). Although there is no guarantee for achieving New Product Success with a structured process, however, it would be helpful to increase the probability of New Product Success (von Stamm, 2003).

2.3.1.1 Linear New Product Development Process

Companies mostly have similar processes because of the nature of New

Product Development (Kahn, 2001), Murthy et al. (2008) indicates there may be differences in steps owing to the differences of the product attribute, innovativeness, production process etc. One significant New Product Development Process was initiated by NASA in the 1960s. The first version of it called “Phased Project Planning” sought to make the management of large scale, complex projects easier (von Stamm, 2003). Morris (1994) disclosed the four main phases: Preliminary analysis, Definition, Design and Operation and stated that the fundamental principle of the model is phase and check, which is still valid nowadays and evolved to a more common New Product Development process model which is known as the Stage-gate Process. For improving the quality, speed and profitability of New Product projects, based on the NASA process, Copper and Kleinschmidt (2001) suggest that “reviews” at certain points are important for New Product Success, and developed the Stage-gate Process (Figure 6):

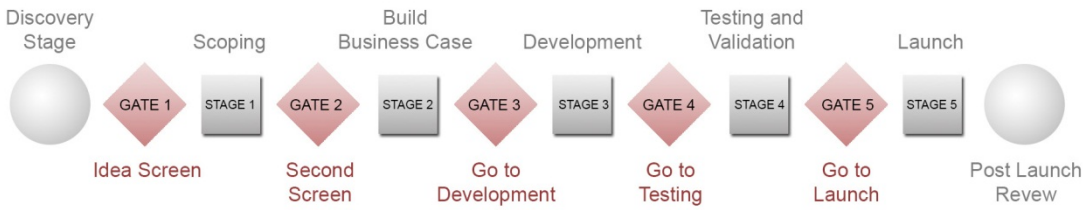

Figure 6. Stage-Gate NPD process Model (Stage-Gate.com, 2013)

Stage-Gate takes the often complex and chaotic process of taking an idea from inception to launch, and breaks it down into smaller stages (where project

activities are conducted) and gates (where business evaluations and Go/Kill decisions are made). In its entirety, Stage-Gate incorporates pre-development activities (business justification and preliminary feasibilities), development activities (technical, marketing, and operations development) and commercialization activities (market launch and post launch learning) into one complete process (Stage-gate.com, 2013).

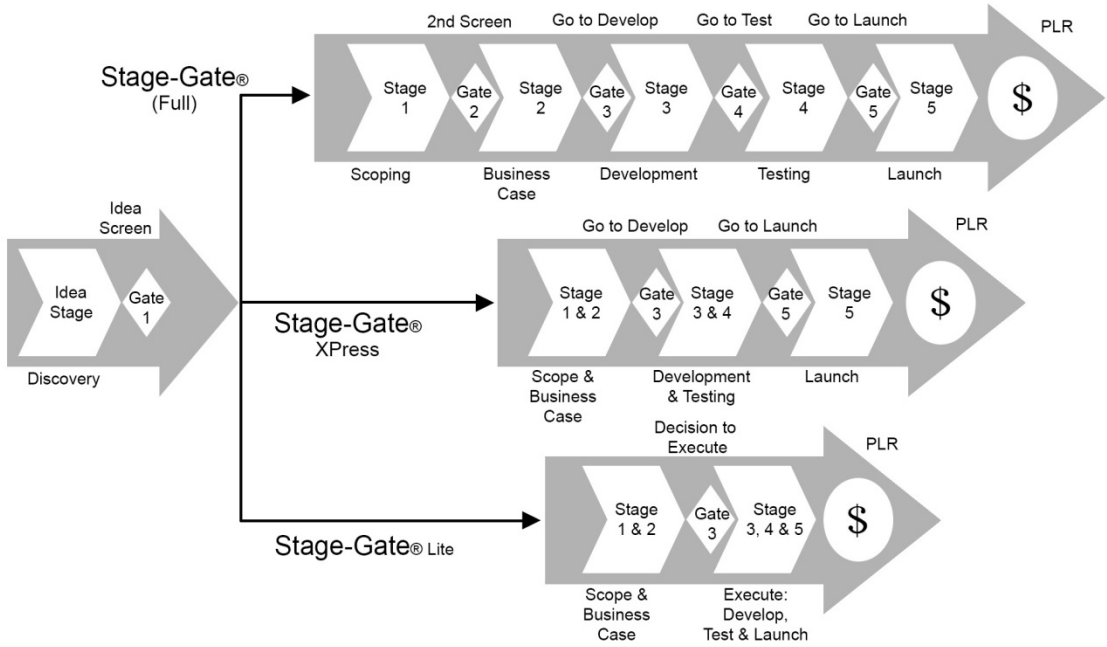

Figure 7. Stage-Gate is scalable (Cooper, 2009)

Cooper (2009) noticed that not all the project needs to go through all five stage and gate processes. For a better fit to business needs and to accelerate project process, different types of stage-gate model were proposed (Figure 7): Stage-Gate Xpress for projects of moderate risk, such as improvements, modifications and extensions; and Stage-Gate Lite for very small projects such

as consumer requests.

2.3.1.2 Non-linear New Product Development Process

These linear development processes were called Waterfall, stage gate, phase gate, toll gate, checkpoint, lifecycle, or structured Product Development by various authors and practitioners (Unger & Eppinger, 2009). Staged processes were popular for decades because of their controlled design structures. These processes methodically follow a series of steps and, are characterised by few iterations and rigid reviews, and tend to freeze design specifications early. Staged processes perform especially well when product cycles have stable product definitions, have high quality standards, and use well-understood technologies, as is often the case for product updates (Cooper 2001, Otto and Wood 2001, Unger and Eppinger 2009). In addition, a non-linear Product Development Process has been adopted in many software companies, which is the spiral Product Development Process.

2.3.1.2.1 *Spiral Process*

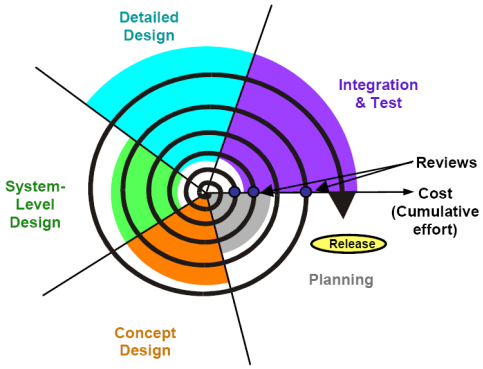

Figure 8. The spiral Product Development Process (Unger & Eppinger, 2009)

The spiral process (Figure 8) allows a brief glimpse into the future to anticipate risks and potential causes (Unger & Eppinger, 2009). This attribute provides the company with the ability to evaluate risk earlier in a project, including poorly understood requirements and architecture, performance problems, market changes, and potential problems in developing specific technologies. These risks can all threaten a project, but the spiral process helps to screen them early, before major costs are incurred (Boehm, 1988). In the meantime, there are several disadvantages such as sophisticated and complex issues that require more management attention; the lack of rigid specifications can potentially lead to delays in developing complex subsystems; and the spiral process may be overkill for simple projects that could use a simpler waterfall process (Boehm and Bose, 1994)

2.3.1.2.2 *Concurrent engineering*

Another non-linear NPD process for speeding up the product development process is known as “simultaneous” or “concurrent” engineering. It carries out all the different functions in parallel and with maximum communication between the different groups involved (Duffy and Kelly, 1989). However, the precise organizational means for obtaining the benefits of teamwork in product development can vary from firm to firm depending on its size and the complexity of the product involved (Walsh et al, 1992).

2.3.1.2.3 *Overlapping process*

Takeuchi and Nonaka (1986) discovered the rugby approach, which is different to the sequential approaches, and the concurrent process, the overlaying occurs only at the border of adjacent phases or extends across several phases (Figure 9).

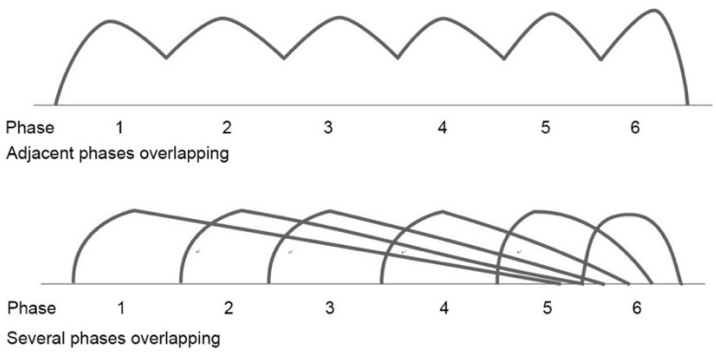

Figure 9. Overlapping Phase of Development (Takeuchi & Nonaka, 1986)

These overlapping processes are found in large corporations, for develop new products quickly and flexibly. It encourages trial and error, and challenges the status quo. Owing to its overlapping nature, there are no clear steps and it is easy to confuse steps between current and the next. It aims to create flexibility, therefore to some extent, can bring chaos to the development process (ibid).

2.3.1.3 Product Development Process Design

Different companies have different circumstances; one or two fixed New Product Development Processes may not fit or be the best fit for the entire situation in companies. Unger & Eppinger (2011) realised the significance of risk, irritation and review, then proposed a Product Development Process design method by case studies (Figure 10).

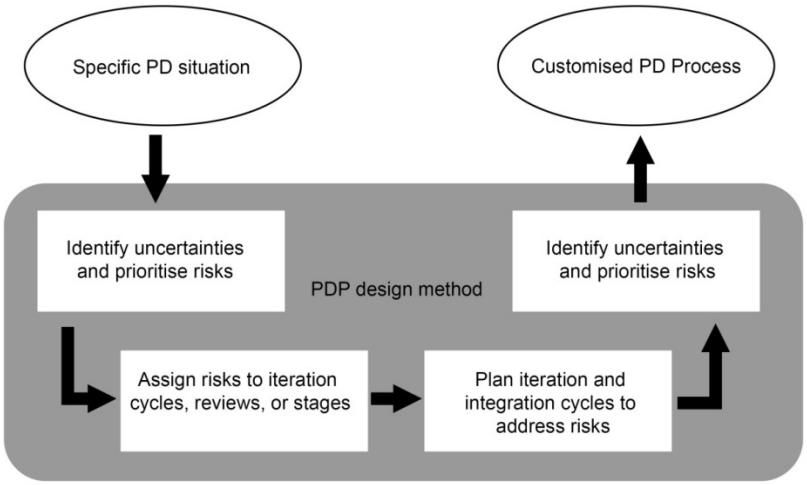

Figure 10. Product development process design method (Unger & Eppinger, 2011)

The Product Development Process (PDP) design method has great flexibility: not every PDP needs to be designed from scratch; so the same steps can be used either to select which of many existing PDPs may best fit a company, or to modify a process already in use (Unger & Eppinger, 2011). This method begins by identifying and prioritising the risks faced in a specific development programme, past experiences is essential for identifying risks and recognising uncertainties. The company should be able to categorise most risks before having a bespoken development method.

2.3.1.4 Summary

The NPD process models are diverse, from linear to spiral, concurrent and overlapping. The differences of these models are derived from different requirements, linear models are aim to confirmed purposes, and the length of the linear model is determined by the complexity of the project. Requirement for flexibility and efficiency, produced the overlapped models; project with largely uncertainties such as software development is suggested to follow the spiral model. All the NPD process models has similar overall steps to indicate tasks from identification of opportunities to production (Ulrich & Eppinger, 1995). The differences may mostly rely on the specific characteristic of product, degree of innovation and specific production process (Murthy et al., 2008). The well-known Stage-Gate process contains a gate in the end of each stage, to

evaluate and validate outcomes of former stages. It shifts the validation efforts to a formal level. In spiral model and overlapping models, redo is suggested to carry as validation to evaluate former work and assuring its validity with flexibility. The Product Development Process design method proposed by Unger & Eppinger (2011) maximized the importance of validation, and suggests customizing a proper process based on the main issues that harm validity, such as uncertainties, iterations and risks. Validation in all kind of NPD processes has been recognized as an important characteristic.

2.3.2 New Product Success Factors

The purpose of developing new products is obviously for gaining success. Therefore, the success factors for developing New Product become critical and worth reviewing.

Montoya-Weiss and Calantone (1994) emphasized that development processes are important for new product success, such as proficiency of marketing activities and protocols, and strategic factors like product advantage and product market strategy. Henard and Szymanski (2001) claimed that the emphasis should be on product characteristics such as product advantage, product meeting customer needs, product technological sophistication; and also a firm strategy for order of entry, dedicated human resources, dedicated

R&D resources; as well as firm process, for example predevelopment task proficiency, marketing task proficiency, technological and launch proficiency; meanwhile, marketplace characteristics, such as market potential should also be taken into account. Parry and Song (1994) investigate New Product Success factors in China, by surveying 129 SOEs (State-owned Enterprises) with 258 successes and failure cases and found that relative product advantage, acquisition of marketing information, level of competitive activity, timing of the product launch, level of proficiency in executing activities in the early stages are correlated with new product success. Evanschitzky et al. (2012) and Parry and Song (1994) both agree product characteristic and marketing are important for New Product Success. The importance of early stage activities and timing of the product launch have been emphasized by Parry and Song (1994). Newberry (2006) surveyed 670 Asian SMEs and found that SMEs are becoming more important and crucial for economic growth by faster reaction and closer customer relationships. Siu (2008) emphasizes the importance of harmony and trust in work relationships can lead to competitive advantage for SMEs.

Developing a superior differentiated product has been recognized as one of the most important factors whether in China or not (Cooper, 1993; Parry and Song, 1994; Evanschitzky et al., 2012). Evanschitzky et al. (2012) suggests to study on users' needs and wants are suggested to be integrated in early NPD

process, because of the “voice of consumers” is strongly connected with the characteristic of new product. Market orientation is also considered to be important, there are four main aspects: customer orientation, competitor orientation, inter-functional coordination, and responsiveness (Kohli and Jaworski, 1990; Narver and Slater, 1990). There are two controllable aspects in NPD, one is customer orientation, and the other is competitor orientation. Lack of market orientation is a crucial factor for new product failure. Cooper (2001) presents a statistical study to summarise the main reasons of new product failure (Table 5):

Table 5. Main causes of new product failure (Cooper, 2001)

All Other Causes	||||||||||||13%
Technical or Production Problems	||||||6%
Poor Timing of Introduction	||||||||8%
Competitive Strength or Reaction	|||||||||9%
Higher Costs than Anticipated	|||||||||10%
Lack of Effective Marketing Effort	||||||||||||14%
Product Problems or Defects	||||||||||||||16%
Inadequate Market Analysis	||||||||||||||||||||||||24%

This empirical study reflects the most important determinant attributes of market orientation. Inadequate market analysis is the most critical factor for new product failure; this fact implies that the competitor orientation should be fixed before main development processes takes place. Customer orientation is closely linked with product characteristic, user tests and user-centred methods seem better to be involved in earlier stage.

Cooper (1993) noticed that a failure defined product before the major development process is a sound reason for new-product failure and can seriously impact and delay time to market, an early and stable product definition is vital for new product success. A project started was not mean it will meet the consumer needs, go and kill decision is crucial for getting new product success. Cooper and Kleinschmidt (1995) suggests that to focus, leveraging core competencies, which means having a strong fit between the needs of new projects and resources, strengths and experiences of all aspects. Previous established knowledge would significantly reduce the development time.

A new product success or failure can be determined by a number of variables, from product level to organizational level. Some researchers mentioned that human resources, proficiency, such as predevelopment task proficiency, marketing task proficiency, technological and launch proficiency are important for new product success (Henard and Szymanski, 2001; Montoya-Weiss and Calantone, 1994); however, these factors are at the organizational level and difficult to control by the NPD process, such as employees' quality, capability, and degree of proficiency. In contrast, product characteristic and market orientation are identified to be critical for new product success and appear to be controllable (Henard and Szymanski, 2001; Evanschitzky, et al., 2012; Parry and Song, 1994). Newberry (2006) proposed a different attitude that a

close relationship with the consumer is crucial for SMEs to win large companies, this can be seen as quick response times, such as dealing with complaint and enquires faster. Siu (2008) considered relationships inside the company as important; this implies that internal communication is better to be initiated as much as possible, hence multi-disciplinary communication should be considered as a method in the NPD process. Consequently, product characteristic, market orientation and speed, owing to their determinative importance for new product success, should be regarded as critical new product success factors.

2.3.3 NPD in Chinese SMEs

Siu et al. (2006) identified that a number of owner-managers even decline to develop new products, owing firstly to, production capacity being fully absorbed by the OEM buyers; secondly, some of SMEs perceived they are producing generic products which have no foreseeable in the targeted market. Four steps were found from companies with NPD experiences: idea generation, prototype development, market analysis and testing, and commercialization. However, owing to the different types of product, buyer, and technique for NPD, Chinese SMEs do not follow the processes step by step and may jump from one to another.

There are two general techniques for Chinese SMEs to do NPD: 'attribute listing' and 'copy-cat' (Siu et al., 2006). Attribute listing is to list the major attributes of an existing product in order to modify each product attribute respectively. This includes modification of the product material, format, and mould design so as to enhance product quality and add new features. The 'new products' are products with modified product attributes only, rather than 'state-of-the-art' new products. Chinese SMEs then learn about the reaction of consumers and dealers towards the prototype and make further modifications before bringing it to market (Siu et al., 2006). The actions of these two process models can be summarised as bellow (Figure 11):

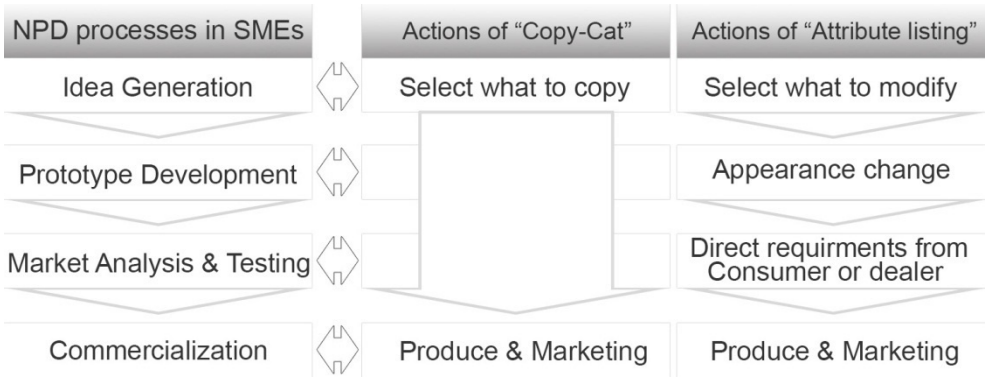

Figure 11. Actions of two NPD techniques in Chinese SMEs (Retrieved from Siu et al., 2006)

To market new products, Siu et al (2006) identified that Chinese SMEs mostly adopt conventional tactics, for example, advertising and posters in shopping malls, offering souvenirs to customers and samples to dealers, and providing

discounts to distributors. NPD practices in most Chinese SMEs are fragmented and characteristically government and customer driven, owner-manager dependent (ibid). NPD strategy in most Chinese SMEs can be seen as blurry and intuitive, simply duplicating product from others is one of the methods to gain profit. The “attribute listing” approach can only be seen as a way of doing variety innovation (Dumas, 2000; Booz, Allen and Hamilton, 1982). Most SMEs lack research to discover needs or latent needs from consumers. Heskett and Liu (2012) identified a few small firms that are using external design consultancies to promote their product competitiveness; however, it was just used design as functional specialism (According to Perks et al., 2005: design has three different roles in the NPD process: design as functional specialism, design as part of multifunctional team and design as NPD process leader).

2.4 Design-oriented NPD strategy

Conventionally, NPD activities are driven by technology, or led by market (Curtis, 2000). In recent decades, scholars found that the role of design in NPD process is increasingly important and in a more prominent position in the management of the product development effort (Turner, 2000; von Stamm, 2003; Perks et al., 2005).

2.4.1 Different types of Design-oriented Strategy

Design-oriented means that the firm's core values are infused by design ideas and design is institutionalized into the firm's strategic orientation. In addition, the firm has a top level manager responsible for design (Kristensen, 1998). A design-oriented NPD is literally means designer has major impacts on and have priority to lead NPD activities. However, different types of design-oriented strategy are identified, they all highlighted the importance of design in their models, but with different approaches. According to the different approaches of these strategies are named: Skills focused (widen designers' skills and actions), design pushed (hire expert designer and give strong resource support), design for business (multi-disciplinary teams competing for ideas to develop), and mass integrated (to integrate design, innovation and resources in a management perspective).

2.4.1.1 The Skills focused NPD strategy

Perks et al. (2005) categorized design in three different roles in the NPD process: design as functional specialism, design as part of multifunctional team and design as NPD process leader. They found "design as NPD process leader" is different in actions and skills. In terms of actions, designers are appointed to drive and support actions throughout the entire development

process and across a broad scope of functional activities such as make direct integration with marketplace/marketers, support manufacturing activities, take part in product launch and engage in after-sale service (Perks et al., 2005). Roper et al. (2012) use “designer-led” to represent this high level use of designers in NPD. There are also varies skills that run out of essential design context associated with this strategy, for example, business analysis, interpret critical information, management related negotiate, motivate and persuade skills, and relationships management (Figure 12).

NPD Phases	Actions	Skills
Identification of the Need	Team Assembly Market Observation and Research MarketSegmentation Business Case Development	Business and Market Analysis Interpretation Research
Concept Generation	Market and Technical Research Informing the Team Trade Show Visits	Business Analysis Motivating Others Relationship Management Communication Project Management
Design and Development	Observation of Response to Design Customer Response Measurement Consider Business Costs Visit to Manufacturers and Suppliers Leading the Team and Stakeholders	Data and Business Analysis Interpretation Leadership
Production	Monitoring Production Quality Dealing with Manufacturing Problems	Persuasion Motivating Others Project Management
Launch	Plan and Review Launch e.g., Manage Public Relations and Marketing	Business Analysis Planning Motivating Others Persuasion

Figure 12. Actions and Skills of Designer-led NPD (Perks et al., 2005)

Perks et al. (2005) concerns that the willingness of the designer to undertake such new roles: it is unlikely that all existing designers are able or willing to

make this transition, and according to the actions and skills are carry, they named this model “designer-led”. Furthermore, in their study, the designer-led NPD strategy relies on a generic NPD process model which was derived from a former Stage-Gate process model (Cooper, 1994). The five steps of NPD process are: identification of the need, concept generation, design and development, manufacture and launch. It is obvious that the findings emphasize much on designers’ action and skills and neglect to redesign the NPD process model. Comprehensive skills are needed for this type of designer-led NPD and exceeded most designers’ skill base, which means extra expenditure and time are needed for making this transition.

2.4.1.2 The Design pushed NPD strategy

Jang et al. (2009) disclosed the development process of one of the most successful mobile phone from LG, named “Chocolate”. There are four main phases within the entire development process: creating product concept, design, developing functions and marketing. There are several factors associated for their design-oriented NPD (Figure 13). From the perspective of design, they nominated distinguished design expert and integrated consumer insight and communication skills. In the perspective of development, they have qualified team that can fulfil all the technological requirements of design, ability to optimize current function aspects, and full support from top management.

Furthermore, they were outsourcing marketing professionals and actively use ideas out of company. Besides, they held a clear and effective communication between different departments and functions in the NPD process, and finally the meaning of NPD was shifted, from product level to organizational level, to impact their innovation culture.

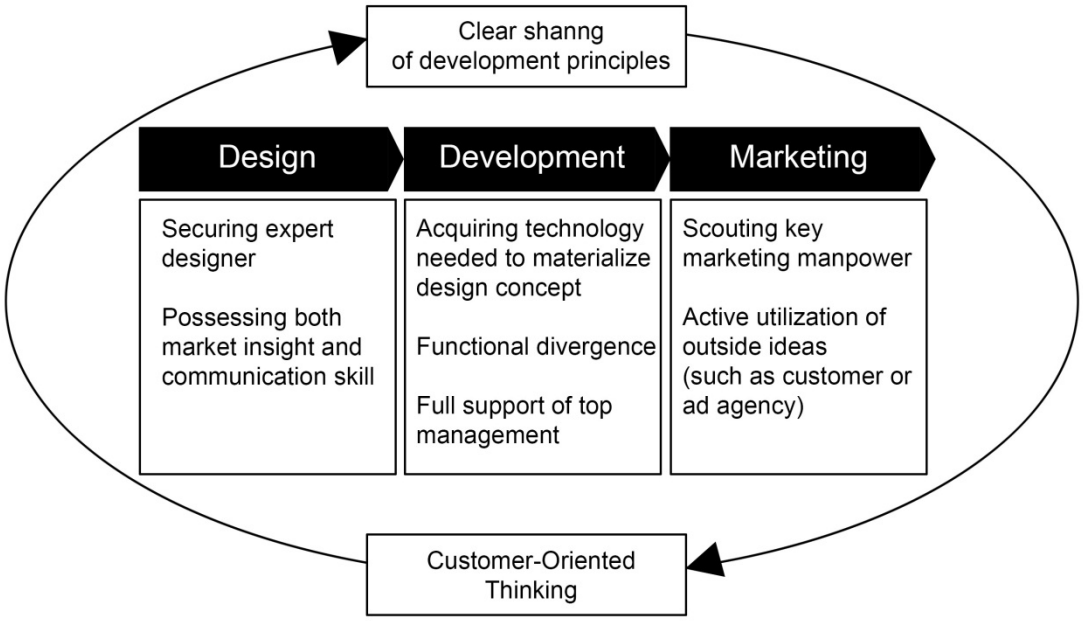

Figure 13. Key success factors in design-oriented NPD (Jang et al., 2009)

The affluence of resources and top managerial supports represent an ideal environment for practicing design-oriented NPD strategy, use design ideas to push technology improvements and marketing strategies. This is an ideal approach for large companies with abundant resources. It mostly utilises design principle or requires to push other functions, such as technology and manufacturing teams, and outsourcing high profile marketing consultancies for

outstanding strategies. Different from the designer-led, “skill focused” approach by Perk et al. (2005), this strategy less emphasises the requirements of designers’ actions and skill beyond “design”, but highlighted the importance of the “design concept” from the expert designer, and utilise the “design concept” as baseline to push other functions.

2.4.1.3 The Design for Business NPD Strategy

The design council (2008) of UK conducted a research to uncover design success lessons with investigating 11 world leading companies (Alessi, BT, BSkyB, LEGO, Microsoft, Starbucks, Whirlpool, Yahoo!, Virgin Atlantic, Xerox, and Sony.). The essential elements were found and summarized as management support, design leadership and business-savvy designers.

Rather than present a step by step process, they present key elements and bring the innovation process of LEGO as example. First, align “between corporate objectives and design strategy”. They see design strategy as important as corporate objectives; this step defines the leading role of design in corporation. Second, “strengthen the collaboration”. Assign a highly collaboration team with design, marketing and product manager. Third, “challenge sessions”. It suggests team members to be critical. Fourth, “develop sequence of activities for product development with frequent

evaluations and decision gates". This step seems like a transfer phase, the emphasize moves from business level to product level. Fifth, "develop standard processes of presenting design outputs for comparison". The internal competition started.

This design for business strategy empathize more on organization level and business level, preparation work such as goal definition, team building and critiques are potentially cost time and less effective in bringing products to market.

2.4.1.4 Mass integrated NPD strategy

Many designer-led or design-oriented strategies and processes are disclosed by investigating large corporation with affluence financial support and management support. There is one that proposed by Acklin (2010) and stated that design-oriented strategy can be applied in SMEs. She analysed the contribution of design research, design, design management and design leadership, with emphasised on integration, multidisciplinary and permeation, proposed an intertwined design-oriented strategy model with six phases: impulse, research, development, strategy, implementation and evolution (Figure 14).

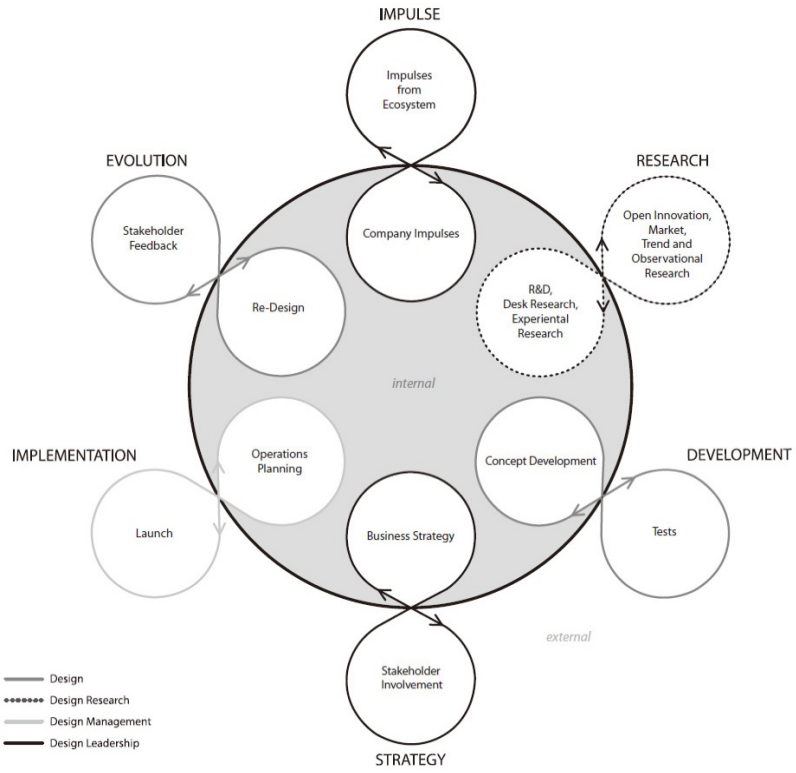

Figure 14. Design driven innovation process model (Acklin, 2010)

Acklin (2010) mentioned that this model is an integration model of strategy building, innovation and design management, and can be conducted concurrently. However, too many contents and terms in this model made it relatively abstract, and it blurs the boundaries of design and business notions, may takes time for Chinese SMEs to understand and effectively adapt.

2.4.2 Design-oriented NPD strategy in China

In about 30 years' times, industrial design developed from an unknown domain to corporate strategy in some firms, such as Lenovo, Haier etc. Heskett and Liu (2012) pointed that design was not considered as a powerful competitive

weapon till China became a member of WTO in 2002, since then there are numbers of large enterprise in China performed excellently in competing through design. These large companies who have excellent performance in markets, design has been emphasised by their top management, the internal design was connected closely with their corporate strategy and well developed. Meanwhile many design consultancies with experience of strategic planning were considered by them as strategic partner (Heskett and Liu, 2012).

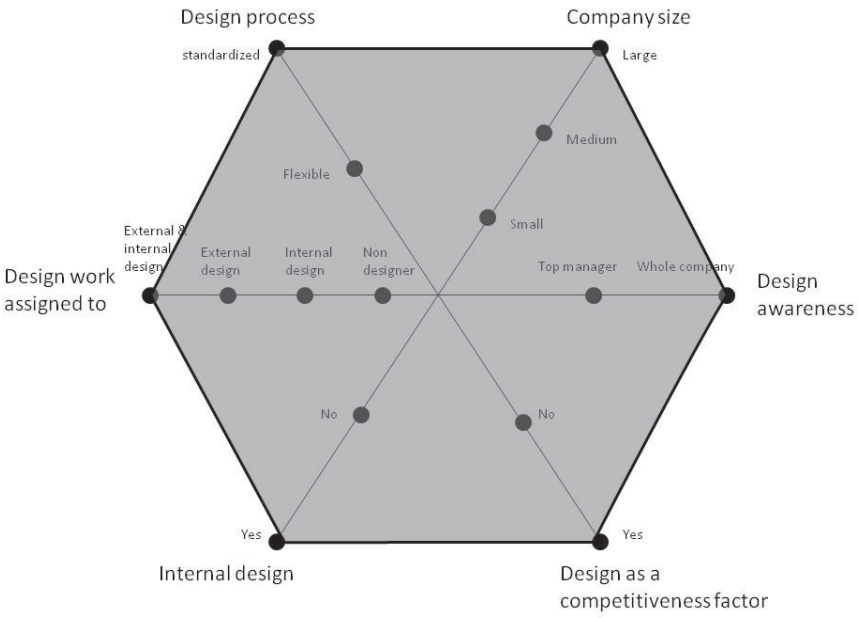

Figure 15. Design-oriented Company Model in China (Heskett and Liu, 2012)

These firms mostly have representatives in top management that are responsible for design, and the companies' core values are closely connected with design ideas, and also design is embedded into the companies' strategic orientation (Figure 15), and this type of firms is design-oriented (Kristensen,

1998). However, according to Heskket and Liu (2012), all the known design-oriented firms are large ones, such as Heng Feng in outdoor goods, Vatti in kitchen appliance, TCL in multi-media appliance. They utilizing and obtaining benefits from design based on their affluence of financial supports, in contrast, small privately-owned enterprises, although they are more flexible and efficient in delivering new products into production, cannot benefit from design as those large companies do, owing to lack of financial supports (Tan, 2001). The funds available for New Product Development in most SMEs are insufficient and precious. This situation is limiting these SMEs to expend their design ability by consulting quality design consultancies. Design is comparatively new and has short history, but with an honourable task that in helping economy transforming from “made in China” to “designed in China”. Design in many large firms was considered important and shifted to company strategic position, rather than SMEs with limited resource and financial support, cannot absorb the full benefits of design.

2.5 Summary

Chinese SMEs are born in an autocratic culture with hierarchy architecture, but design-oriented strategy was initiated by companies in a democratic environment or at least with rich resources. Financial constraints and the easiness of “copy-cat” or “attribute listing” are the main obstructions for

Chinese SMEs to reach the next step development.

NPD process models are sequence of steps but have various forms, and according to the differences of projects, industries and complexity, NPD models may different in purpose of perform an effective management. The leadership role of design in NPD was mostly represented in the NPD process, such as widen a skilled designer's action range (Perks et al., 2005) or using expert designer to carry concept design (Jang et al., 2009). Design-oriented strategy is considered beneficial to company growth (Turner, 2000; von Stamm, 2003; Perks et al., 2005, Jang et al., 2009; Design Council, 2008; Acklin, 2010; Roper et al., 2012). A number of large Chinese companies have already started and benefited from adopting design-oriented NPD by cooperating with top class design consultancies (e.g. Heng Feng, Vatti, TCL). While one strategy is acknowledged positive in one context, not means it still adaptable in the other.

This also explains why Chinese SMEs do not follow those design-oriented NPDs, due to the extra costs. Cost on training skilled designers, cost of hiring expert designers, cost of time and funds to have internal competition or adapting new management knowledge. Design process models contain a large number of similarities to the linear NPD process models. In terms of the easiness of understanding and adapting, the common implemented design

process model can be the foundation for a NPD process model with five phases: ideation, conceptual design, detailed design, prototyping and evaluation. However, how design-oriented NPD performs and in what form, in Chinese SMEs - companies that lack of finical support and competing in a market with counterfeiting behaviour – remains unknown.

Chapter 3. Methodology

This chapter starts with detailed statement of the research questions, and selects qualitative approaches to reach the research objective. The type of this research explains what methods are chosen for answering each of the research questions. Aside from basic information gathering methods such as observation, interview, documenting, recording and photo shooting, case study, questionnaire and experiment approach are selected for obtaining preliminary information and progressing the implementation. This research overall act as part of an action research with the purpose of optimise the NPD process, and the research design and overall research methodology are given in the end.

3.1 Research question

A well-defined focus is foundational before data collection (Eisenhardt, 1989). According to the literature review, the current state of the art for design-oriented NPD strategies and models, are not appear in Chinese SMEs. Therefore, the objective of this research is set to investigate design-oriented NPD strategy in Chinese SMEs. Subsequently, the initial question is “Can a bespoke design-oriented NPD strategy be created tailored for Chinese SMEs?” it requires to be answered from two perspectives, feasibility and instrument. Feasibility is the fundamental structure of this research, "Whether Chinese

SMEs welcome changes that contains positive meanings?" It determines whether this research can be continued, the scoping study in chapter 4 positively confirms the possibility therefore this able to be moved on. On other hand, design-oriented NPD strategy is a concept and needs an instrument to deliver, according to the literature review, the study of existing design-oriented NPD displays that the “design-oriented” is mostly represented in a NPD process, to customised a NPD process model is a proper way to tangibly represent a design-oriented NPD for Chinese SMEs. The detailed feasibility and instrument related details are displayed in Chapter 4.

Furthermore, usability and performance of the introduced design-oriented NPD needs to be measured. In quantitative perspective, to produce a questionnaire and deliver to as many as Chinese SMEs, and collecting feedbacks of their interests and comments could be an effective way to understand the whether design-oriented NPD is applicable for Chinese SMEs. However, according to the preliminary understanding of Chinese SMEs’ NPD behaviour, they are cautious on decisions without previous proof, therefore to conduct a qualitative practical application is more applicable to obtain the first proof. Intuitively, the sales data and return on investment (ROI) in comparison of previous products is appropriate and commonly used as evidence; this requires strategy of company selection and get permission to data collection. On one hand, the uncontrollable variables are various, such as the change of external

environment (competitor, policy etc.), would impact on the collected numbers, rather than only by the introduction of the design-oriented NPD. On the other hand, to get permission to implement the design-oriented NPD in business practise is convincing but difficult. Thus, the second research question is “How can a design-oriented NPD strategy to be introduced into Chinese SMEs?” Chapter 5 displays the executive process of applying selected approaches and detailed implementation process for overcoming above issues.

Moreover, NPD is not a one-off work, it takes place in companies continuously for further growth and survival, consequently, the third research question is “What are the impacts of a design-oriented NPD strategy adoption in Chinese SMEs?” The changes of the company’s NPD behaviour are represented by detailed case study of their another following-up NPD project is covered in Chapter 6. The overall objective of this research and three main research questions are summarised in table 6.

Table 6. Research Objective and Questions

<table>
<tr><td>Objective</td><td colspan="2">Investigate design-oriented NPD strategy in Chinese SMEs</td></tr>
<tr><td rowspan="2">Question 1</td><td colspan="2">Can a bespoke design-oriented NPD strategy be created tailored for Chinese SMEs?</td></tr>
<tr><td>Feasibility</td><td>Instrument</td></tr>
<tr><td rowspan="2">Question 2</td><td colspan="2">How can a design-oriented NPD strategy be introduced into Chinese SMEs?</td></tr>
<tr><td>Get permission</td><td>Implementation</td></tr>
<tr><td>Question 3</td><td colspan="2">What are the impacts of a design-oriented NPD strategy adoption in Chinese SMEs?</td></tr>
</table>

3.2 Research type

It is necessary to identify the type of this research. The types of research are various according to researchers' different backgrounds and different aims. Pride & Ferrell (2012) thought researches can be categorised into exploratory research and conclusive research, they separate research projects into eight components and use to distinguish the type of research, and explores the differences of them. (Table 7).

Table 7. Differences between exploratory and conclusive research (Pride & Ferrell, 2012).

Research project components	Exploratory research	Conclusive research
Research purpose	General: to generate insights about a situation	Specific: to verify insights and aid in selecting a course of action
Data needs	Vague	Clear
Data sources	Ill defined	Well defined
Data collection form	Open-ended, rough	Usually structured
Sample	Relatively small; subjectively selected to maximise generalisation of insights	Relatively large; objectively selected to permit generalisation of findings
Data collection	Flexible; no set procedure	Rigid; well-laid-out procedure
Data analysis	Informal; typically non-quantitative	Formal; typically quantitative
Inferences/recommendations	More tentative than final	More final than tentative

Allan and Randy (2005) considered research can be divided into two groups: descriptive and analytical. Descriptive research usually involves surveys and studies that aim to identify the facts, and mainly deals with the description of the state of affairs that is at present; analytical research is to make critical

evaluation by using and analysing facts or information which already available. Biggam (2008) divides research into applied research and fundamental research. Applied research is also referred to as an action research, and the fundamental research is sometimes called basic or pure research. Kumar (2005) summarises the main differences of applied research and fundamental research (Table 8).

Table 8. Difference of applied research and fundamental research (Kumar, 2005)

Applied Research	Fundamental Research
Tries to eliminate the theory by adding to the basics of a discipline	Aims to solve a problem by adding to the field of application of a discipline
Problems are analysed from the point of one discipline	Often several disciplines work together for solving the problem
Generalisations are preferred	Often researches individual cases without the aim to generalise
Forecasting approach is implemented	Aims to say how things can be changed
Assumes that other variables do not change	Acknowledges that other variables are constant by changing
Reports are compiled in a language of technical language of discipline	Reports are compiled in a common language

According to the acknowledgement of the type of research, this research is about to investigate design-oriented NPD strategy in Chinese SMEs, with construction of the instrument, and test the instrument and learn the impact, therefore leans on exploratory, descriptive and applied. Due to the lack of precedent, this research requires to start from a scoping of the feasibility, to construct a customised NPD process model with design-oriented aspects and

able to better fit into their practice, and also requires to form a convictive and acceptable examining approach, and then learn the impacts of introducing of the design-oriented NPD strategy.

Observing, questioning, documenting and gaining subjective information of participates is necessary in the perspective of discovery; and most parts of this research are in a practical context, and investigates practical behaviours and actions. In contrast of positivism research, which is mainly rely on questionnaires, or totally objective and detached from the research objects (Blaxter, Hughes and Tight, 2010), this research requires to be set in real-world environment, make impacts to and learn from business practice; consequently, this is an interpretivism research, to discover what is happening in the given context (Carson et al., 2001). Also the optimise and refine of the NPD process model is unable to meet the end because of NPD projects will takes place continuously, therefore in this perspective, this research is the starting point of an action research.

3.2.1 Action research

Action research involves the co-generation of new information and analysis together with actions aimed at transforming the situation (Greenwood and Levin, 1998). Action is undertaken to understand, evaluate and change

(Costello, 2003). Hart and Bond (1995) set seven criteria to further understand action research: it is educative; deals with individuals as members of social groups; is problem-focused, context specified and future-oriented; involves a change intervention; aims at improvement and involvement; involves a cyclic process in which research, action and evaluation are interlinked; is founded on a research relationship in which those involved are participants in the change process. Action research is an applied approach and can be seen as experimental. Atwel et al. (1998) presented a spiral of participatory action research in Figure 16.

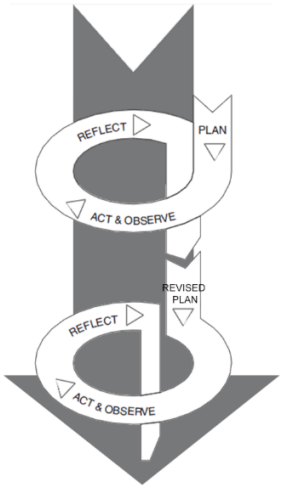

Figure 16. The participatory action research spiral (Atweh et al., 1998)

Action research challenges traditional social science by having a loop of making changes, it satisfies the research objective which brings new knowledge to an organised group, the Chinese SMEs, and make changes of their traditional behaviour on developing new products; secondly, changes that

made in selected SMEs are inevitably to go through plan, action, observe and reflect loops, one change trigger the other. There is no end for companies that willing to be more innovative, as well as the research. This research is set to understand the changes at the starting point, to firstly combine theoretical design-oriented NPD approaches to Chinese SMEs' business practice, and according to the action and reflection, to activate another action to understand the impacts.

Owing to the action research nature of this research (NPD strategy as objective to optimise), it combines the deductive and inductive approach. Deductive approach is concerned with developing a hypothesis based on existing theory, and then designing a research strategy to test the hypothesis (first implementation); Inductive is about moving from specific observations to broader generalizations and theories (derive the process model of their second implementation). Figure 17 displays the overall research activities in the form of action research.

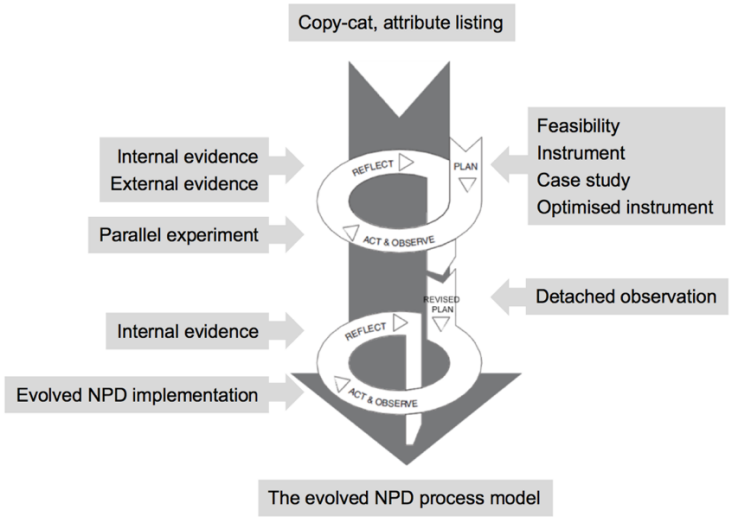

Figure 17. Overall research activities represented as action research

3.2.2 Case study, Experiment, Questionnaire

Case study is analysis of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more methods (Thomas, 2011). Case study of business practice is an appropriate way for enrich the knowledge that constructed by literatures, to find underlying principles (Shepard and Greene, 2003) in business practice. It is also functional on validating obtained verbal statement from interviews. In this research context, case study is suitable to be used to enrich the knowledge base of NPD behaviour and process of business practice in scoping companies. On the other hand, it validates the reliability of data from interview and represents that oral information in the visible way. In chapter 5, case study is used to understand and confirm their existing NPD process.

Experiment approach is used to test theories or hypotheses in order to support or disprove (Wilczek and Devine, 2006). Therefore, the theoretical instrument (a customised design-oriented NPD process model) could be tested, and both the internal feedbacks and external sales data could be collected as evidence to compare with former developed products. According to Kumar (2005), an applied research requires decrease the impacts of interfere variables, the daily change external market environment could be the most uncontrollable variable, and an experiment requires minimising variation between the experimental group and control group (Bowling, 2002). Therefore, the experiment needs to be set in a comparison perspective, two NPD projects by two teams on parallel, and members of the teams requires maximised similarities from background to experiences. In chapter 5, a parallel experiment is given, two NPD projects are set, one follows their own behaviour, and the other are guided by the design-oriented NPD process model.

Questionnaire is a common tool for obtaining quantitative data with the merits of cheap, less effort required from respondents, and pre-set scaled answers are easy for analysing. In this research, with the reason for no taking the participant too much time for interview, and have a standard scoring system to measure and obtaining internal evidence to compare the two parallel NPD processes and outcomes, questionnaire is selected to be the form of the metrics tool, and it is discussed in details in section 5.3, chapter 5.

3.3 Data analysis, reliability and validity

This research is conducted as an interpritivism research and qualitative, consequently, those quantitative analysis approaches such as dispersion, percentiles, correlation coefficient, quartiles, trend lines etc. are inappropriate at this time. Schuut (2001) thought qualitative analysis is about to finding common trends and contradictions by data reduction and data displays. Owing to this nature, data in this research is re-organised and mostly descriptive.

Reliability is related to whether same answer can be gained by using same instrument more than once (Bernard, 2013). Validity is about how the research findings match reality, or to what extent that the research findings can be replicated to other environments (Pelissier, 2008). These terms are popular in quantitative investigations. In this research, owing to the exploratory attribute, and is an investigation of business reality, reliability and validity are represented in the process of getting data, and present those obtained data to relevant participants to conduct double-checks and make final confirmations.

3.4 Research Design

Literature review is firstly conducted before all actions in this research, for having an explicit research objective and proposing appropriate methodology. The research objective and three main questions were then proposed by

understanding knowledge obtained from literatures. The research follows the routine of answering the three sequence questions. The aim of this research then is set as implement design-oriented NPD strategy in Chinese SMEs. To approach this aim, the research then is set into three phases: pre-implementation, implementation process and post-implementation. These three phases are represented by the three research questions.

The first research question is “Can a bespoke design-oriented NPD model be created tailored for Chinese SMEs?” This question is separated to two aspects, feasibility and instrument. For understanding the feasibility of this research, in the later process of literature review, a scoping study was conducted, to have a validity of knowledge obtained from literature, and check the feasibility of conducting further investigation. It validated the findings in literatures and also confirmed the feasibility of making further effort of this research. Information of scoping study is provided in Section 4.1, Chapter 4. According to the design-oriented NPD nature, the instrument to introduce design-oriented NPD is a NPD process model which named the “conceptual designer-led NPD process model” (Section 4.3, Chapter 4). It is built by analysing and synthesising knowledge from current research on NPD, NPS, design-oriented NPD, and Chinese SMEs practice.

The second research question moves to “How can a design-oriented NPD

strategy be introduced to Chinese SMEs?" Two approaches were considered, the first one is to present the proposed "conceptual designer-led NPD process model" to as many Chinese SMEs, and collecting their feedbacks towards the model. The other is to bring the conceptual model to NPD practice. The later option seems more robust than only collecting feedbacks, to learn not only "what they say, but what they do." Therefore, to answer the second research question, owing to the risk taken nature of implementing untested theories in business practice, and according their NPD schedule, one of the three contacted companies was accepted and signed agreement for supporting this research. To avoid external impacts on the validity of the result, parallel experiment approach was selected, thus two parallel NPD projects that following different models were set and implemented. The conventional NPD process model in the selected company was learnt, and the "conceptual" model was optimised with practitioners before the experiment started (Chapter 5). Additionally, a metrics tool was generated with practitioners; it aims on obtaining viewpoints of participants from two NPD teams as internal evidence (Chapter 5). And six months' sales data were also collected as external evidence to understand the performance of the outcomes of two NPD projects.

For answering the last question, "What are the impacts of a design-oriented NPD model adoption in Chinese SMEs?" Explicit and detailed data of the later on NPD project implementation process was collected, to understand the

impacts and subsequently, derived the evolved NPD process model for understanding their changes on further NPD (Chapter 6).

There were two “act and observe” taken place, the major tasks of obtaining qualitative data was conducted by using onsite studies, due to this research was closely associated to business practice. Table 9 displays the detailed time and objective of each onsite investigation.

Table 9. Onsite studies and objectives

Onsite studies	Objectives
1st Nov 2013 - Jan, 2014	Understanding the current “conventional” NPD process model
	A final optimised model for practical application
	Concurrently implementation of two NPD models
1st Nov, 2014 – Feb, 2015	Understanding impacts by monitoring their continue NPD activities

3.5 Overall Research Methodology

The overall research methodology is summarised in figure 18. A sequence flow starts from the literature review, and knowledge from literature is analysed and synthesised into the “conceptual designer-led NPD process model”. In the empirical investigation phase, a site is firstly selected to learn their NPD process model, and then co-generated the metrics tool and optimises the proposed conceptual model. Phase 4 is the practical implementation process; an experiment is setup and two NPD teams are built to follow different NPD

process models. Along with continuous monitoring the further NPD activities, plus the subjective data and objective collected from phase 4, performance of design-oriented NPD in Chinese SMEs is then evaluated and draw the conclusion.

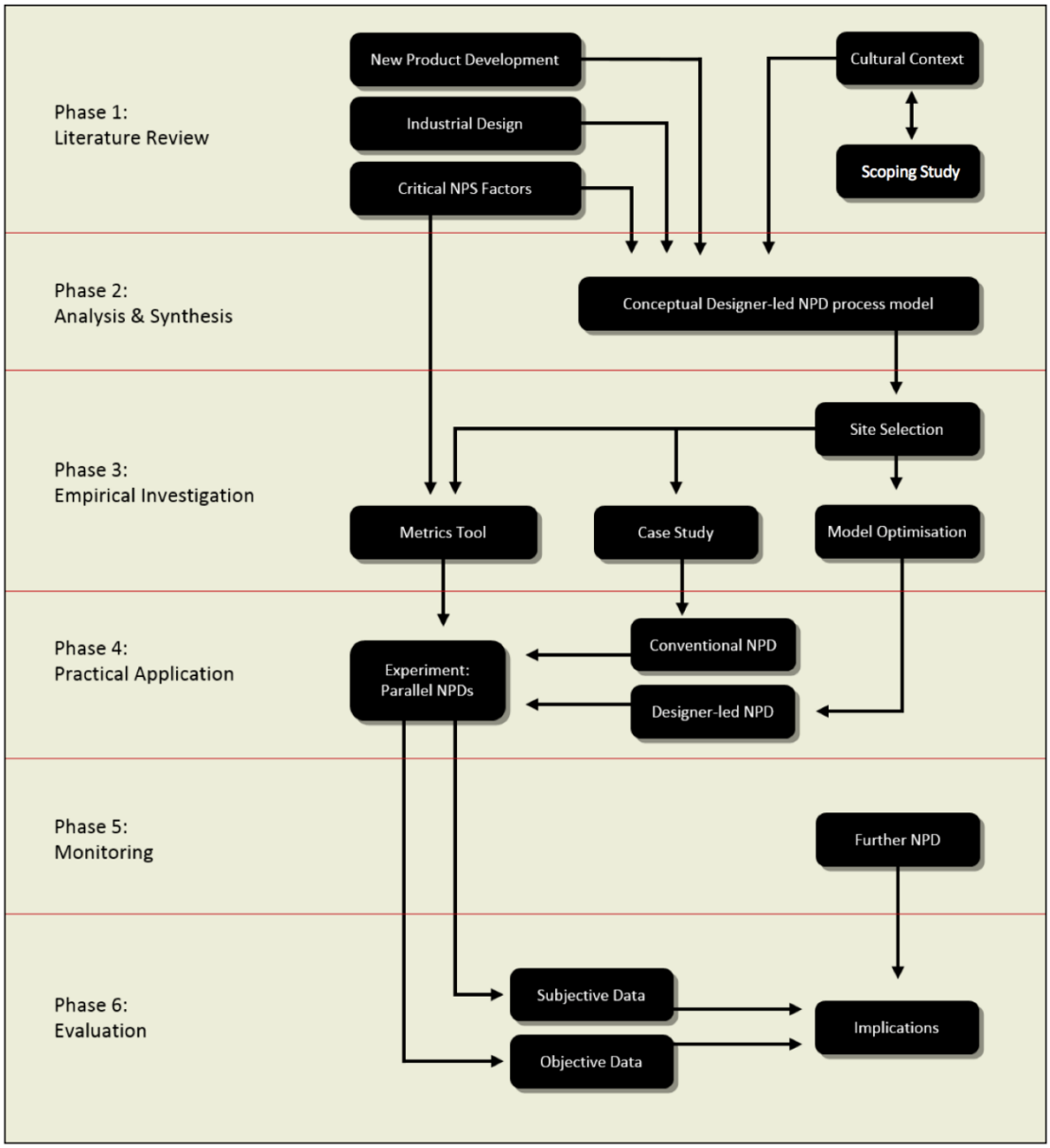

Figure 18. Overall Research Methodology

Chapter 4. Feasibility and instrument

This chapter mainly focus on answering the first research question and deals with pre-implementation issues: Can a bespoke design-oriented NPD model be created tailored for Chinese SMEs? It needs to firstly understand whether Chinese SMEs welcome change making, scoping study was used to examine the openness to further investigation. The process of developing the instrument is also provided. Analysis and Synthesis knowledge from literatures is the main approach to form the conceptual designer-led NPD process model.

4.1 Scoping Study

The main purpose of scoping study was to understand whether there is space to conduct further actions for this research. While bringing something new to especially to business practice, the risks associated with those new things will be reflected as financial matters. Therefore, a mutual trust between researcher and research objects is essential before the new things are generally identified as positive. Consequently, three companies were selected because, firstly they have former built mutual trust with the researcher; secondly, they are manufacturers with self-owned trademarks; thirdly, NPD is one of their vital business practice. Table 10 displays the general information of the three contacted companies.

Table 10. Contacted company for understanding research feasibility

Company name	Industry
Huoyun Electric Vehicle Co., Ltd (HEV)	E-vehicle and accessories manufacturer
JinZhongYi Furniture Co. Ltd. (JZY)	Furniture manufacturer
USbright Technology Co., Ltd. (UST)	Electronic vehicle accessories manufacturer

According to the initial telephone communications, a further onsite investigation and face to face communication decision was made on Huoyun Electric Vehicle Co., Ltd. It mainly because this company was in a scandal by producing fake “Smart”, the popular compact cars by Daimler AG. This helped to understand the counterfeit issue from the origin side.

4.1.1 Approaches

Prepared notebook with keywords was used to guide the whole process. The conversation was recorded by noting keywords, flexible and open to new topics. Lindlof and Taylor (2002) recognise it as a semi-structured interview. Beside, many informal conversations took place in many other situations, such as in non-working time (meal time). Information gathered through this form was represented by recall and research dairy. Apart from asking questions, the researcher watched, listened and learned (Ekanem, 2007). Camera was also used to record relevant information mainly in relation to manufacture facilities, prototypes and physical working environment. It was also necessary to

observe their behaviour and actions as it occurs in “mundane” everyday life (Shaw, 1999). In terms of the previous case: Chinese “Smart”, which is a purely appearance copy of the Smart Car of Daimler AG. It was conducted by interviewing the top manager. The overall objectives and approach for the scoping study is summarised in table 11.

Table 11. Objectives and approach for scoping study

Objective	approach
Management structure	Interview
NPD approach	Interview + Photo
Preference	Interview
Understand of design	Interview
Attitude towards change	Interview
Case of counterfeiting	Interview

4.1.2 Findings

The management structure keeps a vertical hierarchy, there were three levels of staff in the company (table 12). Chair of the group was staying on the top, and not involving in company daily affairs; top managers of companies were at a senior level and deal with company operation issues; Staff was on the bottom level of this hierarchy structure, and carries out tangible everyday works.

Table 12. Management Structure of Company

Level	Role	Task
Top	Chief of group	Funding Key client Marketing
Senior	Top managers of each company	Everyday operating Patent managing
Bottom	Staff	Assemble and install parts Test and validate products

According to interview and observations, no manufacturing facilities were found. The top manager mentioned that their manufacturing facilities located in another city, many of their manufacturing tasks are using outsource for reducing facilities investment, the key tasks of this company are assembling, testing and validating products. In terms of design, the manager noticed that they have a close relationship with an external design consultancy; meanwhile, they hold many patents and do have had NPD attempts. There are two approaches for doing NPD in the company (Table 13).

Table 13. Two types of NPD

Type 1 NPD (Key Client)	Type 2 NPD (Internal Ideation)
Requirements from key clients	Ideation
Available technologies and patents exploration	Available technology and patents exploration
Outsourcing parts manufacture and details design	Outsourcing parts manufacture and details design
Assemble parts to product sample and communicate with key clients	Parts assembling and tests
Mass production and delivery	Iterative details modification and internal communication

One is directly obtaining requirements from key clients, and uses outsourcing to accomplish parts manufacturing, then assemble them within the company and deliver to the clients. The other is internal ideation, use external design consultancy to achieve design and use outsource to conduct parts manufacturing, all manufactured parts will be delivered to the company for assembling and testing. There are no clear marketing strategies for products generated by internal ideation, but maintain internal creativity. The first type of NPD, key client approach has economic benefits; however, the second NPD model seeks investment for new opportunities.

In the interview, the top manager expressed an eagerness to hear from the latest technology and electric vehicle industry development of western countries, such as new battery technology for vehicles, new materials for vehicle bodies and chassis etc. The “key client” NPD strategy is the main business model for company survival; there are no strong requirements of design, but the performance of their product functionality, so it is easy to understand that the tendency of the top manager will be technological. The preferences of top manager are summarised in table 14.

Table 14. Preferences of the top manager

Technology	Material: strong but light weight Battery: High capacity, low weight, high stability New technology
Marketing	Flexible
Design	Flexible
Cooperation	Desire to obtain cooperate opportunity worldwide

In terms of the business model of the company, the top manager mentioned some patents in terms of battery and hybrid power techniques are owned by the company, they receive license fees annually by licensing these patents. Investment in the company was mainly made on technology and marketing, design was recognised only on the appearance of a product (Table 15).

Table 15. Main investment spends

Type	Aspects	Investment
Technology	Engine and power	High
Marketing	Distributors	High
Design	Appearance	Few

Staff in the company was mainly requested on assembly tasks, and occasionally on ideation in group meetings lead by the top manager. People involved in ideation was mostly voluntary and has no professional background. The main approaches of design and ideation, according to the top manager, were mostly rely on intuition of the participant. The top manager owned an absolute decision making rights in the company. Design and ideation process

was informal, and ideas were mostly in verbal communication. The detail design and visual identity of a product were mainly accomplished by using design consultancies (Table 16).

Table 16. Design tasks and methods

Design tasks	Methods
Ideation	Internal meetings
Visualization and others	External design consultancy

In 2006, the company tried different ways to achieve a rapid growth, “Smart” was the key case of their attempts. The company contacted a Chinese trading company skilled on international trading. Over 100 fake “Smarts” with electric engine were sold to Europe at 2400 euro each. The company then were engaged in a lawsuit against the automobile giant, Daimler AG, and obviously lost. Consequently, the company guaranteed to quit counterfeiting actions and stop selling the fake “Smart” with receives no monetary punishment. In 2010, the company had a new investment and was bought by the current owner at the price of 30 million Chinese yuan (close to 3 million pounds). They gave up the copy-cat methods and utilised outsourcing to upgrade their product appearance.

This scoping study of this Chinese SME confirms the findings of Siu et al. (2006). Design in SMEs is not recognised as important, and design is only linked with the appearance of a product. On the other hand, this company

started to develop new products by internal ideation, and gave increasing attention of technology development and patent producing, and started to use design consultancies, proves they are in the process of get rid of being a counterfeiter. In terms of cooperation, they expressed an open attitude, and would like to have attempts to achieve growth. Table 17 summarises the objectives and results of this scoping study.

Table 17. Objectives and results of the scoping study

Objectives	Results
Management structure:	Hierarchy
NPD approach:	Serve key clients
Preference:	Technological performance
Understand of design:	Appearance (design consultancy)
Attitude towards change:	Positive
Case of counterfeiting:	From copy to use design consultancy

Phone calls were made to the representatives of the other two companies, with the same objectives, to learn their management, NPD approach, understanding of design, and whether they accept change making. Table 18 summarises the collected information of the other two companies.

Table 18. General information of the other two companies

	Jinzhongyi Furniture (JZY)	USbright Technology (UST)
Management structure	Hierarchy	Hierarchy
NPD approach	Internal ideation	Internal ideation
Preference	Marketing	Technological performance
Understand of design	Appearance (design consultancy and in-house design)	Appearance (in-house design)
Attitude towards change	Positive	Positive

It can be seen that all of the three scoped companies are maintaining a hierarchal management structure; the profitable NPD approach in the HEV mainly relies on key clients; JZY and UST are directly facing the mass market by using internal ideation. All of the three companies acknowledge design is about appearance of a product, and HEV mainly rely on using external design consultancies; UST use only in-house design, and JZY uses design consultancies, and also has their own in-house design team. The open and positive attitudes toward change making, plus their aspiration of growth determined that this research have large possibility to be moved on.

4.2 Analysis & synthesis

Based on knowledge from previous literatures, an NPD process model was selected to be the instrument for further practical implementation of a design-oriented NPD strategy. A conceptual designer-led NPD process model is proposed by analysis and synthesis of knowledge from contextual issues,

critical NPD success factors, lessons of generic NPD process models and implications of existing design-oriented NPD strategies.

4.2.1 Understanding the NPD Process Model

A Company that aspires to be more innovative usually starts by upgrading their NPD process model (von Stamm, 2003), although there is no guarantee that New Product Success (NPS) will be achieve with a structured process; however, it would increase the probability of NPS (ibid). An NPD process model that incorporates design-oriented aspects became the instrument for utilising design-oriented NPD strategy in business practice (Perks et al., 2005; Jang et al., 2009; Acklin, 2010). Consequently, the possible route for bringing design-oriented NPD strategy to Chinese SMEs is to introduce a customised NPD process model with design-oriented aspects.

It seems there is no consensus among researchers as to what constitutes design-oriented NPD. Perks et al. (2005) thought it would be totally designer-led, and emphasis placed on expanding designers' actions and skills set; while research conducted by the UK design council (2008) indicates the importance of design engaged pre-NPD work such as team building and internal competition. Whereas, Jang et al. (2009) proposed that design-oriented NPD should engage expert designers and use design to push

technology development; yet, Acklin (2010) thought design-oriented NPD in SMEs should integrate design and other management efforts, and involve stakeholders in the NPD process. Almost all the design-oriented design strategy is built for large corporations with abundant resources, such as affluent financial supports, distinctive human resources and rich development time.

NPD strategy in Chinese SMEs is mostly fragmented and immature (Siu et al., 2006). In comparison with large companies, SMEs have fewer resources, and so bringing design-oriented NPD strategies which were initiated by large companies is impractical. Owing to the special business contexts of Chinese SMEs and immature recognition of design management, Acklin's model seems less likely to be accepted and adapted, with two reasons: firstly, Chinese SMEs with the approach of "copy-cat" or "attribute listing" to develop new product (Siu et al.,2006) focus more on product rather than management; secondly, in the scoping study, the inquired companies appeared have less knowledge of design management. Consequently, an optimised NPD process model with consideration of contextual aspects is essential for introducing design-oriented NPD strategy to Chinese SMEs.

4.2.2 Contextual Issues Implications

Counterfeiting and financial issues are the main obstacles. Due to the financial issues in Chinese SMEs, funds available for developing new product became precious, thus cost at each stage of NPD needs to be evaluated. Counterfeiting behaviour is immoral and illegal; increasing the speed of NPD adoption is a way to reduce the harmfulness from counterfeiting. Concurrent engineering is a popular approach for shortening and effectively using product development time (Duffy and Kelly, 1989). This implies the customised NPD process model should have different functions working in parallel, with the aim of saving product development time. This is also a critical new product success factor proposed by researchers (Evanschitzky et al., 2012; Cooper and Kleinschmidt, 1996; Ernst, 2002; Griffin, 1997; Mishra, Dongwook, and Dae, 1999; PRTM, 1995). This implies that speed and cost evaluation are two essential requirements for customising NPD process models.

4.2.3 Critical NPS factors Implications

Aside from saving development time, Evanschitzky et al. (2012) indicates that proficiency of predevelopment task, marketing tasks, technological and launch are critical factors that impact upon the NPD executive process. Lack of proficiency in all aspects is to some extent the main differences between large

companies and SMEs; however, these factors are unable to be solved by a NPD process, but majorly by human resources. User involvement in product development is important and highlighted by researchers, design research methods, include approaches with and without users engaging (consumer orientation) worth to be included. Moreover, according to the literature, cross-functional teamwork and communication is considered to be important for NPS, as it able to speed up the inter-functional coordination and responsiveness (Kohli and Jaworski, 1990; Narver and Slater, 1990). Communication in a multi-disciplinary environment is worth to be strengthened in the NPD executing process.

4.2.3.1 Critical Factors at NPD Process level

Researches on NPS indicate that product characteristics, market orientation and speed are critical factors (Cooper, 1993; Cooper, 2001; Henard and Szymanski, 2001; Evanschitzky, et al., 2012; Parry and Song, 1994). And from understanding the Chinese cultural context, ‘shanzhai’ (counterfeit or imitation) phenomenon and financial issues can be concluded as main barriers, for overcoming these barriers, fast reaction and cost valuation is critical. Hence these factors can be synthesized into four: product characteristic, market orientation, fast reaction and cost valuation.

4.2.3.1.1 *Product Characteristic*

Designers are trained for achieving products with better product characteristics. A leading role for designers in design-oriented NPD projects is essential for getting products with better characteristics. Moreover, for gathering and electing quality ideas. Designers in team requires flexibility, give not only the functional tasks such as product design and package design, but also access to engage in the production process; to confirm the outcomes and the tangible product quality on one hand. On the other hand, design engagement in the production process is beneficial for enriching designers' knowledge base and is suggested by Perks et al. (2005), and designers possibly apply their vision and thinking on production process and get special insights which cannot be gained from user research and market research.

4.2.3.1.2 *Market Orientation*

There are two main aspects of market orientation in NPD process, one is consumer orientation and the other is competitor orientation (Kohli and Jaworski, 1990; Narver and Slater, 1990). Designers would contribute more on consumer orientation; such as use user-centred research methods or involve users or buyers at the early stage. Competitor orientation is mostly relevant to locate competitors and recognize opportunities of a specific market. All team members are suggested to integrate while locating opportunities and

recognizing competitors, and market information and competitor activities is suggested to be regularly reviewed. Similar to design engagement in the product process, design engagement in marketing activities, is able to maintain products and design works are marketed as intended; meanwhile, designers can obtain knowledge from participating marketing activities and and contribute their vision and thinking to marketing.

4.2.3.1.3 *Fast reaction*

There are three aspects that associated to fast reaction. Firstly, policy change or superior products from competitors may change the market environment and lead to new product failure (Cooper, 2001); this requires fast react on market change and competitors' activities. Secondly, potential conflicts from buyers or consumers could harm product or brand market performance (Newberry, 2006), fast processing complains and enquiries from buyers and consumers can mostly lighten this tension. Thirdly, development time cost and postponement would potentially lead missing timing to market (Henard and Szymanski, 2001; Montoya-Weiss and Calantone, 1994), and receive more pressure from 'shanzhai' (counterfeit or imitation) products, it implies developing new product has to be rapid and continuous.

4.2.3.1.4 *Cost valuation*

Lack of financial supports is one of the key characteristics of Chinese SMEs (Wang and Yao, 2002; Peng, 2002; Siu et al., 2006;), therefore the cost valuation becomes to a critical factor for Chinese SMEs in NPD executive process. First, design research methods are suggested to be adopted. Many of these methods are effective and cost effective, such as intuition (Yang et al., 2009), secondary research (review of existing information about consumers, competitors, policies and social and economic trends), observation, brainstorming, character profiles (identify key characters of user that are going to be design), being your user (in user's situation for a period to understand him/her well) etc. Some conventional research methods such as quantitative surveys, focuses group, and other similar methods that are potentially generating extra expenditures, from the cost effective point of view that invest on these research methods are optional. Second, varies risks and iterations would appear in the process of product testing for market desirability and technology feasibility. This attribute determines that expenditure will emerge in this process for assuring production. Cost saving in this process is less accessible; in contrast, tests at this phase should be made till the design concept can be confirmed as market desirable, technology feasible, producible and satisfy the NPD team. Third, the main expenditure process, such as parts mass production and assembling, are closely linked with product quality,

subsequently, user experience; cost saving is not a factor in these actives. Fourth, participate in and win notable design awards is bringing design to a strong marketing tool, company is able to benefit from media promotion and exhibition by wining design awards, to some extent it is cost effective than using traditional ways of promoting, such as media marketing, exhibition participation, advertising and using marketing agencies.

4.2.4 Generic NPD Process Models Implications

The NPD process models are diverse, from linear to spiral, concurrent and overlapping. The differences of these models are derived from different requirements, linear models are aim to confirmed purposes, and the length of the linear model is determined by the complexity of the project. Requirement for flexibility and efficiency, produced the overlapped models; project with largely uncertainties such as software development is suggested to follow the spiral model. All the NPD process models has similar overall steps to indicate tasks from identification of opportunities to production (Ulrich & Eppinger, 1995). The differences may mostly rely on the specific characteristic of product, degree of innovation and specific production process (Murthy et al., 2008). The well-known Stage-Gate process contains a gate in the end of each stage, to evaluate and validate outcomes of former stages. It shifts the validation efforts to a formal level. In spiral model and overlapping models, redo is suggested to

carry as validation to evaluate former work and assuring its validity with flexibility. The Product Development Process design method proposed by Unger & Eppinger (2011) maximized the importance of validation, and suggests customizing a proper process based on the main issues that harm validity, such as uncertainties, iterations and risks. Validation in NPD process has been widely recognized as important; hence it should be taken out as an essential task.

4.2.5 Design-oriented Aspects

Design works mostly start by a brief from client, and it is important to define the boundary of the following research works. The research conducted by Design Council (2008) points that designers' engagement in pre-NPD tasks such as define the NPD project is important. It is a divergent and convergent process, helps on push ideation boundaries and recognizes direct and indirect competitors (competitor orientation) and users before having an idea, therefore a briefing phase for the NPD process model is necessary.

In a design-oriented company, design need to be fully supported by top management (Perks et al., 2005; Jang et al., 2009). The support from management is to satisfy design requirement by providing management rights, sufficient human resources and facilities support etc. Aside from assign

management rights to design, other approaches (provide sufficient human resources support or facilities support) can generate extra cost which is a contradictory factor for companies with limited financial capability. However, designers are trained for achieving better products and deliver products with improved product characteristic. In the viewpoint of cost effectiveness, giving the management rights to design, is also a solution of the “top management support” for companies with limited financial supports.

Owing to the targeted practitioners have limited management knowledge and preference of spending efforts on product, Acklin’s (2010) design driven model appears too much on management for them to understand and utilise into practise. Therefore, the easiness of model adaption, and able to be brought into practise is vital. According to the joint goal of design and NPD, design and NPD process has a number of similarities, a NPD process model that based on design process is easier to be understood and adapted by their current designers, as well as other functions of a NPD team.

4.3 Conceptual Designer-led NPD process model

Several important aspects for constructing a customised NPD process model for Chinese SMEs can be derived. Faster development for saving time and Cost evaluation is highlighted by learning the cultural context (Section 4.2.2); frequent validation is critical and is suggested by various forms of NPD

process models (Section 4.2.4). Product characteristics, market orientation, fast reaction and cost valuation are concluded as vital NPS factors (Section 4.2.3). Design emphasis, start from briefing and easy adapted is considered as design-oriented aspects (Section 4.2.5). Table 19 summarises these implications from different knowledge areas, and displays proposed solutions for building a NPD process model.

Table 19. Knowledge areas, implications and solutions

Knowledge areas	Implications	Solution for building a model
Cultural Context	Faster development	Concurrent tasks
	Cost evaluation	Confirm the cost at each step
NPS factors	Product characteristics	Designers are provided senior management rights
	Market orientation	Frequent check the external information
	Fast reaction	Concurrent task
	Cost evaluation	Confirm the cost at each step
Generic NPD process models	Frequent validation	
Design-oriented Aspects	Design emphasis	Designers are provided management rights
	Start from defining the NPD project	Adding briefing phase
	Easy Adapted by designers	Rely on common implemented design process model

Based on a generic design process model that commonly implemented in Chinese SMEs (Cheng, 2006), the suggested phases are simplified into

ideation, conceptual design, detailed design, prototyping and evaluation (Section 2.2.2, Chapter 2). A NPD process model is constructed with highlighted the importance of designer and combined the above solutions of implications, therefore named “conceptual designer-led NPD process model” (Figure 19).

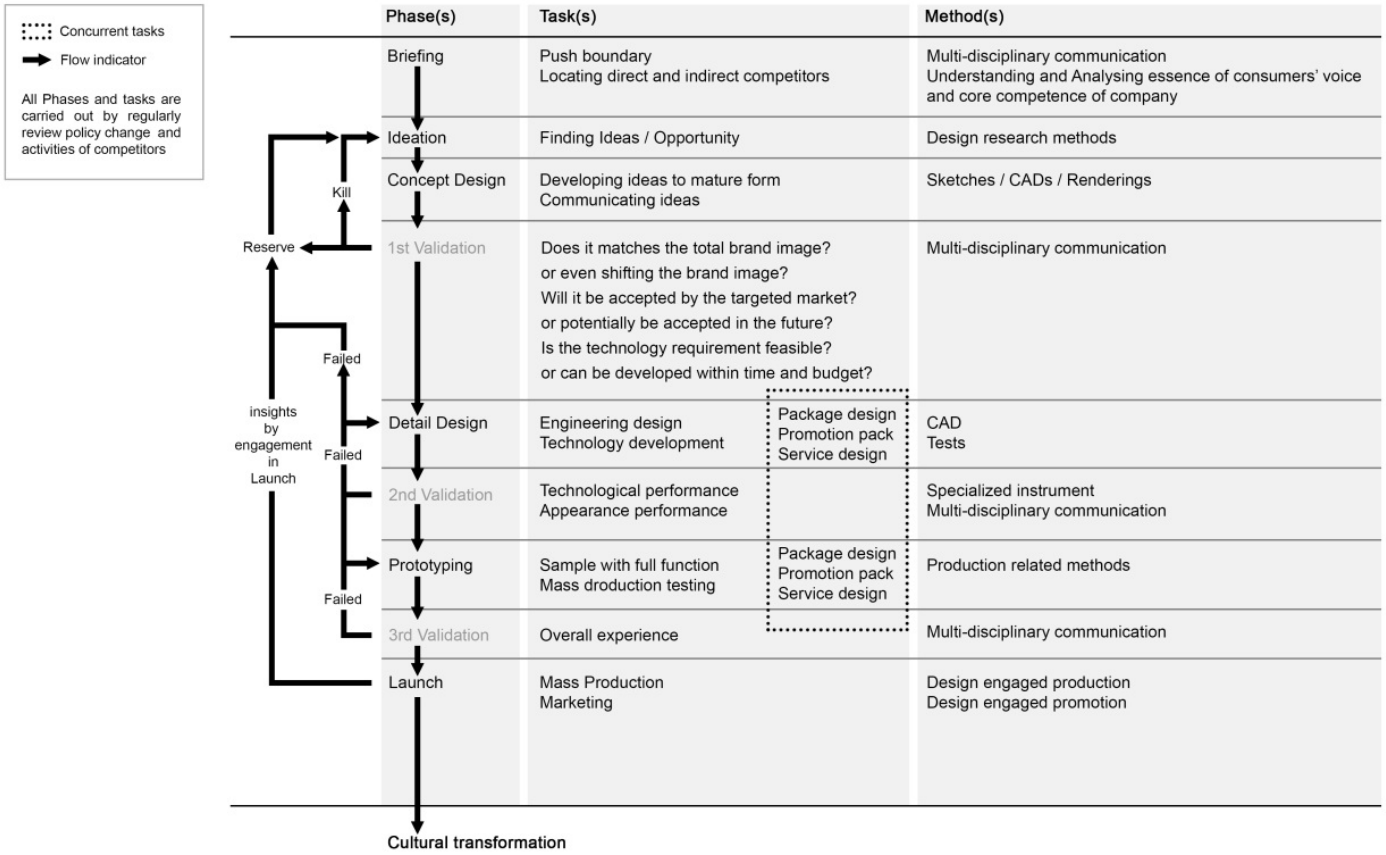

Figure 19. Conceptual Designer-led NPD process model

The briefing phase is the first step to initiate a NPD project. The main purpose of this step is to push the boundary of an NPD plan and provide new access for locating opportunities. Design engagement in a multi-disciplinary discussion, to understand and analyse the essence of consumers' voice, and find the connections between essences and company core competence. It also helps on locating competitors, from direct ones to indirect ones. This phase pulls designers to organizational level and see their task strategically, it seems to be helpful on doing radical innovation.

In the conceptual model, ideation phase is used for finding proper ideas or opportunities that based on the principles that built in briefing stage. Design research methods are recommended to be carried through this phase, as most design research methods are cost effective in comparison of doing quantitative market research (Yang et al., 2009). Idea or opportunities should be produced from this stage. There are no ideas screening or evaluation process are suggested, owing to most ideas are in their infant forms. Siu (2008) pointed the importance of internal communication, hence, for avoiding misunderstanding or partial understanding of ideas, a following phase that named concept design carries out. Use design techniques such as sketches, Computer Aided Design (CAD) and renderings to help on developing ideas to comparatively mature forms and assuring information are well organized and can be well

communicated for the first validation. The design concept will be evaluated from mainly three questions: does it match the total brand image or even shifting the brand image? Will it be accepted by the targeted market and potentially be accepted in the future? Is the technology requirement feasible or can be developed within time and financial budget? A decision will be made by multi-disciplinary discussion, to determine that the concept will go to next phase, be stored or killed. If the concept that failed to pass through this validation, it will restart from ideation, it works as a loop till proper concept is generated.

A design concept that passes the first validation can then move to detail design phase. An embodiment of product concept such as engineering design, technology development will be carried out in this phase. And product associated package, promotion pack and service will also be designed once the designed product pass through the second validation process and send to prototyping phase. The second validation mainly focuses on technology performance and design quality. Product associated tasks such as package design, promotion package, and service design are suggested to be made concurrently with prototyping phase. Then a final validation process takes place to evaluate the experience of prototype with full functions the in the designed package, this is an overall experience validation. If all passed through, then move to the launch phase, to mass production and marketing.

Design engagement in those activities to assure the quality as expected and obtaining insights from these processes. And potentially obtain insights that can be reserved for next NPD project. Finally, the product will be on the market, its performance will provide reflection to manager and the NPD team. All the process will be conducted with monitoring the activities of competitors and policies, to have an always up-to-date understanding of market and make right decision on NPD investment. There will have no kill after first validation, in purpose of saving material cost.

4.4 Summary

The scoping study confirmed the feasibility of continuing this research, and the customised designer-led NPD process model is built as an instrument to introduce design-oriented NPD strategy to Chinese SMEs. However, the conceptual model is built by analyzing and synthesizing knowledge from the literature, it is in its infant form. Hence, further empirical investigation is necessary to evaluate and enrich the content of this conceptual model, and shifting the conceptual model to an applicable practical model. And in terms of its practical effectiveness, the most appropriate evaluation method is to bring it into NPD practice.

Chapter 5. Model Optimization and Application

This chapter represents the practical NPD implementation experiments: two NPD teams were built to implement two NPD projects with different NPD process models. One team followed their existing “conventional NPD process”, and the other team followed the “designer-led NPD process”. A company was firstly selected according to their NPD schedule and research schedule. The “conventional NPD process” of the selected company was learnt and the “designer-led NPD process” was optimised with practitioners in the company. Before the before the parallel implementation experiment, the position and role of researcher was confirmed, and a metrics tool in the form of questionnaire is constructed with practitioners for conducting subjective evolution, and sales data of the two outcomes in six months is also collected for objective evaluation.

5.1 Site Selection

Personal contacts were used to undertake the company selection. On the other hand, the situation of a proper company for conducting this research needs to satisfy some characteristics.

5.1.1 Criteria

Several characteristics were considered when selecting the target company. First, the selected company needed to be a small or medium size Chinese manufacturer and produce products under their own brand: a number of Chinese SMEs are running as Original Equipment Manufacturers (OEM), they do not directly sell products to consumer but are contracted by other companies to manufacture products. Generally, it is the contracting company which is responsible for manufacturing. Thus a company that is responsible for the NPD process was essential. Companies producing products with their own brand would most likely undertake NPD. Second, a company that has experience of working with designers: SMEs which do not have experience of using designers would imply that this type of company may have limited knowledge of design. It is hard to directly introduce designer-led NPD to those companies and it may take a long time for them to incorporate design into their structure and processes. Thus, a suitable company that sees design as useful and better to have in-house is essential. Third, a company that wants to grow and is willing to take the associated risks: a conceptual model is mainly generated by synthesizing knowledge from the literature and theories, although there is some empirical data for constructing the conceptual model; however, it cannot assure its perfection, potential risks may be contained within especially for first time application, such as overestimating designers'

capability and contribution, unexpected mistakes etc. Fourth, NPD projects within an appropriate complexity: the selected company must have an NPD plan and not be doing overcomplicated NPD projects or too simple project. The complexity of an NPD project may be reflected by the development time. An appropriate NPD project time cost is up to six months. Fifth, the selected company must agree to disclose relevant information in relation to the NPD experiments and in the form of literatures. This is an academic research project, and writing reports are a primary work of any academic researcher, and it is inevitable that the research information and data will be disclosed to others for academic purposes.

5.1.2 Convincing approach

In the process of convincing companies, the potential outcome of this research is presented with ethical considerations: 1) ideally, this research can help company to produce competitive new products and add value to the brand in the long run. Owing to the realism behaviour of practitioners and desire to have competitive advantage, the potential of bringing benefits to company was firstly presented to motivate practitioners to get involved. 2) The external environment changes were presented to validate and support the positive assume: national design promotion and the continuous increase of people's income determined that the market environment will gradually change from

preferring “good price” to “good quality”. It is the time to transfer the company's profit strategy by only quantity to quality and quantity. 3) Use the conclusion that proposed by many researchers to strengthen the robustness of the first statement: design-oriented companies in western counties are identified gain more return and growth than others. 4) Propose the experiment approach to compare and understand the differences of design-oriented NPD: schedule two NPD projects that are following different NPD process. 5) Pointed the potential negative aspects and emphasis the long-term benefits: design-oriented strategy may cost more than before but is potentially helpful for company's long-term development.

5.1.3 Selected company

Three companies were deemed to be suitable for this research (Section 4.1). All these three companies were using designers within their NPD process. However, two of the companies hesitated to take part as they were unable to accommodate the research project schedule. The company left was seeking a new way of product expansion and accepted to cooperate and support the research project by providing relevant information, trademark of the selected company is given bellow (Figure 20).

Figure 20. Trademark of the selected company

The selected company USbright Technology Co., Ltd is a small enterprises located in one of the most manufacturer-intensive cities, Shenzhen, China. It started as an Original Equipment Manufacturer (OEM) in the mid-2000s, in 2011, the trademark 'USbright' was officially registered, with the aim of providing power adaptor solutions on the one hand, they played the role of supplier for other companies by providing moulding services and adaptor related technology consultant services, this accounts for about 87.4% of overall income in 2012. On the other hand, the comparatively new brand 'USbright', started the first shipping in Later 2011, accounting for 12.6% of total income in 2012. There are about 55 employees with slightly changes according to the orders, while the moulding team takes over three fifths of all staff. An initial observing and questioning is conducted in the selected company with the purpose of having a general understanding, related information is given in table 20.

Table 20. Information of General Understanding the selected company

Objectives	Results
Management structure:	Hierarchy
NPD approach:	Initiated by internal ideation
Preference:	Technological performance
Understand of design:	Appearance (in-house design)
Attitude towards change:	Positive

The top manager of the company is the only investor and also in charge of the trademark. Detailed tasks are carried out by two vice-general managers (Project managers). The rest of the company staff are parallel from the management perspective. In terms of design, there are two in-house industrial designers mainly working on ODM requirements, and a graphic designer was in charge of website design and brochures.

5.1.4 Data collection, records and analyse

In the process of onsite studies, a role that able to access research relevant materials is essential. The top manager of the selected company accepted to support this research and signed the agreement (Appendix 2); and a senior secretary role is assigned. Firstly, permission is given to access, observe and document their communications in meetings. Secondly, rights are given to have conversations and questions with stuff according to their schedule and access their detailed tasks. They are using online files management software

to archive and management their NPD related files, the administrator account was also given to get access to those documents (Figure 21).

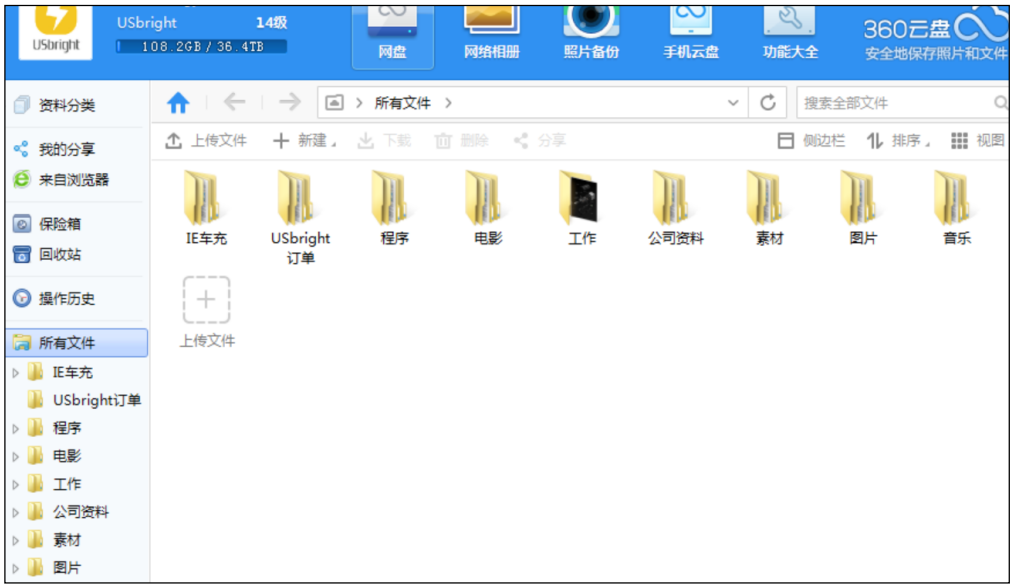

Figure 21. Screen shot of the files management software

The top manager also agreed to disclose original ideas and reveal their unpublished concepts during the research process. Firstly, he perceived that the market environment is mostly transparent, pre-disclose of unpublished concepts would be in a way of advertising. Secondly, if there was someone copy the unpublished concept means that the concept is to some extent welcome.

Interviews were take places with the top manager, in the purpose of understanding the company's managerial structure, their current "conventional" NPD process model, and a case study of their former NPD project. The top

manager also agreed to do voice recording, photo and held an open attitude (ask specific stuff to have screenshots), it appears that nothing is more important than bring the company more profitability. Key information of the collected data from notes, voice transcript, memory recall and photos was weekly organised, and extracted, to represent the information that related to the answers of research questions. Interference to the process and outcome of two NPD projects were not made in the NPD executing process, and the extracted data was presented to the top manager to double confirm the validity.

5.1.5 The “conventional” NPD process model

According to Siu et al. (2006), the NPD process in Chinese SMEs has four stages: ideas generation, prototype development, market analysis and testing, and commercialisation. Similar to their findings, the top manager mentioned there are no proper NPD models were following, the descripted NPD process in the selected company can be represented by the four stages, starting from ideation, for finding an idea or opportunity (see item 1, Figure 22); however, it was not conducted by a NPD team, but purely by insights of the top manager or project manager. The second stage is development, there are four sub-stages in this development process, firstly to investigate technological feasibility by reviewing existing technology and making tests, and then creating

appearance and style by in-house designer or design consultancy. While the appearance was assured, engineering design started by using Computer Aided Design (CAD) tools, and finally uses production related methods for prototyping (see item 2, Figure 22). The third stage is validation, to value the overall experience. Similar to ideation, the manager's perspective determines whether it can be processed to the launch stage (see item 3, Figure 22). In the launch stage, the product firstly must be mass produced, and then the in-house designer contributes a package design to wrap the product before phoning distributors and doing online advertising (see item 4, Figure 22).

Phase(s)	Task(s)	Methods(s)
① Ideation	Finding Ideas / Opportunity	**Manager's accidental insight**
② Development	Technological Feasibility *Appearance & Style* Engineering Design Prototyping	Review Existing Technology & Tests *Inhouse Designer / Design Consultancy* CAD Production related methods
③ Validation	Overall experience	**Personal perspective of Top Manager**
④ Launch	Mass Production *Package Design* Marketing	Production related methods *Inhouse Designer* Phoning Distributors / Online Advertisement

Figure 22. Current NPD process model in the selected company

There is no perceived failure of their current NPD process, because the top manager and project manager always set 'safe objective' with almost no risks:

making little changes and based on mature solutions. Bold writings in Figure 22 are activities execute by the top management; italic writings are activities undertaken by industrial designers. Industrial designers were only responsible for the appearance styling and package design. There is a review section while the appearance model/prototype was delivered to the project manager. However, the review focused only on the technical flaws. If any flaws were discovered, then the design was returned to the development phase (stage 2). The Top manager provided the following statement:

"We are producing power adaptor related products, the functionality is much more important than the appearance".

5.1.6 Case Study: "IG" Project

Document of a former developed product coded as 'IG' was reviewed to understand their current NPD process (Figure 23). In the first ideation stage, the top manager had an idea that to replace the non-transparent material inside the USB ports by transparent or translucent material, for having better vision of the build-in LED. It was recognised as the upgraded version of car charger products in company, and then assigned a project manager to deal with this. Moulding technician within days' tests and successfully replaced the material (see item 1, figure 23). Product designer made a rendering image,

and passed it to engineering designer to accomplish the inside structures (see item 2, figure 23). A functional prototype then was delivered to a manager, who tried and was satisfied with the product (see item 3, figure 23) it then moved to package making and the promotion phase (see item 4, figure 23).

Figure 23. The 'IG', a recent developed car charger product.

In their current NPD process model and product development process, management plays a key role and to some extent is autocratic. The management contributes ideas, and validates the outcome of ideas. Capability of design is limited to only styling, and package design are not seen as important for validate the overall experience. However, this way of doing NPD is comparatively low risks, because of most actions in their current NPD process is rely on previous experiences and mostly no challenges.

5.2 Conceptual Model Optimization

In the study of their current NPD process (conventional NPD process) in the

selected company. A former case coded as “IG” was provided as evidence and validate the collected oral data from top manager of the company. The conceptual designer-led NPD process model is then optimized in group discussion led by the research. Finally, a ready to use optimized designer-led NPD process model was generated.

5.2.1 The optimized conceptual model

For further applying the designer-led NPD process model, the conceptual model was introduced and optimised. Six staff members were invited by the top manager to a group discussion due to their individual schedule, these included: the top manager, one project manager, and two engineering designers, two technology specialists and one industrial designer.

Table 21. Comments toward the conceptual model

Role	Comments
The Top Manager	Need good designer, Not sure about the designer-led
Project Manager(marketing background)	Good to have more people for ideation
Industrial Designer	Revolutionary Can contribute more Need try hard
Engineering Designer	Hope not be given to hard tasks more conversation with ID
Engineering Designer	Monitoring production is not useful
Technology specialist	Need more conversation with ID
Technology specialist	Silence

After a brief self introduction, the conceptual model and a statement of the potential merits and demerits of this research was given (section 5.1.2), participants then made comments toward the conceptual model (Table 21), and owing to their tight schedule, those invitees were return to work shortly after give comments on the conceptual model. According to their comments and suggestions, the model was then modified afterwards, with following the perceptions that proposed by the top manager.

While the top manager mentioned “not sure about the designer-led”, and pointed his concern of whether the industrial designer familiar with skills in relation to sourcing, negotiation etc. The industrial designer admitted his lack of these management abilities, therefore in the later on experiment process, a project manager was assigned to fill this gap and co-management the NPD project (section 5.4.1).

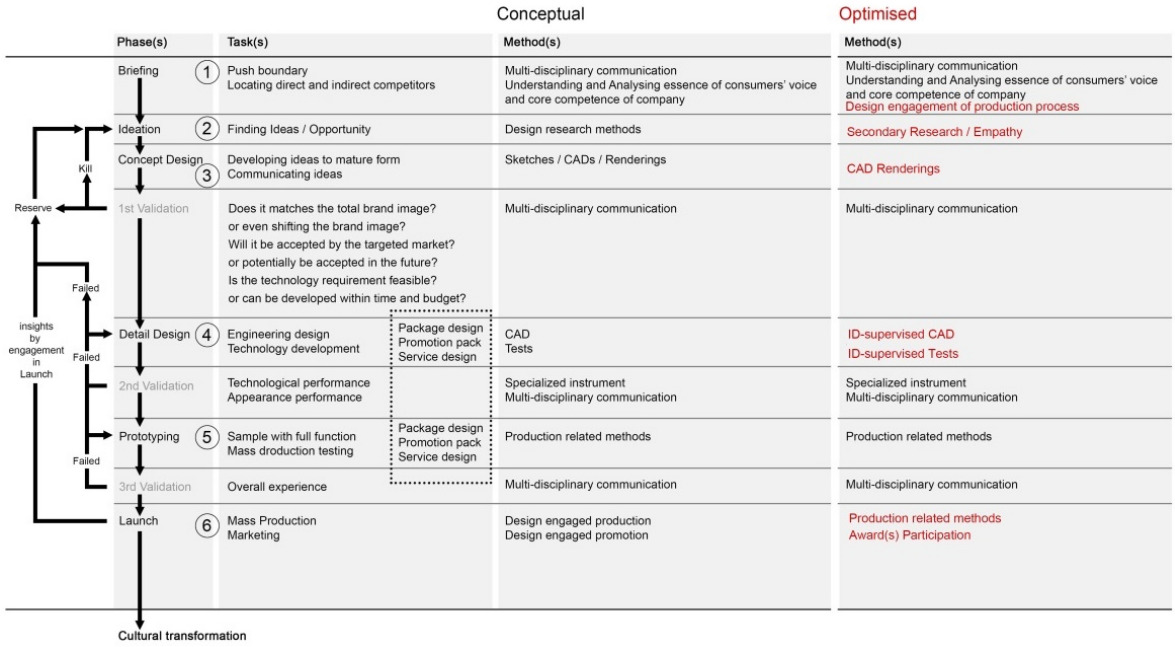

Figure 24. Modification of the Conceptual designer-led NPD process model

Based on the conceptual designer-led NPD process model, the optimisation process took place; however, owing to there was no team assembling are mentioned is the conceptual model, only elements associated with methods were modified. These modifications in Figure 24 are highlighted in red.

Design engagement in production process was moved from launch stage to Briefing stage (see item 1, figure 24). Rationale for having the Design engaged in production was to find insights for future NPD projects and to increase control of the product quality. However, one of the engineering designer suggested that letting designers involve in production process to do quality control would not be practical. He argued that the technicians already try their best to fulfil the proposed tasks; and that the only benefits for designers

engaging in production was providing them with insights of manufacturing process. He also pointed that the designer can contribute to production, such as proposing good design with consideration of engineering designer's, to simplify the production process; hence, detailed design activities were changed to "ID-supervised CAD" (see item 4, figure 24). The top manager stated that only low cost ideation methods are accepted, because of the limited budget. Therefore, ideation methods were limited to secondary research and empathy (see item 2, figure 24); the top manager also pointed that sketches from industrial designers are sometimes hard to be understood without designers' explanations; therefore, suggested that designers to communicate ideas and/or concepts in a way that technicians and engineering designers are able to understand these from the drawings. Therefore, it was suggested that only CAD renderings to be accepted to represent concept designs (see item 3, figure 24). And design engaged in marketing activities and promotion were changed to awards participation (see item 6, figure 24). The top manager and the project manager agreed that designers engaging in promotion or marketing is not needed, as there are already specialists to deal with consumer services, so suggested to prepare document for awards, and win prizes, is the best way for design to get involve in marketing.

5.3 The Metrics Tool

For further understanding the internal performance of the optimized designer-led NPD process model, members from two NPD teams (two NPDs was setup during the experiment process, one conventional team followed their own NPD process and one designer-led NPD team follow the proposed designer-led NPD process model) were asked to contribute on developing a post-NPD measurement tool.

In the process of building this tool, eight staff members from the two teams were asked to mark key factors from the critical NPD success factors pool (Appendix 3) that was synthesized from literatures, and to present their personal perspectives. In an open discussion, these factors were agreed to be marked by following three aspects, NPD outcomes, the NPD process and the personal progress respectively. product advantage, meet customer needs and technological sophistication were agreed to be the measurement for NPD outcomes; time cost, investment spent and risks & iterations were the measurement for the NPD process; productivity and workload were agreed to measure the personal progress.

The confirmed tool was constructed by eight questions to represent selected factors. The first three questions were used for collecting the participants' viewpoint towards the NPD outcomes; "Product advantage" was used to

understand their attitude towards the competitiveness in comparison of the product from competitors. “Meet customer needs” was try to let them to value the product in the eye of consumers’. “Technological sophistication” was about to understand the easiness of being duplicated by counterfeiters. The follow-up three questions were about perspectives toward the NPD process, “time cost”, “investment spent” and “risk and iterations” were used to assess whether the facts satisfied their expectations. Last two questions were generated for understanding participants’ personal progress. “Productivity” meant to make self-measure on their personal contribution to the NPD project. “Workload” was used to understand whether they devote extra hours on the project.

The tool incorporated eight questions; each question in the tool incorporated a five- level Likert scale, with “-2” indicates options strongly negative, “-1” means mostly negative, “0” is neutral, “1” means mostly positive and number “2” indicating a strongly positive score (Table 22).

Table 22. Questionnaire as metrics tool

Product Advantage	Will the new product be competitive against competitors' products?				
	-2(No)	-1	0 (Neutral)	1	2 (Very much)
Meet customer needs	Will the developed product meet customers' needs?				
	-2 (No)	-1	0 (Neutral)	1	2 (Very much)
Technological sophistication	How difficult will it be for competitors to copy?				
	-2 (Easy)	-1	0 (Neutral)	1	2 (Difficult)
Time cost	Did the process take the time expected?				
	2 (Less)	1	0 (Neutral)	-1	-2 (More)
Investment spent	Does the developing cost meet expectations?				
	2 (Less)	1	0 (Neutral)	-1	-2 (More)
Risks & iterations	How much iteration was required in the development process?				
	2 (Little or none)	1	0 (Neutral)	-1	-2 (Much)
Productivity	Has your contribution been as expected?				
	-2 (Less)	-1	0 (Neutral)	1	2 (More)
workload	Have you spent more hours on the project than expected?				
	-2 (Less)	-1	0 (Neutral)	1	2 (More)

The questionnaire was used as metrics tool to collect views of members in two NPDs teams as subjective evidence. For avoiding insufficient understanding of the other NPD project, members from each team were only asked to mark the questionnaire to measure the NPD that they were engaged in.

5.4 Experiment: Parallel NPD projects

Execution of the two design processes were in parallel by two independent

NPD teams. These two teams were kept separate to avoid any possible cross-contamination of ideas. One of the teams carried the 'Current Conventional NPD' process (Conventional NPD team), and the other team adopted the 'Optimised designer-led NPD' process model (Designer-led NPD team).

5.4.1 Team assembling

Each team consisted of four staff each having different expertise. The teams included: a project manager, a technologist, an engineering designer and an industrial designer. The aim for team assembling was assures each team to have members with similar backgrounds and work experiences (Table 23).

Table 23. Members' expertise and backgrounds

	Conventional NPD team		Designer-led NPD team	
Title	Tasks	Experiences	Tasks	Experiences
Project Manager	General management	6+ years' experience on marketing	Co-management	6+ years' experience on marketing
Senior Engineering Designer	Engineering Design, Prototyping	10+ years in manufacturing industry	Engineering Design, Prototyping	10+ years in manufacturing industry
Technology Specialist	Technical Solution	6+ years' experience on power adapter solutions	Technical Solution	6+ years' experience on power adapter solutions
Industrial Designer	Design	BA Industrial Design, 3+ year experience on electronics product	Design / Co-management	BA Industrial Design, 3+ year experience on electronics product

Each team included a project manager with marketing backgrounds, dealing with general NPD issues, such as: time management, sourcing of required parts, managing funding etc. Both technology specialists have over 6 years' experiences on producing adaptor solutions and those two engineering designers both with over 10 years' experience and familiar with production process. Industrial designers in company were comparatively less experienced. One joined the company 18 months and the other is just about a year, but both have over 3 years' experience on electronic devices design. The industrial designer who assigned to designer-led NPD team, was permitted to co-manage the NPD project with project manager as "designer-led". This meant that the designer in designer-led NPD team had priority to make decisions and setting plans.

5.4.2 Schedule

Table 24. Timetable of Two NPD teams

<table>
<tr><th></th><th>Conventional NPD team</th><th colspan="2">Designer-led NPD team</th></tr>
<tr><td>Week1</td><td>Setting Goal</td><td colspan="2">Find Goal</td></tr>
<tr><td>Week2</td><td>Design Concept Ready</td><td colspan="2">Internal Resources Reviewing</td></tr>
<tr><td>Week3</td><td>Engineering & Technology Ready</td><td colspan="2" rowspan="2">Design Concept Ready</td></tr>
<tr><td>Week4</td><td>Product Prototyping</td></tr>
<tr><td>Week5</td><td>Preparation for launch</td><td>Engineering &</td><td>Package &</td></tr>
<tr><td>Week6</td><td></td><td>Technology Development</td><td>Promotional Files</td></tr>
<tr><td>Week6+</td><td></td><td colspan="2">Preparation for launch</td></tr>
</table>

Table 24 displayed the timetable of two NPD teams. Owing to the fast-pace culture, both teams have very compact schedule for developing new products. The conventional NPD team set a 5 weeks fixed plan from having a goal to preparing for mass production. Similarly, the designer-led NPD team had a same plan till the industrial designer in team acquiring more time for adaption. Consequently, the developing time was extended and set with flexibility.

5.4.3 Practical implementing process

Two NPDs were carried out with different NPD models. These two models were reflected by two different practical processes. For the Conventional NPD team, they held seven steps; this can be seen in Figure 25. In the ideation stage, there was no method for obtaining ideas from team members, but only personal insights of the project manager. The project manager tried hard to ‘think what should be improved as a user’, and concluded ‘a car charger with two USB ports and having different lighting colour’ as aim of this NPD project. The development stage included all process to materialise the idea: concept design, technological design, engineering design and prototyping. The design concept was a one-time work, with no iteration and rework, and successfully obtained satisfaction from the project manager. In the process of technology development, technology specialist proposed a solution that based on a previous Printed Circuit Board (PCB) and upgraded the process unit. Similarly,

the engineering design was also a previous design work with few modifications. A prototype then was fulfilled by combining above works. The validation stage had two steps. Firstly, the prototype was accepted by project manager, and then it was passed to top manager to make further decision: schedule for mass production or lay aside.

Figure 25. Conventional NPD team practical application process

The conventional NPD was effective and owing to most time-cost tasks were based on previous mature solutions, the developing time were significantly saved. Therefore, the conventional NPD team successfully accomplished the aim within the scheduled time on one hand. On the other hand, most decisions were determined by the project manager and top manager's intervention at validation stage was crucial.

Different from the conventional NPD team, the designer-led NPD team firstly reviewed the production process for obtaining internal knowledge (Figure 26), and all members in team were gathered together to explore ideas that could potentially compete with competitors' products. An idea that "design for precision" was proposed by reviewing the production process in meeting. Also the designer in team mentioned that the new product should has distinctive functional performance, and raised the concept of "dual core", which suggests to incorporate two power chips into one product.

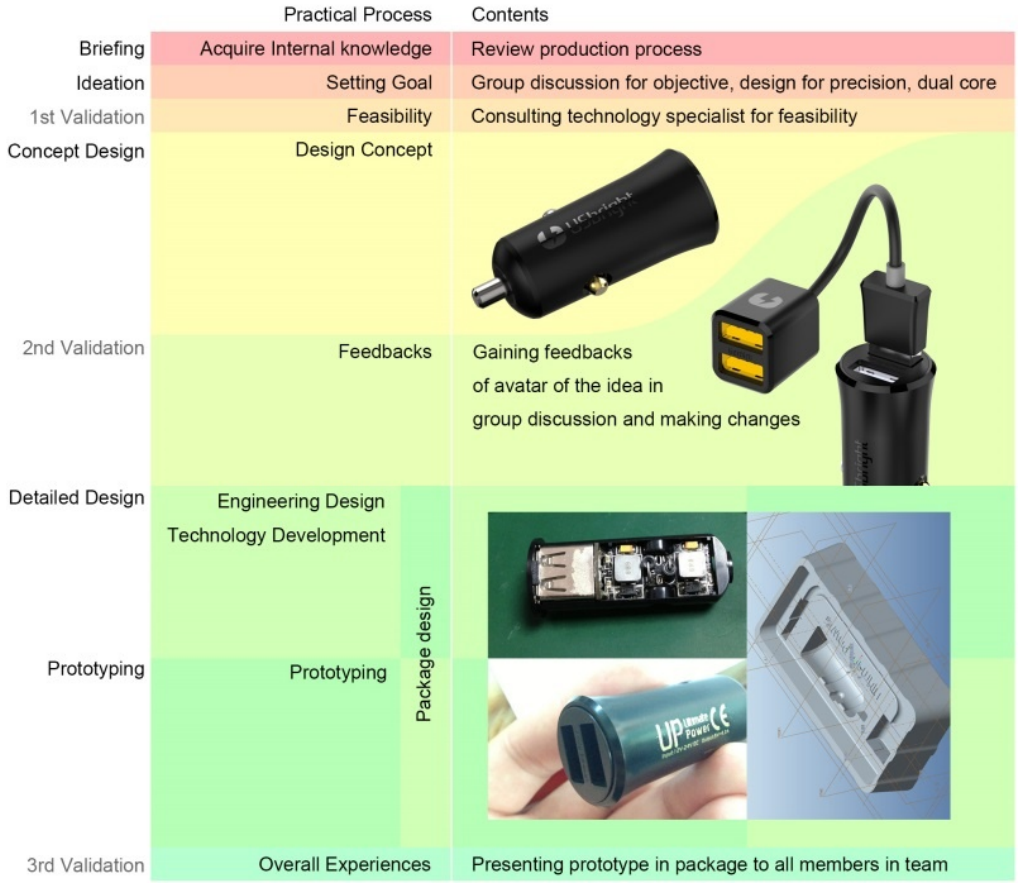

Figure 26. Designer-led NPD team practical application process

A concept design represents the “design for precision” with the “dual core” was proposed by the industrial designer with consulting team members in relation to feasibility. Thanks to the co-management settings, the industrial designer was given the rights to access decision making, obstructions, such as over sensitive on unit cost, was erased. In the second validation stage, the industrial designer expressed a willingness of presenting his work to the other team members and obtaining feedbacks, consequently, changes were made: an extension cable was added for having more ports to utilise the full functional performance of the “dual core” concept. In the detailed design process, although the technology specialist in team confirmed the feasibility of the “dual core” idea, but made multiple time consuming tests for functionalization. The engineering designer also cost an extra time than former NPD projects, owing to the “design for precision” concept was a gapless appearance, which he had no previous experience. While technology specialist and engineering designer were striving on their tasks, the industrial designer turned to package design. After all the detailed design process accomplished, the first prototype in package was presented to all members and also the top manager was invited for making comments.

However, although there were concurrently processes for doing tough tasks (redesign a PCB board that support the “dual core” concept, and develop a mould to produce product parts and made these parts gapless while

assembled), the time cost still far beyond their expectation, from scheduled 6+ weeks maximum time to about 10 weeks. For having an idea, the “design for precision” and “dual core” were confirmed at first week, the design concept was given and presented in the 2nd week. Changes were made in the 2nd validation, the finally concept design was produced and confirmed in the 4th week. The rest of 6 weeks were spent on testing the gapless body (design for precision) and combining two processors onto one compact PCB board (dual core). Although the final outcome matched the stated project aim, the team experienced conflicts between different members. For example, during the prototyping phase, the engineering designer complained that the high standard quality specified by the industrial designer requires more tests, such as adjusts the draft angle. Industrial designer acquired high performance but in a compact space, this resulted more tasks for technology specialist to redesign the PCB board and layout. The project manager considered all of these tasks take too long for having a new product, and even serious, cost too much on paying these testing bills. However, both the engineering designer and technology specialist agreed this product would be unprecedented. Afterwards, the “dual core” concept on car charger was successfully obtained the certificate of national utility model patent.

5.4.4 Result by Metrics Tool

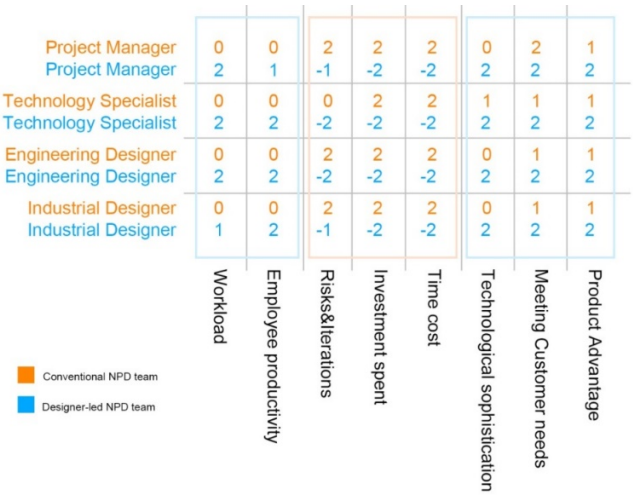

Figure 27. Result of metrics tool questionnaires

After each participant marked their questionnaires, short conversations were conducted with each participant, to confirm those given marks. Result of metrics tool was collected and shown in figure 27 (-2 to 2 means from very negative to very positive). It shows that overall score of designer-led NPD team is lower than the conventional NPD team, it mainly because of extended time and cost on tests (time cost, investment spent and risks & iterations are all marked below 0). Aside from that, it can be seen that staff in designer-led NPD team spends more efforts (employee productivity, workload all marked more than 1) in NPD process and achieved a product that seems satisfied all members in team (product advantage, meeting customer needs, technological sophistication all marked to max).

In the conventional NPD team, the project manager claimed that the “new product” with two lighting colours (ports with different lighting colours mean different types of power output performance) is special and competitive. Firstly, he pointed that the “two lightning colours” concept is new to the market; previously, print a line of texts next to the ports was the solution to indicate the power output. The “two lightning colours” solution replaced the former one by assigning two ports different lightning colours (marked score 1 on product advantage). And he perceived that this idea was attractive to users (marked score 2 on meeting consumer needs), but too easy to be copied by other manufacturers (marked score 0 on technological sophistication). The new product with this new feature was accomplished on schedule, and cost nothing beyond the budget range (marked score 2 on time cost, investment spent, risks & iterations). He recognised the productivity and workload of him remained the same as in previous NPD projects (marked score 0 on employee productivity, workload). Similarly, the technology specialist, engineering designer and industrial designer in the conventional NPD team perceived that their workload and productivity kept the same of former NPD projects (marked score 0 on employee productivity, workload). Only the technology specialist in the conventional NPD team pointed that the risks and iterations beyond former NPD projects (while they others marked score 2 on risks & iterations, the technology specialist marked score 0), owing to the key feature “two lightning colours”, rely much on his contribution, which requires him to test and integrate

two different coloured LED on one PCB board. And he also claimed this is difficult for others to duplicate (marked score 1 on technological sophistication while others marked score 0).

In the designer-led NPD team, it seems all team members agreed the outcome was a competitive and satisfying product, but the time and investment cost for development were not satisfied. While technology specialist and engineering designer in team perceived there were many risks and iteration during the development process, but project manager and industrial designer thought there were not as many risks and iteration as the others thought.

The current NPD process (conventional NPD) in company seems not tap all the potential of members in team (employee productivity, workload all marked 0 as usual), and indeed, members in conventional team once finished their job for the NPD and immediately move to new assigned tasks. In contrast, members in designer-led NPD team contribute all their working time on the single project, and even needed to extend the scheduled timetable. Iterations associated risks, but not all. In this study, there were almost no iterations in the conventional NPD process, it does accelerate the developing process and saved developing time; however, there is no iterations are needed since they holed an ‘incremental’ view.

5.5 Issues and following-up actions

Two new products from these two NPD were added to the production queue, this means outcomes were both internally successful. The new products were produced and launched both in late July 2014. The one developed from designer-led NPD team named as “UP”, and the other one from conventional NPD team is called “SP”. A period of six months’ market data collection started. Data include number of sales and feedbacks from consumers and distributors will be collected and analysed. Issues associated with production and assembling was collected by remote communication.

5.5.1 Continuous issues associated with new products

Although prototypes were made and production process has been tested, the issues in mass production cannot be all predicted. Especially on product developed by the designer-led NPD team (The one named “UP”). The top manager of selected company mentioned that defective “UP” products account for around 30% of total produced ones. Owing to the high defect rates and former higher product development price, the cost per unit of “UP” is twice more than “SP”. Furthermore, “UP” incorporated new design from appearance to mechanical; it changed their familiar way of assembling, and to some extent, this need time for assembling staff to adapt. It resulted the assemble time cost

also twice more, the time spent for assemble about ten thousand “SP”, can only accomplish about five thousand “UP”.

Table 25. Production issues solved with time

Issue	content	solution	result
High Defect rates	30% plastic shell failure, not match	Redesign and modify mould	Less than 1% failure
Assemble slow	100% more time cost for 1 unit	Need time to familiar with	Similar assemble speed

The manager accepted the higher defect rate at beginning, and he recognised that the defect rates would be solved (Table 25). The moulding technician pointed that the defect is about fitting of two parts, because of the shrink of plastic (ABS+PC, a synthetic plastic material for obtaining better flame retardance); different plastic material suppliers offered raw material have varied shrink rates, to solve this issue need to increase tolerance, modify the mould and enlarge the gap between two paired parts (Figure 28), consequently, the defect issue instantly disappears.

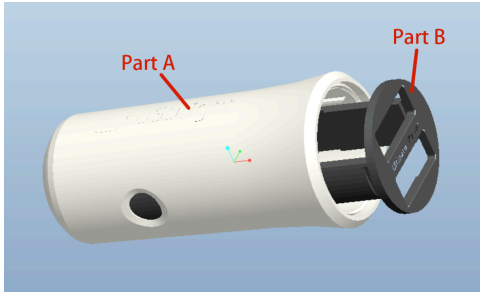

Figure 28. Two paired Parts

Besides, assembling speed issue was solved naturally, because staff in assemble line needs about one-week time to familiarise the new assemble process. In the following week, thanks to the two pieces' design, the speed of assembling "UP" reached at almost the same as "SP".

Owing to the comparatively higher quality and better functional performance, the top manager decided to sell "UP" at almost two times of the price of "SP", and owing to the increased speed of assembling "UP", the unit cost decreased and therefore, profitability increase relatively. After the first week since mass production, the profit of selling one "UP" went to about three times of selling one "SP". Also the top manager disclosed that two thousand units' shipment of 'UP' at the price of wholesale, could cover the previous extra development cost. It seems the following-up units' shipment will generate more profit, at about three times of "SP".

5.6 Subjective evaluation

Both new products developed by different processes were accepted by top manager and added to the production queue. Although the two teams followed different NPD models, the practical application process were similar to some extent. This related to the nature of developing new products, having an idea, develop the idea and market the idea (Kahn, 2001).

Table 26. Differences of two NPDs in practical view

Conventional NPD	Designer-led NPD
Autocratic	Democratic
Experience Based	Aim for Challenge
Low risks	risky
Less internal impacts	Great Internal impacts

In comparison of two NPD projects so far (Table 26), the conventional NPD team started by an idea from the project manager, and the outcomes were only validated by the management, less people were engaged in decision making process, it was an autocratic process to some extent. In contrast, group discussion took place several times because of industrial designer in team was permitted to co-manage the project, and he wanted feedbacks from others, it relatively is a democratic process. Members in conventional NPD team conducted tasks mostly based on previous cases and experiences, thus the risk of NPD failure decreased significantly; rather than the designer-led NPD team set challenging goals, spent much effort and fund for achieving the goal, but there was no guarantee for success, all time and efforts may result profitable return, or nothing. The conventional NPD owing to its autocratic, there were less communications between members and consequently, less learn and impacts took place between members. Unlike conventional NPD team, designer-led NPD team had much communications and discusses because of industrial designer wanted feedbacks of their own work; meanwhile,

took challenging objectives need well co-operation between members; therefore, learn and impacts between members were obvious.

The current NPD process model in company is time saving, cost saving, it is a mature process for company to creating incremental products rely on previous experience. However, the success of new product relies much on the vision of people in management roles. Design in this type of NPD only in charge of styling and have less contributions and impacts on overall product, package design was seen as not important in this NPD process. They lost the opportunities of making radical products. The introduction of designer-led NPD process brought democratic atmosphere to company, they experienced the benefit of cross functional communications and faced challenges with passion; meanwhile, they were on the way of doing radical new product which like many large companies, to find challenges, face it and overcome it. However, the drawbacks are obvious. Designer-led NPD is a relative time consuming way for developing new products. Consequently, the extra time cost generates additional expenditures. Staff members involve in designer-led NPD would have limited time for doing other works because of the workload is relatively high. It appears that the proper way for SMEs to develop new products is mixed two processes: applying the conventional NPD process for developing incremental products, while using the designer-led NPD for generating radical innovations.

5.7 Objective evaluation

Design awards participation was suggested in designer-led NPD process, it is a path for design engaged in marketing. However, not only the new product from designer-led NPD team will be delivered to the judge panel, the one from conventional NPD team will be delivered as well. It is also a way of making comparison of two results from different processes, and international recognized experts will be the judge. On the other hand, six months marketing sales data of the developed new products is collected and analysed as external objective evidence.

5.7.1 Award result and reflects

The international recognized design award “IF design awards” was recommended due to the appropriate schedule. Firstly, the two new products were mass produced and decide to be launched in July, the submission deadline was on 24th October, 2014, there was rich time for preparing required participation documents; secondly, the awards result was set to be released on 28th January, 2015, this matched the research schedule. However, none of the employees experienced in participating design award neither national nor international; they spent months for preparing those required two images of each product till the deadline approached.

Those required images were prepared by members from both teams, owing to their personal schedule and interests, project manager and designer of both teams were invited to prepare and select prepared files. Consequently, an internal committee for award participation was constructed by these four.

Figure 29. First images of “Smart Power” (Left) and “Ultimate Power” (Right)

In the agreement of members from temporary committee, the final agreed first images of “SP” and “UP” were the perspective view of product contents and product package; it displayed comparatively rich contents, from external package to product (Figure 29). And the second image of “Smart Power” emphasized the dual lighting colours by displaying a working photo (Left image, Figure 30). And the second image of “Ultimate Power” expressed the feature that the car charger was working together with mobile application, which is a concept that proposed by the graphic designer in next NPD begging process (Right image, Figure 30).

Figure 30. Second image of “Smart Power” (Left) and “Ultimate Power” (Right)

Those final prepared files were uploaded to the IF design award committee two days before the deadline. The required document production takes more than three months, and during the process of producing images (Figure 31), another NPD project since later July was proceed simultaneously (Chapter 6). In the process of images selection, designers in the temporary committee had no change to approach decision making, but those two project managers did. Two dissatisfy appears were made by two project managers, designers returned to their functional role, to satisfy project managers’ interests.

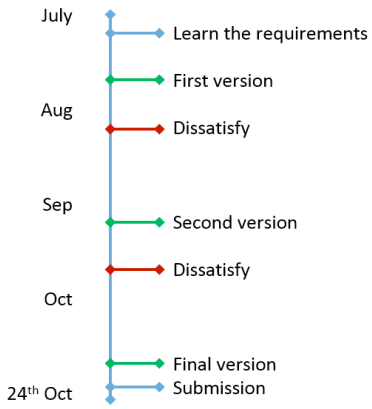

Figure 31. Dates and actions till submission

The award results were disclosed on 28th January, 2015. According to online records and received emails, neither of those two products was awarded. However, the result was not surprise to team, but triggered them started to look into products of award winners and reflected in different dimensions: Firstly, external causes, the nature of the award. They discovered most award winning products are consumer electronics, and focused much on appearance, shape, material and combination. Secondly, internal subjective causes, the submitted products, those submitted products were focused too much on functionality, the jury cannot observe the designed light, and according to App downloading records, no one tried to download the mobile application for testing during the jury session; meanwhile, those items were delivered in the package designed with saving costs, it to some extent decreased the overall experience of the products. Thirdly, internal objective causes, the design capability of company was not as good as international competitors. The self-reflected failure causes and future solutions were summarized in Table 27.

Table 27. Reflections of failing to win an international design award

	External	Internal	
		Subjective	Objective
Causes	Award nature	Products	Design capability
Solutions	Review and learn	Consider Jury's experience	Self-learning, cooperation

In terms of external facts, such as the lack knowledge and experience of

participating design award, they proposed the solution that to review and learn previous award winning products, especially those products located in a similar category. The delivered products were considered overlook the jury's experience, many aspects may miss to presented to the jury. On the other hand, the designed product was relying on only one designer's vision and experience, they reflected as to increase time on self-learning and involving more views on design by cooperation with others. The top manager of "USbright" expressed confidence of receiving those reflections, and recognized that design should not only about the tangible part of product, but all the associated "parts", which includes "package", "easiness of access the App", and "environment" where people met the product. He also pointed that "the value of product needs to be communicated correctly". He commented that the introduction of design-oriented NPD is valuable for company development, and emphasised that the award result "encouraged" him and all the involved staff: although failed to win an award, but started to create new things and has "courage" to compete with international giants.

5.7.2 Marketing data and reflections

Six months' sales data of the two new products were collected at the beginning of February, 2015. It is part of objective evidence of identifying whether design-oriented NPD performs better than their own NPD or not. There is

relatively no internal factors impact on the sales of the two products, because the top manager agreed to promote those two products at same level.

5.7.2.1 Calculation method

The marketing data was calculated monthly, started from August, 2014. For have a better understanding of the relationships of the sales number and profit return between products, marketing data of a former produced product, named “IG”, was also collected; additionally, the marketing data of “IG” in the same period last year was also collected to reference.

Tax to a certain extent impacts on company financial income, and the sales and transactions amount of company bank account determined the total tax. Most SMEs using external financial consultancies to deal with tax issues, so does the selected company. Firstly, the fees for having one in house trained financial and accounting specialist cost at least ten times more than using financial consultancy. This saved a considerable amount of company capital. Secondly, the external financial company were experienced in terms of managing SMEs' finance and produce financial reports, and capable to reduce the harmful impacts on company profitability. For those reasons and easy reading, the number of sales and annual income were in normalised data, and only use to reflect the relationships between these products.

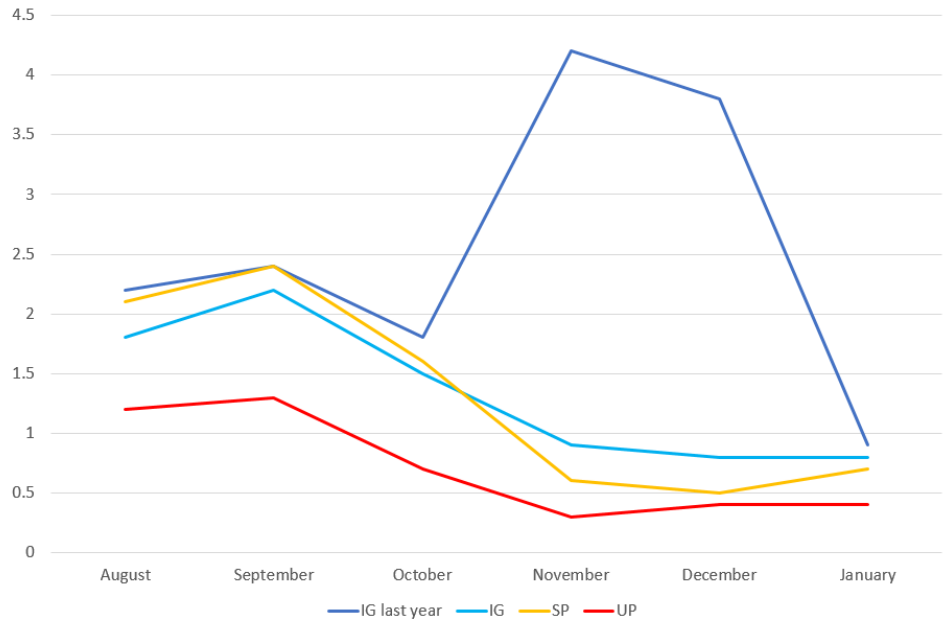

Figure 32. Number of shipments data from August 2014 to January 2015

In Figure 32, the dark blue line represents the number of delivered “IG” product from August 2013 to January 2014; the light blue line is the delivered numbers of “IG” product from August 2014 to January 2015; orange and red lines represent “SP” and “UP” respectively from August 2014 to January 2015. It can be seen that the shipment of IG slightly decreased in August 2014 than in 2013, and in September, the sales remained mostly the same; in 2013, the sales of “IG” in October had a little decrease but grow seriously in November and December, and suddenly decreased in January 2013. This related to a national promotion fair; it is one of the key variables that impact the sales and profitability (See detail in section 5.7.2.2). According to sales data form August 2014 to January 2015, “SP” had almost the similar marketing performance to

“IG”; and in terms of “UP”, which was developed from the designer-led NPD process, reached only about half of the “SP” shipment.

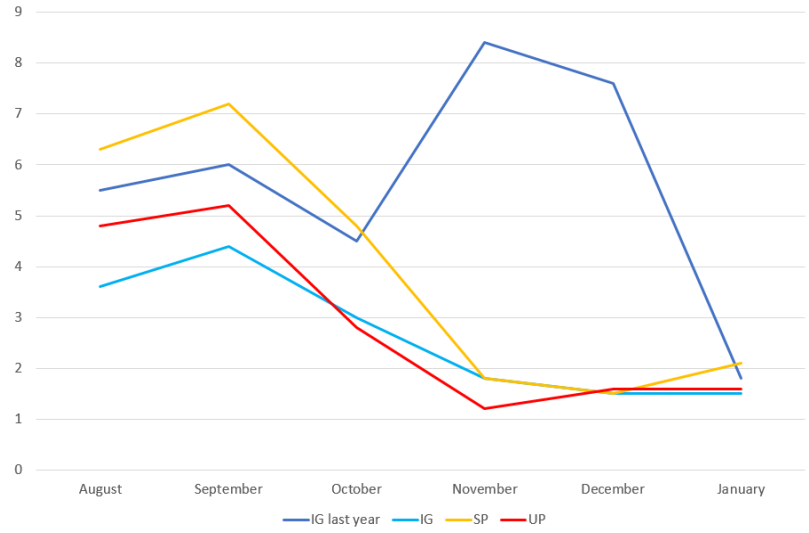

Figure 33. Profit capability data from August 2014 to January 2015

Figure 33 displays the profit capability of these products. Dislike the number of shipments, “UP” contributed more profit to company than “IG” this year, but cannot compare with “SP”. However, in November and December, the profitability of all the products are seriously decreased accompany with the decreasing of number of shipments.

5.7.2.2 Variables

The number of shipments and profitability are closely related to two variables. Firstly, the national promotion fair, known as double eleven in November

(11.11) and double twelve in December (12.12), seriously harmed the marketing performance of all products between August 2014 to January 2015. It also can be seen from Figure 33, the number of product shipments started decrease since October, owing to consumers were preparing to purchase in November with considerable discounts. The top manager complained that in last year, only in those two month, the marketing performance was good, but in January, the number of shipments decreased seriously, consequently he tried to avoid that situation happens again, and rejected to participate these national promotion events. However, according to the marketing data of August 2014 to January 2015, reject to participate those national promotion fairs, will not save the number of shipments in January, but seriously harm the company's overall profitability. He admitted that he overlooked the various substitutions for consumers during November and December.

On the other hand, the pricing policy impacted the sales. The unit cost of "IG" and "SP" is mostly the same; however, owing to the new feature of "SP", the retail price is at the price of "IG" last year. This year's "IG" was to set on 70 per cent of the price of "SP". Owing to the extra developing time cost and unit cost, the price of "UP" was set too high, it exceeded the price of "IG" and "SP" combined. Owing to the high pricing strategy, the number of shipment of "UP" was not satisfied the team's expectation; nevertheless, the profitability was considerable; subsequently, "UP" was internally recognised as successful to

be the tool of bringing the brand to approach high-end consumers. It encouraged the company to continuously producing high quality products, and continuously discovering the better solution in terms of relationships of pricing and profits.

5.7.2.3 Reflections

They previously acknowledged that low price was the only weapon for wining from market; according to the profit gain from selling “UP”, although it made less profit than “SP”, but displayed them the possibility of getting involve in mid to high-end market, and to have a larger profit margin. Accidentally, they learnt that rejected to join national promotion fair is a serious mistake, and planned to return to those fairs in upcoming years. The top manager commented that they will continuously and actively to participate any promotional events.

5.8 Summary

The parallel experiment has been applied after site selection and the conceptual model optimisation. According to the sales data and result from participate design awards, the introduced design-oriented NPD strategy did not make visible returns to company. However, the company still recognise the design-oriented NPD strategy is positive and brings valuable experience to them; this is reflected mainly by the result of the metrics tool. The soundest

evidence of understanding their acceptance of design-oriented NPD strategy is to make continuous investigation on their following-up NPD project, to learn whether their NPD activities is changed or not.

Chapter 6. Change: absorb and evolution

To further understand the impact after the design-oriented NPD is introduced, continuous data collection is conducted on their follow-up NPD project. Research techniques that include in the experimental process, such as observation, voice recording, access to their technical documents, photo shooting, requiring for screenshots (section 5.1.4), are followed for continuing data collection. Different from the experimental process, this NPD project is asked to follow their (mainly from the top manager) understanding of the design-oriented NPD that formed by the experiment. The data collection process is purely in an observing and documenting perspective, organised weekly with check and permission from the top manager, then extract to represent the whole NPD process, to display changes of their NPD behaviour.

6.1 The new NPD team and company strategy

In Later-July 2014, the two new products from the experimental process were mass produced and launched. The top manager expressed satisfaction on both the two outcomes, and especially, for receiving of the “dual-core” patent. Hence, he decided to start another NPD project. The first action was team building. According to the top manager’s understanding of the design-oriented NPD, he invited two vice general managers (project managers in former

experimental NPD projects) and all designers in the company (3 in total) to a meeting, and planned to have another NPD project. One vice general manager (the project manager in the former designer-led NPD team), withdrew from the meeting owing to his personal schedule and heavy tasks from OEM buyers (the other side business of the company), and consequently, a new team with four members was appointed by the top manager.

All of the designers in the company were selected (3 in total), experiences and backgrounds of team members are given in table 28. The project manager (PM) in the new team was the previous project manager in the “conventional NPD” team; designer A (IDa), an industrial designer, was selected in the “designer-led NPD” team in the former experiment. Designer B (IDb), the other industrial designer, was in the former “conventional NPD” team. Designer C (GD), the only graphic designer in the company, was responsible for the company’s website, packages, and brochure design, also he helped the package of former experimental products in the mass production process.

Table 28. Team members' expertise, functions and experiences

Identifier	Expertise	Function	Experience
Project Manager (PM)	Marketing, Resourcing	Previous manager of former conventional NPD team	More than 7 years experiences on marketing
Designer A (IDa)	Industrial Design	Designer in former "designer-led NPD" team	More than 4 years in product design
Designer B (IDb)	Industrial Design	Designer in former "conventional NPD" team	More than 4 years in product design
Designer C (GD)	Graphic Design	Responsible for website design and package for "SP"	More than 3 years in package and graphic design

The new setting of the NPD team was made by the top manager. In comparison with the team setting of the experimental design-oriented NPD project, engineering designer and technology specialist were removed, owing to the top manager perceived these roles are more important in the production process rather than the idea generation. Furthermore, during the "UP" pricing process, the relative higher development cost pushed him to price the product higher, and this inspired him to rethink the current strategy of the company and most competitors, which he commented "low on price", subsequently, "low on quality, and competing on price", and he recognised, "most products with international brands are relatively expensive". Thus, he proposed the "higher quality than the domestic product, lower price than the international brand" strategy, and collected all the "innovative minds" in the company, and aimed to produce "quality innovative products". Additionally, he gave no schedule to the

team, but full support to implement his new strategy.

6.2 Review loops

This NPD project was progressed in meeting-action loops: start from discussing and cross criticising detailed tasks, then conduct actions for next round criticism and discussion. The first meeting was initiated for finding directions, no guide lines or limitations was set. Each meeting was held by the project manager, in a free and open atmosphere for having a objective to for the next discussion.

In the initial meeting, IDa stated that “there are many car charger products decorated with metal parts, aesthetic and popular”, and suggested producing “a new car charger with metal appearance”. The IDb held the similar opinions and agreed with this direction. The GD communicated that the fundamental philosophy of wining on market, is “highlights” of a product, and suggested to have ideas by seeing from different angles. The PM confirmed that metal appearance is “aesthetic”, and also presented the negativity associate with metal appearance: may delivers the “feeling of conducting heat and electricity”, which closely linked to danger. And he suggested to “break the boundary” of current product lines, to have some ideas on other domains such as mobile power bank. These statements reflected their ways of having new ideas, except the GD, the others in team are all following the market trend.

Suggestions that given by each member are summarised in table 29.

Table 29. Initial suggestions and concepts

Member	Suggestion	Concept
Project Manager (PM)	Following market, expand product lines	Mobile Power Bank
Designer A (IDa)	Following market, renew former product	Metal decorated car charger
Designer B (IDb)	Following market, renew former product	Metal decorated car charger
Designer C (GD)	“Highlights”, differentiation	Application

While the IDa and IDb agreed to produce a new car charger to enrich the current product line, and the PM proposed to extend the current product line by adding mobile power bank, the GD held a different solution, highlighted the “highlights” of a product and proposed “differentiation” approach. He rose that to have a specified mobile application could be the way of differentiation. This aroused others interests and a discussion on mobile Apps; however, this not led to a final solution, but ended with “bring something to show next time”.

6.2.1 First Review Meeting

Base on the conversation in the initial meeting, those team members then went to seek ideas separately, and prepare to present their concepts in next meeting. The IDa and IDb spent days on browsing website, includes

e-commercial websites, using online search engine, design award website (during this time, The IDa and IDb were in the internal committee for preparing document for awards participation), cool products website etc. Similarly, the GD reviewed the e-commercial websites, and using search engine; besides, he also browsed and searched mobile Apps in relation to the keywords “battery”. The PM was carrying two side tasks, to deal with visits from OEM buyers, and solve complains from distributors.

According to the PM’s busy schedule, the first review meeting occurred after 3 weeks since the initial meeting, team members were asked to present their concepts. The IDa who designed “Ultimate Power” car charger, presented his “Ultimate Power +” (Figure 34). It was an appearance upgrade of “Ultimate Power”, metal parts, which he personally preferred, was added onto this new design.

Figure 34. “Ultimate Power +” concept(Left) and “Ultimate Power” (Right)

Besides, he also noticed that the former products, which have light from those USB ports, “those lights are blocked and unable to be seen while two USB ports were all occupied”; therefore, he added a small hold in the middle of two USB ports, and put a little “diamond” inside. However, this design concept was criticised by others in team, owing to the high appearance similarity of competitors’ products (Figure 35).

Figure 35. Car Charger produced by competitor

However, the car charger in Figure 35 is not originally designed, it partly copied a popular and award winning car charger designed by “Just Mobile” (Figure 36), but was sold at about a quarter of the price of the original one.

Figure 36. “Highway Pro” Car Charger produced by Just Mobile

the IDb presented a car concept with metal and leather decorates. In terms of the appearance, it also gained criticism from other team members, commented that it replaces only the top part of an original “Ultimate Power” by metal and leather textured plastic (Left image, Figure 37).

Figure 37. Leather textured Concept (Left) and Ultimate Power (Right)

Far different from those two industrial designers, the GD presented no computer simulated rendering or sketch, but a user interface design of mobile application, and suggested to have a mobile application with function of “battery management” (Figure 38). He mentioned that “Battery management” related Apps are popular owing to the high battery consuming of smartphones, to have a customised mobile App for the new hardware would be able to add value to the product; and he pointed that “others only sell hardware, we sell hardware and give free mobile App”, and claimed that could be the key differences.

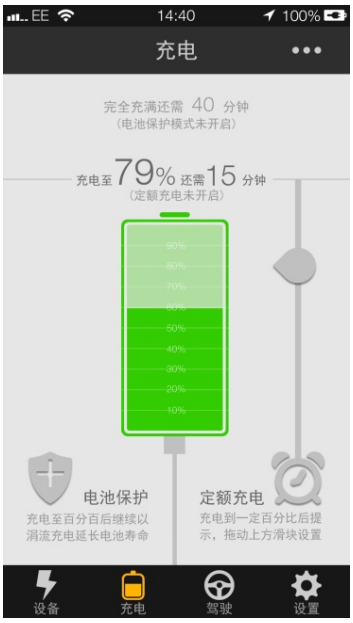

Figure 38. User interface of mobile app concept

He explained that the main function of the mobile App is “battery management”, which is “help users to understand current input, output and battery temperature while in charging or not”, and also “user can directly see and understand the remaining time for charging battery to full”. This relative different angle of having ideas received agrees and welcomes from other team members. The PM presented no concepts, but delivered the collected feedbacks from distributors and technicians, to help designers to understand what problems need to be solved and where can be optimised. He provided an issue that complained by many distributors, which received from users, “too tight in some cars”; he firstly thought this could be a technical problem and headed to engineering technician, but received the fact that “different cars may have differences socket sizes”, “one just fit into the socket of a BMW, may too

tight for the Mercedes". Accordingly, he asked technician to produce a form with accurate numbers to indicate the different socket size in different cars, and asked to give a most appropriate size (Table 30).

Table 30. Different car charger sockets size in different brand cars

	A	B	C	D	E	(Unit:mm)
D	21.20	20.85	22.25	20.80	-20.5/+17.75/ + B 16.85	20.5/+17.75/16.75
H	33.33/31.40	33.50/32.25	32.70/30.20/2.5	34.75/33.20/1.55		X>34
H-	25.25	25.25	24.90	26.00		
+	8.08	8.25	6.25	7.60	+7.30/P2.0/-24.4	X>8.5
-	19.73	17<x<19.73				X>20

According to the knowledge provided by the PM, the IDa made a comment that to make the width "adjustable", and received agreement from other members. Besides, the little diamond idea that contributed by the IDa, was agreed to be positive for being an extra working indicator. In terms of the mobile App idea, owing to the company had no software development experience, the PM promised to provide a list of software companies to outsource the mobile App development. This meeting ended with claim "to discover more rather than only focus on car charger" by the PM. All concepts, feedbacks of team members and actions before next meeting are summarized in table 31.

Table 31. First internal review

	concept	Feedback	Action
Designer A (IDa)	Ultimate Power+	Positive: little diamond	redesign
Designer B (IDb)	Leather textured concept	Nothing positive	redesign
Designer C (GD)	Mobile application UI	Positive	development
Project Manager (PM)	External feedbacks, support data	Positive	Seek external software company

In the first review meeting, one direction was emerged, which is to develop a mobile App for the future new hardware. The GD was responsible for developing required document for the mobile application development; however, the direction of hardware part remained blurry.

6.2.2 Second Review Meeting

According to the outcomes of the first review meeting, team members went to develop their own ideas separately. Those designers conducted research tasks by using secondary research, which mainly is collecting relevant information online. In the second review meeting, the IDa presented another car charger concept, and named it “Infinity Energy” (Figure 39). He visualised the former proposed “width adjustable” concept, and borrowed the mechanism of screws. He argued that the metal part of this concept is using anodised

aluminium, which was used on many smartphone design (e.g. iPhone), and contains no “danger” to users.

Figure 39. Infinity Energy Concept

The IDb gave a totally different concept than the last time, a mobile power bank for charging smartphones (Figure 40). He followed the former statement made by the PM and claimed “current mobile power banks on market mostly have huge capacity, consequently need all night to be charged to full”, and his concept was incorporated “high speed charging, not for mobile phones, but charge the mobile power bank”. He also introduced an animation on the front side of the mobile power bank, to indicate charging states. Additionally, he complained the difficulties of having a distinct and different car charger.

Figure 40. Mobile Power Bank Concept

The GD presented a new user interface, a UI design with many “Apple iOS” design language, and “the diagram displays the real-time battery current charge and drain”. He thought this mobile App would be able to deliver the feeling of “original”, and the hardware is professional and reliable.

Figure 41. Mobile User Interface

The PM provided him a list of software development companies. Companies in the list also included a referral price on developing similar apps, the highest one even 10 times higher than the lowest. He mentioned if have another car

charger, to have it in a compact size is the first priority; because “consumers claimed the merits of no blocking on former smaller products”. Besides, he restated that a metal part used on power adapters, and especially where has contact with the fingers, would deliver the feeling of danger, he criticised the “Infinity Energy” by saying “iPhone’s power adapter is made by plastic”.

However, using the “screw” approach to adjust width of car charger was supported by all members of the team, and praised by PM, and “it broadens the compatibility of car charger from fit into most cars to all of the cars”, he also mentioned “the animation solution used in the Mobile Power Bank concept could also be incorporated in many other product”. The Mobile Power Bank concept was reserved at this meeting, which means it will be optimised and conduct further development later, “because it shares almost similar technology with the car charger”. Based on the mobile App concept that proposed by the GD, a multi-function concept initiated by the PM was discussed: firstly, genuineness verification; the PM disclosed that “there do have someone copy our products”, and “most users cannot distinguish the fake one”. Secondly, functionality; the PM thought “have a customised application for the hardware, could be marketed as smart hardware”. Owing to the IDa and IDb have almost no experience on mobile application and UI design, all tasks associated with this mobile application development were assigned to the GD. Concept and comments and actions in this meeting are

summarised in table 32.

Table 32. 2nd internal review concepts, feedbacks and actions

	Concepts	Feedbacks	Actions
Designer A (IDa)	Infinity Energy	Positive “screw”	Redesign
Designer B (IDb)	Mobile Power Bank	Positive “animation”	Redesign
Designer C (GD)	“original” application	Positive, need more	Responsible for all
Project Manager (PM)	Supportive suggestions	Positive	Not defined

6.2.3 Third Review Meeting

In the second review meeting, the hardware direction mostly fixed to have a new car charger. IDa and IDb had some informal conversation towards to have a new car charger. IDb suggested IDa to revise the metal part, move from top to bottom of the product body, and IDa mentioned the “LED animation” could be incorporated. A “Smart Energy” concept initiated by IDb was proposed in the third review meeting, it combines the contribution of IDa and IDb. It has a “diamond” with breath LED, and “width adjustable” functions; for avoiding delivers a dangerous feeling, the metal part was set to down sides where fingers won’t reach. The two parts solution provided a possibility to do colour and material variation, to have different materials and colours match (Figure 42).

Figure 42. “Smart Energy” material and colour matches

Based on the visual and size produced by IDb, IDa simplified the appearance (Figure 43). The final simplified concept received consensus among all team members, and PM praised this design is a “fashionable functional object”. And also he mentioned that the different colour matches would helpful on making different pricing policy.

Figure 43. The “fashionable function object”

In this meeting, “Smart Energy” concept was confirmed to be moved to mechanical design. At the same time, GD was on tasks of the mobile

application side, and communicate with external software development companies. Concepts, feedbacks and actions associate with this meeting is displayed in table 33.

Table 33. 3rd internal review concepts, feedbacks and actions

	Concepts	Feedbacks	Actions
Designer A (IDa)	Smart Energy	Positive	Mechanical Design
Designer B (IDb)			
Designer C (GD)	Application in progress, nothing presented	\	Document development
Project Manager (PM)	\	\	\

PM asked one of the engineering designers to accomplish the mechanical design of this appearance. In days time, the engineering designer produced a rough mechanical structure design (Figure 44), and gave the specific size of inside space to technology specialist, for him to plan the PCB board design.

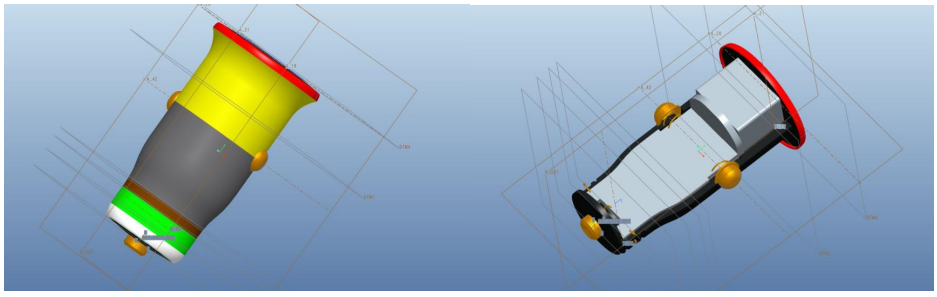

Figure 44. Rough engineering model for PCB board design

6.2.4 Fourth Review Meeting

Although the “Smart Energy” concept was confirmed, but details of the design still required to be developed; therefore, IDa and IDb worked on detailed design seperately. GD perceived himself can make limited help on hardware development, thus asked to focus on produce the required document for mobile application development, and was agreed to absent from the meeting. Therefore, the meeting was held by three team members. PM delivered the suggestion proposed by the engeering designer, aim to give more space to PCB board, to replace the former USB ports part with a smaller one (Figure 45).

Figure 45. The new smaller USB port (Left) and former large USB port (Right)

IDa and IDb agreed that change and mentioned it won’t impact the appearance. Furthermore, PM asked to clarify the material of the metal parts, and expressed worries about the product costs. He explained: this design will “increase the number of components”, subsequently, extra time for assembling is required; and the only approach to have high precision metal parts, is to use

CNC (Computer Numerical Control); therefore, the cost of per unit of only metal parts, account for the whole unit cost of former developed “SP” car charger.

In terms of the metal parts, IDa and IDb insisted their perceptions of having high precision products, and proposed to use cooper as material, with the reason of having better appearance and heat dissipation. Moreover, they also expressed the careless of unit cost and later on production process, such as the number of components and speed of assembling, and suggested to price the product higher. Opposite of this careless, project manager commented that he will consult the engineering designer to reduce the number of component, and find substitutions for reducing cost. This is summarised in Table 34.

Table 34. Concepts, feedbacks, actions in 4th review

	Concepts	Feedbacks	Actions
Designer A (IDa) Designer B (IDb)	High precision	Insist high cost Price higher	Detailed design
Designer C (GD)	\	\	\
Project Manager (PM)	Smaller USB ports High unit cost	Too Expensive production cost	consult engineering designer for cheaper solutions

6.2.5 Fifth Review Meeting

In the fourth meeting, GD absented and focused on the mobile application development. He presented his up-to-date documents in this meeting. Figure 46 is the delivered UI design of the “Battery Management” App. However, he mentioned that the selected software development company cannot fulfil some of the functions, such as explicit displays “current charge and battery drain”, and “the remaining life of battery”. He further explained that the software development company claimed they are capable to fulfil these required functions on iOS, but later on disclosed that can only provide those functions on jailbreak iOS devices. The team perceived this behaviour of the software company is cheating, and asked GD to change to another one.

Figure 46. The “Battery Management” mobile application

Aside from the “Battery Management” Application, GD also produced the architecture of the “big” App (Figure 47). The “Battery Management” is a part of

the “big” App. He explained that this “big” App integrated “verification (to avoid being copy, confirmed in the second review meeting)”, and “smart function (the ‘battery management’ function, to display detail battery information)”. And he also added “warranty management”, especially for users to understand the warranty, review detailed information of purchased products. Three pages were used in this mobile application to represent those three major functions, “product” page, “control” page and “options” page. He also explained the detail operating process of each function:

Firstly, “verification”: user can use the camera function to “scan” a unique QR code, and only the genuine code can be recognized and verified. Product information is enclosed in the code. If the QR Code is true and first scanned, the genuine product page will pop up; at the meantime, the specified “smart function” will be activated and linked with the product name in “product” page. On “control” page, user was permitted to rapidly retrieve the “smart function” that last time used. The “Battery Management” is the one to be displayed at this page. On “options” page, users are permitted to review they scanned products and review the remaining warranty time.

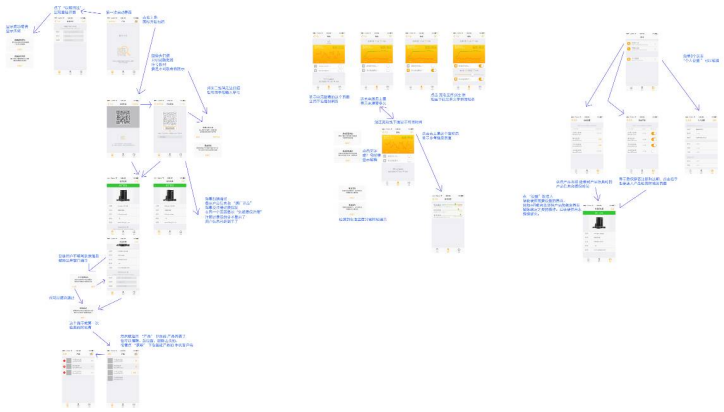

Figure 47. Architecture of the “big” mobile application

GD also considered the business side, and pointed that this app would be able to integrate a shopping mall for making it to a close circle, to introduce the next new product to existing consumers (Figure 48). It starts by obtaining user from selling current products, and while users use this mobile App, they can also get access to the in-app shopping mall, where they can purchase more products. PM mentioned this is about to become an IT company, “to build a platform and providing benefits, and gain profit by advertising and membership.” However, PM also mentioned that there were many “smart hardware” manufacturers already promote their products in this way, but the “verification” to activate “smart function” was considered new to him.

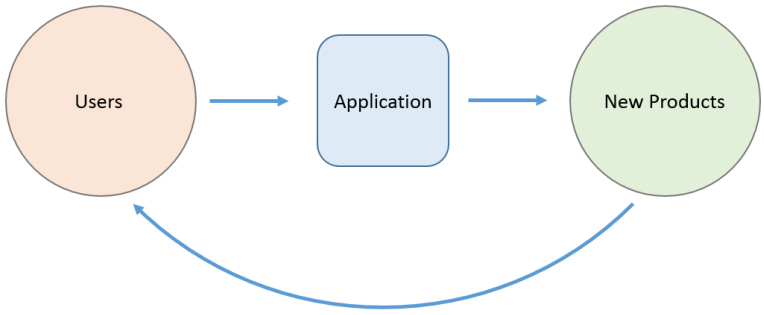

Figure 48. Relationship of User, Application and New products

In terms of hardware development, PM recognised the preliminary tasks is to reduce future production cost, he consulted the engineering designer and learnt that using cooper is far more expensive, but aluminium is acceptable, especially the anodised aluminium, which is “cost effective” and “hardly to be scratched”. This suggestion was supported by the industrial designers. And they presented their detailed design.

Firstly, IDa presented his computer simulated detailed design with five main parts (Figure 49). It combines pre-confirmed “diamond”, “width adjustable” concepts, and has a “bucket” body design. He claimed that this designed inherited the merits of “UP” (the outcome of designer-led NPD team in former experimental application), and the gapless plastic body would increase the toughness and deliver the feeling of high quality. He also mentioned the little edge and texts around the USB ports represented the “attention to details”.

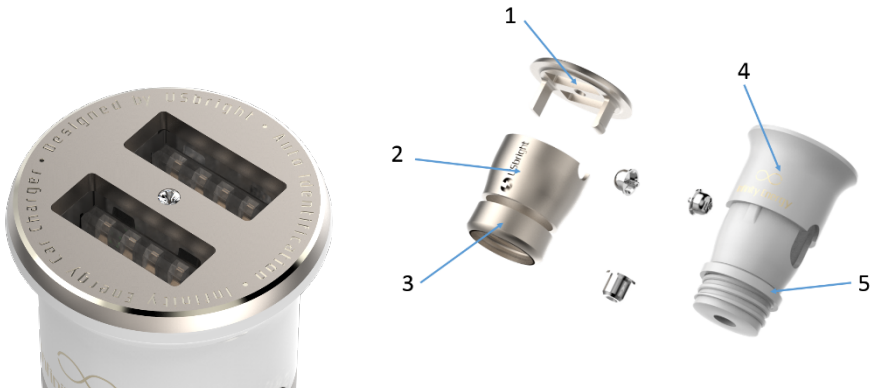

Figure 49. Detailed design by designer A

The other detailed design presented by IDb, it follows the roughly designed mechanical body provided by the engineering designer (Figure 50). It separates the product to two layers, inner layer and outer layer; and he claimed this is easier for assembling although there are more parts in this design.

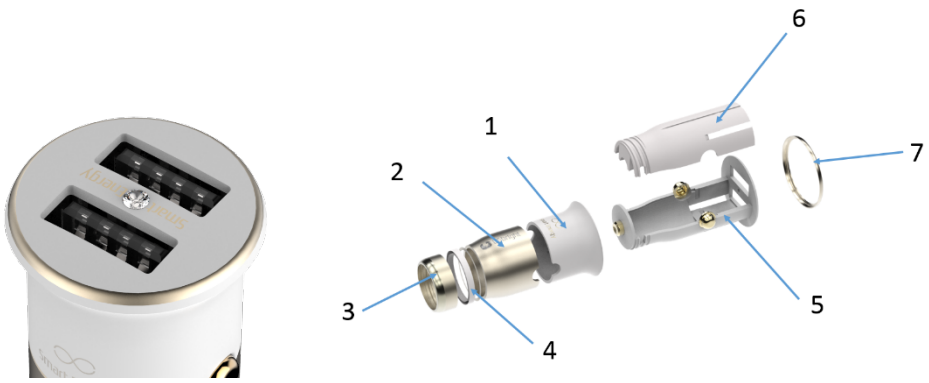

Figure 50. Detailed design by designer B

Owing to the less parts and comparatively high quality of computer simulated images presented, the detailed design produced by IDa received more votes.

PM claimed that fewer parts would decrease the possibility of making mistake, and GD commented “if the two products priced the same, I would prefer to have the one with more metal and details”. Consequently, the “bucket” body design was agreed to be delivered to engineering designer. Summary of this meeting is listed in table 35.

Table 35. Concepts, feedbacks, actions in 5th review

	Concepts	Feedbacks	Actions
Designer A (IDa)	5 Parts Detailed design	Positive	Detailed design
Designer B (IDb)	7 Parts Detailed design	Negative	
Designer C (GD)	Application Architecture	Positive	Development
Project Manager (PM)	Anodised aluminium as metal parts	Positive	consult engineering designer for redesign

6.2.6 Sixth Review Meeting

According to the final confirmed detailed design, PM committed the engineering designer to produce the full sized mechanical body. It was upgraded from the A-B combined body to the “bucket” shape body (Figure 51).

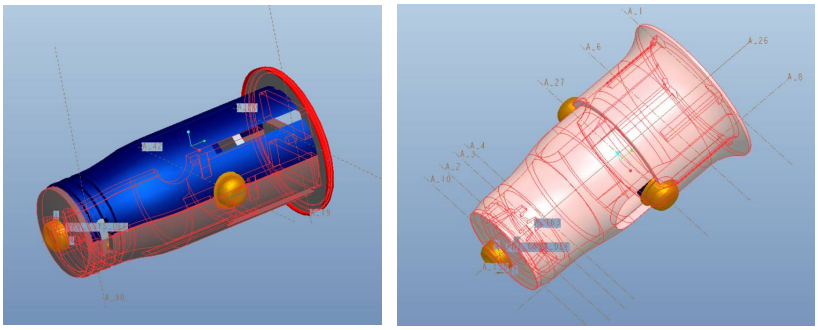

Figure 51. A-B combined body (Left) and bucket shape body (Right)

PM also provided the “screw” prototype (Figure 52). It gave confidence to team and proved that the “screw” was not only a concept but a mass producible idea. However, the “screw” concept was aim to be adjusted by fingernails, but on testing, it discovered that the fingernails will be hurt while the “screw” (Figure 53) is turned to the end. Therefore, IDa suggested to attach a small screwdriver with this product.

Figure 52. Adjustable negative dot, the “screw”

Figure 53. Positive dot, negative dot and spring prototype

Moreover, owing to this design was a combination of two materials, metal and plastic, PM pointed that the selected “PC+ABS” plastic have a certain degree of “shrink”, but metal won’t. Consequently, the order of production was determined by that fact, and the plastic part need to be produced first, then adjusting metal parts to fit into plastic.

There was also a discussion on the name of the product. “Smart Energy” was firstly agreed to be the name of the new product; however, PM pointed that this product have almost no relation to the former “Smart Power (The outcome of conventional NPD team in the experimental process)”, and “Smart Power” was priced at “entry level consumers”; “Smart Energy”, the name is easy confuse with “Smart Power”. The two industrial designers also noticed that the unite cost of the new product will goes far beyond the “Smart Power”; consequently, the name of the new car charger was returned to “Infinity Energy”. IDa mentioned that the design tasks that associate with hardware were almost

accomplished; it is the time to turn to package design. Therefore, he asked to think about the package design, especially on how to connect hardware and the mobile application. GD delivered the “inaccurate” issues on software development, PM expressed worry of investing on software, and owing to that hardware experience is not adaptable on software development. However, IDb proposed a solution to deal with this issue, and thus the software can be progressed (Section 6.3.3).

Table 36. Concepts, feedbacks, actions in 6th review

	Concepts	Feedbacks	Actions
Designer A (IDa)	Screwdriver?	\	Package design
Designer B (IDb)	Mathematical solution	Positive	
Designer C (GD)	Inaccuracy	\	Development in progress
Project Manager (PM)	Mechanical design “Screw” prototype Rename	Positive	Prototyping

6.2.7 Seventh Review Meeting

While the industrial designers were working on package design, GD was working on the mobile application, the plastic prototype was firstly produced (Figure 54). It is ABS (Acrylonitrile butadiene styrene) prototype. PM initiated a

meeting with two industrial designers, and they noticed that the new product even compact than it was in the screen.

Figure 54. ABS prototype parts

PM disclosed that the purpose of this meeting is to confirm the finish technique. “Regardless of the increased cost of using CNC to process the aluminium alloy, the main cost relies on appearance finish techniques”, he pointed the secondary anodising would cost far more than expected. Figure 55 displays the parts that require being secondary anodised. PM mentioned that the cost of doing secondary anodizing on the edge (Marked A, Figure 55) will increase the unit cost to 200% of anodising normal aluminium alloy; moreover, if have secondary anodising on the edge and texts (Marked A and B, Figure 55), the cost will be increased to four times of a normal anodised parts. At this time, owing to the serious high cost, two industrial designers agreed to remove those design for saving costs.

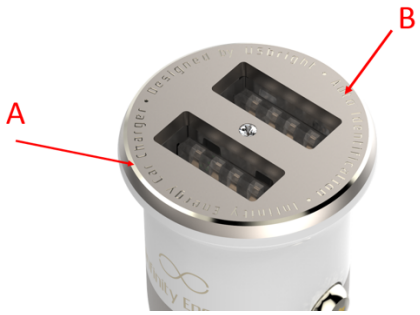

Figure 55. Secondary oxidation required parts

IDa provided a computer simulated image to compare the differences. It was recognised that the differences between using one time anodise and secondary anodise are not obvious (Figure 56), but largely different on cost. In terms of those texts, the PM mentioned according to his experience, it could be processed by laser etching, which is cost saving, time saving and high precision.

Figure 56. Simulated secondary anodise (Left) and one time anodise

Therefore, the production process was decided, from using secondary anodise to one time anodise with later etching. Owing to this selection, the estimate unit production price decreased. However, PM indicated that the unit price still goes two times of the “UP (the outcome of designer-led NPD team in former

experimental application)". And in terms of the "breathe LED", PM said that the technology specialist required two cable go cross the board to deliver signal. And IDb commented to integrate the cables onto the PCB board. PM and IDa thought that solution worth to make a try. Table 37 is a summarisation of this meeting.

Table 37. Concepts, feedbacks, actions in 7th review

	Concepts	Feedbacks	Actions
Designer A (IDa)	\	\	Package design
Designer B (IDb)	Integrate cable on PCB board	Positive	Package design
Designer C (GD)	\	\	Development in progress
Project Manager (PM)	Production techniques PCB design issues	Confirmed	Prototyping

6.2.7.1 Post-meeting tasks

After the meeting, considerable tasks were processed. The detailed prototyping tasks was carried by PM, industrial designers were developing the package, and GD still worked on the mobile application development, and also produced the laser etching files owing to his graphic design background. He produced the laser etching required files with three different options: the fonts from light to bold (Figure 57).

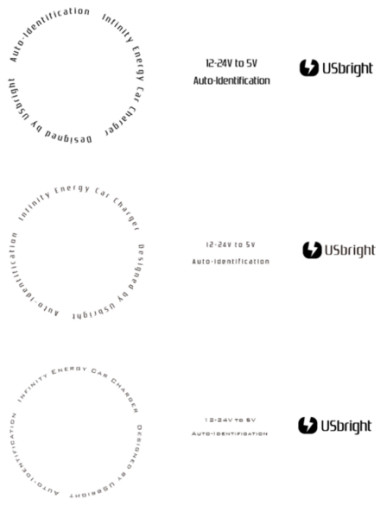

Figure 57. Screenshot of provided graphic document

PM consulted the engineering designer to produce the production required files, and he was provided five separate files represent the five parts of the product respectively (Figure 58). All of those files were sent to the representative of metal production.

HEAD_2015.igs	IGS 文件
COVER_2015.igs	IGS 文件
Body_2015.igs	IGS 文件
ABSPC_ring.igs	IGS 文件
ABSPC_body.igs	IGS 文件

Figure 58. Screenshot of production files

Those files were modified according to the production requirements, for especially satisfy the tool bit tolerance of the CNC machine. The main changes were made on the “USB cover” (Figure 59). The provided files require high precision and thus, the tool bit need to be replaced. For saving the cost of

purchasing new tool bit, but also satisfy the assemble tolerance, another engineering designer based in the metal factory redesigned the “USB cover”.

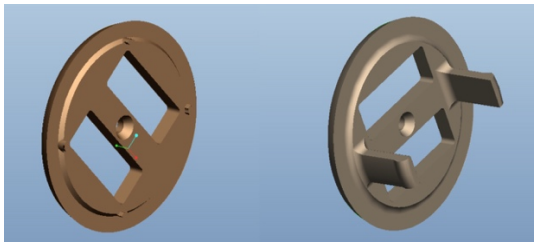

Figure 59. Former model (Left) and modified model (Right)

The provided version of “USB cover” was precisely designed to fit the plastic body, the engineering designer pointed that due to the shrink of plastic, the tiny metal teeth will tightly bite the plastic body. However, it was removed and redesigned. In the production process, all “igs” files were transferred to graphic drawings, and printed out to guide machining technician. A mistake occurred due to the small size of this part; the original design of the three “dot” in texts was misunderstood as holes, and three tiny holes were drilled (Figure 60). On the other hand, the appearance of those metal parts was asked to be produced in light golden, and they provided only in the colour of “original” aluminium alloy and black.

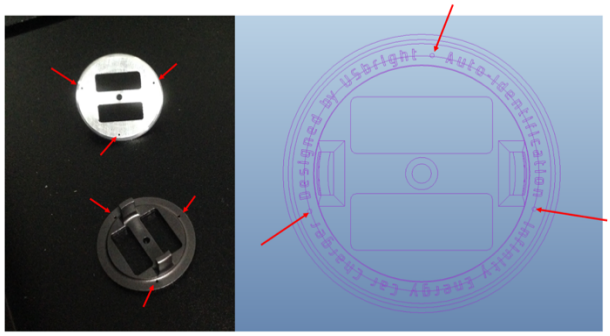

Figure 60. Drilled holes on misunderstanding of CAD drawings

6.2.7.2 Laser order experiments

In terms of using laser etching, the representative of metal production suggested two ways, later etching first and then anodises; or reverses this process. However, PM asked prototype with both ways. Figure 61 displays the prototype with anodising before laser etching. The text was obvious and the original metal colour was exposed.

Figure 61. Laser etching after anodising

Then PM asked to revise the process, laser etching before anodising, and asked to use light golden as the colour. A light golden prototype was produced, and displays in Figure 62. Neither the colour nor the laser etched text satisfied PM. The representative of metal production mentioned more tests are required, because there are no anodising facilities, he need to bring those metal parts to another factory, to adjust the colours, and also texts, and he also mentioned it is hard to distinguish the difference between those fonts.

Figure 62. Laser etching before anodising

6.2.8 Eighth Review Meeting

In this meeting, several hardware prototypes were presented (Figure 63). GD presented the functional and submitted mobile application prototype, and the two industrial designers provided their solutions of package design.

Figure 63. Part of produced prototype samples

In terms of the hardware prototype, all the team members including PM, agreed to have more tests till it satisfied the team. Complains mostly located on the texts, and finally agreed to choose the light fonts, and use the technique which laser etching before anodising. Additionally, owing to the rigidity of selected aluminium alloy and its tough anodised surface, scratches issue that took place on former plastic products, was solved by using metal.

According to those provided prototype, a serious issue was discovered and could potentially led product fail: A “huge” gap between the “USB cover” and “USB ports” was discovered by IDb (Figure 64), the causes of this issue was concluded by the PM as the poor accuracy of the tool bit in CNC machine.

Figure 64. Potential assembling gap caused by CNC tools

On the other hand, two package design solutions were provided and discussed. IDa commented that the package design for this product will be different from former ones, owing to its function of connecting hardware and software.

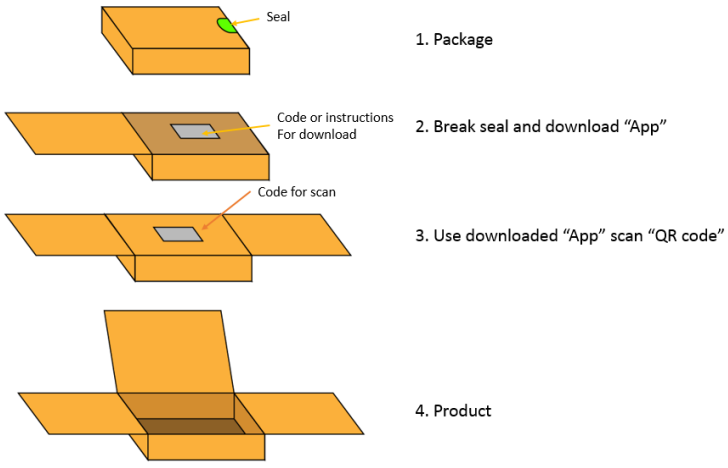

Figure 65. Package logic design by designer A

Figure 65 displays the solution that provided by IDa. He used two QR codes on separate places. "The mobile application needs to be downloaded first", hence he included one code for software downloading and the "other code for product genuineness verification". He explained that this package design solution

similar to the experience of opening a book.

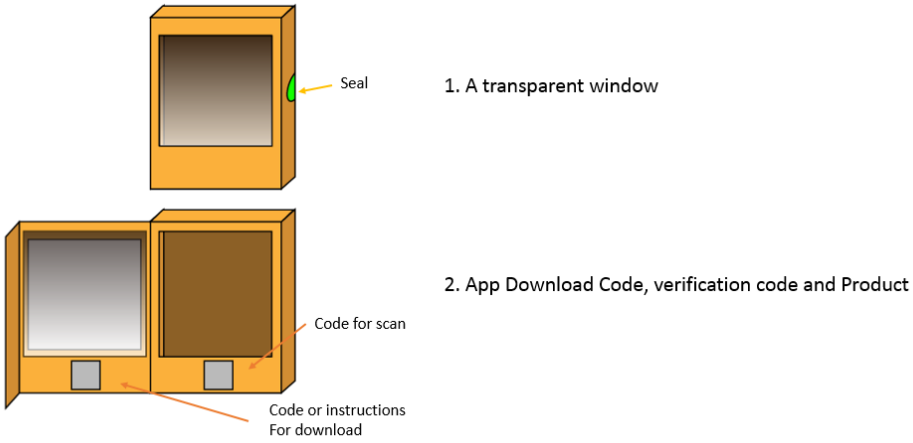

Figure 66. Package logic design by designer B

Similar to the book design of IDa, in Figure 66, IDb proposed a designed package with transparent window. He commented that the product “Infinity Energy” is a product with “the best appearance that the company or even the market ever has”, thus the transparent window offers a direct view of it. However, in team discussion, the package logic was not the key point, but the two codes. All team members considered that those two codes will to some extent complicate the experience.

Printed circuit board (PCB) is the main part to make the product functional. The “width adjustable” concept and compact design seriously compressed the space for placing PCB board; especially the “breathe LED” concept, the technology specialist firstly accomplished it by adding two extra tiny cables

based on former developed PCB board. IDa pointed that the two extra tiny cables solution would potentially increase the complexity of assembling, and also raises the failure rates, accordingly, IDb proposed a PCB board solution by integrating these cables onto the PCB board, and it was accomplished by redesigning the PCB board (Figure 67).

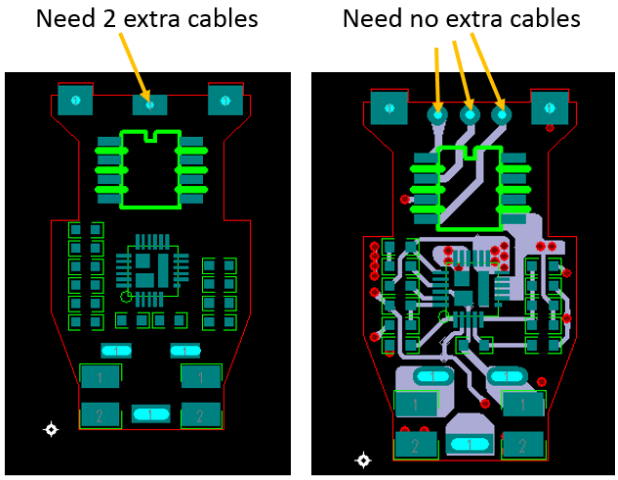

Figure 67. Former developed PCB board (Left) and new PCB board (Right)

GD presented the up-to-date mobile application prototype, and commented it has been submitted to learn the official review process. He learnt that each mobile application need to be submitted and reviewed by the operating system provider, and the review process is strict and the rejection percentage is high. Figure 68 displays the screen shot of the submitted application, it incorporated a diagram to display the real-time battery charge and drain. GD commented that he was focusing on producing the required document of the “big” App.

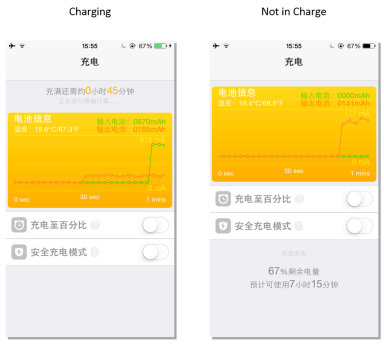

Figure 68. Main interface of the submitted application

The other team members tried the prototype, and complained the long wait for having the accurate data. GD commented that he tried to find new solutions, and according to his experience from consulting two software development companies, the required battery data cannot be accessed on especially iPhone, but will keep on seeking new solutions.

In this meeting, most hardware associated substantial tasks had been confirmed: the production required documents, material and finish. The software and package design were on the way. Those proposed concepts, feedbacks and actions are listed in table 38.

Table 38. Concepts, feedbacks, actions in 8th review

	Concepts	Feedbacks	Actions
Designer A (IDa)	Package design	Neutral	Package design
Designer B (IDb)	Package design	Neutral	Package design
Designer C (GD)	Application prototype	Neutral	Further development
Project Manager (PM)	Prototypes PCB solution	Confirmed	New tool bit More tests

However, owing to their almost zero experience on software development, the mobile application development was progressed slowly; moreover, they have to cooperate with external resources.

6.3 Mobile application development

Since PM provided the list of companies for mobile application development, the company which quoted the lowest fees was firstly selected to be the outsource partner; however, it was switched to another company (the second lowest) because the first selected company expressed dishonesty of their capability. The graphic designer (GD), who raised the idea of having a customised mobile application, was agreed to responsible for it. GD mentioned that he was using a step by step strategy to conduct outsourcing. He separated the mobile application development to two tasks, the first one is to develop the “battery management” function, and the other is the whole “big” application which includes “genuineness verification”, “smart function” and “warranty management”. He thought in the “battery management” development process, the development capability of the company can be learnt, and “according to the outcome, to decide whether move on to next step”, also he can “development the ‘big’ App required document while they were programming the ‘battery management’”.

There were five prototypes provided till the “battery management” application

was submitted. There are three documents to represent requirements and issues appeared in prototypes, and one animation was produced for representing the required experience in the application development process. This is summarised in Table 39.

Table 39. Stages till application submit

	Content
Requirement	11 pages computer drawings to explain requirement
1st Prototype	Functional application with plenty bugs
Requirement & animation	Bugs identification and animation guide
2nd Prototype	unaccomplished animation with few bugs
Requirement & issues 3	Inaccurate data and few UI bugs
3rd Prototype	Inaccurate function with (slide)
4th Prototype	Texts errors, performance
5th Prototype	Bugs most fixed, compatibility optimisation

6.3.1 The requirement document

GD produced the initial requirement, includes very detailed application pages. Those includes application icon, launch scree, warning pages etc. The application icon adopted the company trademark, and incorporated with standard iOS design guide (Figure 69).

Figure 69. "Battery management" application icon

GD mentioned this application mainly contained two pages, the main view is about to display some basic battery information and animation of battery charge and drain. The other page is “options” page, includes detailed battery information and “battery consumption by Apps”. The “battery management” is a simple application in terms of the number of pages. However, owing to the functions that incorporated in those two pages, GD used 11 pages to describe this App.

Figure 70. Launch Screen, not in charging and refresh

It starts from the launch screen. While the application was launching, the launch screen firstly appears (Launch Screen, Figure 70). It is an exact company trade mark with designed texts in vertical style. This follows the standard of application design, started by launch screen. And then the main view appears, with page title and an option button on the top, the dynamic

diagram in the middle and the remaining usage time at bottom (Not in charging, Figure 70). While slide-down, the app will “refresh” and displays the latest data (Refresh, Figure 70). The orange diagram displays much useful information: “battery temperature”, “current charge and battery drain”, and the diagram will automatic update with every two seconds. Also there were two switch buttons to control two functions, “charge to per cent” and “safe charging mode”. He explained “charge to per cent” is used to “understand the time cost for charging from now to selected percentage”. He gave an example, “if someone drive to my place and pick me up in 30 minutes, I can then use this function to learn how many batteries I will got before leaving.” In terms of “safe charging mode”, he explained “cold or hot charging environment will harm the performance of mobile phone battery, therefore this function is used for warning users to disconnect the charging cable in that situation.” Bellow those two switch buttons, there were small texts indicate “not in charging”, and followed by larger texts display the remaining battery usage time. At the end of the page is the company name in text.

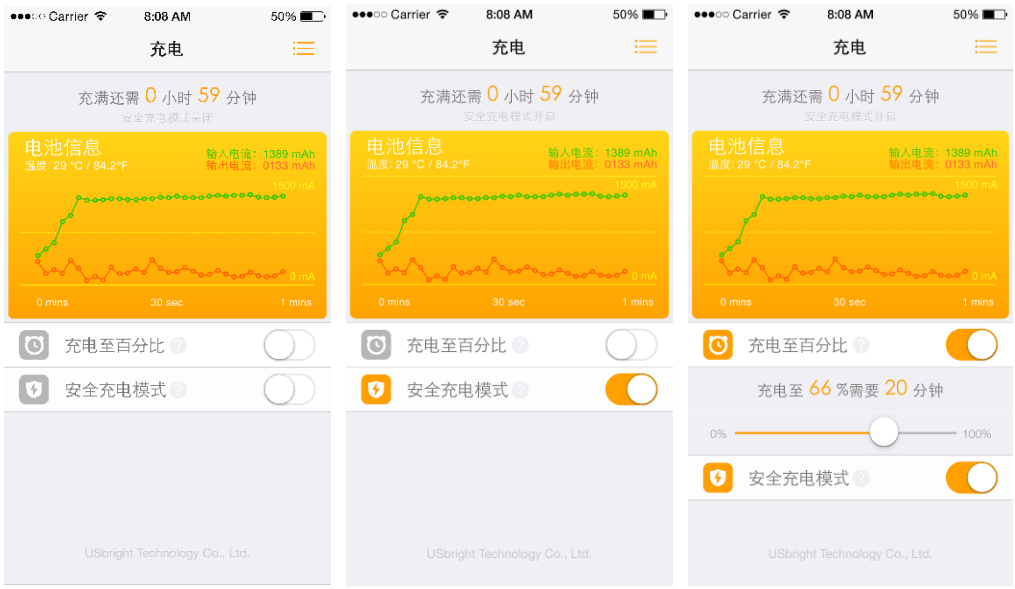

Figure 71. In charging page status

He also logically considered the application in various situations, such as the battery charging status changes (Figure 71). While in charging, the bottom texts will disappear, and “required time for charging to full” appears on the top of the orange diagram. Green coloured lines appeared to indicate the battery current charge. Also there is a line of very small texts between the “required time for charging to full” and the orange diagram, used to indicate whether “safe charging mode” activate or not. While switches were switch on, the colour of icons and switches will turn to orange, and for “charging to per cent”, the slider bar will appear (Right image, Figure 72).

Figure 72. “Options” page and warning page

Figure 72 displays the designed “options” page and warning page(s). In “options” page, the top three lines of texts and bars display “battery temperature”, “battery life” and “capacity”. Below is the application discharge rank, displays from the most battery consuming application. In terms of warning page(s), “there are four different one”, these are “battery too hot”, “battery too cold”, description of “charge to per cent” and description of “safe charging mode”. GD communicated with the representative of the final selected software development company before all prepared files were sent.

6.3.2 First application prototype and issues

The first version of the functional application prototype was delivered in a week; however, plenty of issues and bugs appeared, GD summarized it to a

document with proposed solutions for each issue. Those discovered issues and solutions are given in table 40.

Table 40. Discovered issues and bugs, proposed solutions

	Discovered Issues and bugs	Proposed Solutions
Issue 1	Dark edge of app icon	Square image
Issue 2	Launch screen error	Bug
Issue 3	Main page pop-up from bottom	Launch screen fade out
Issue 4	Solid page	Dynamic page
Issue 5	Font and touch sensitivity	Bug
Issue 6	Gestures are not supported	Add gesture functions
Issue 7	Input current error	Bug

The first discovered issue is the application icon; the given application prototype has a visible dark line around edges of the icon (Figure 73). GD claimed that “App icon is the media for users to have the first image”, it is “equal to brand logo on tangible hardware”.

Figure 73. Dark edged icon (Left) and Normal icon (Right)

This almost invisible flaw is discovered by GD, and he concluded that the causes of this issue owing to the low resolution of image or using of edge-filleted image. He mentioned that most screens of nowadays mobile

devices have higher resolution, “at least 326 PPI (pixel per inch)”; therefore, the prepared image file must “have 326 DPI on screen or more”. Furthermore, the image required for development is better to be “squared image”, the “edge will be processed by devices automatically while displaying”, consequently, there was no need for edge-filleting. GD also produced the differences of those icon images, and it is displayed in Table 41.

Table 41. Image files for a correct icon

			
Low resolution	Edge-filleted	Squared (correct)	Icon on device

GD commented that “low resolution image will cause image blur while displaying on mobile devices”, furthermore, “the inaccurate edge of low resolution images will cause dark edge”, and “issues appears on edge-filleted images as well”. “Squared image” is the only appropriate files for icons on Apple’s mobile devices, and while viewing on devices, the squared image will be edge-filleted automatically.

The continuous issue was an easy identified problem. Launch screen of the given prototype is obvious larger than provided design layout (Figure 74). The cause of this issue was acknowledged as different layers of using images, and mostly relies on coding errors.

The third discovered issue was related to an animation, “the main page pop-up from bottom overlaid the launch screen”. GD pointed that this way of displaying main page is abnormal, strengthened the importance of logo, and less emphasis the main page. Therefore, he suggested replacing the pop-up animation to launch screen fade out.

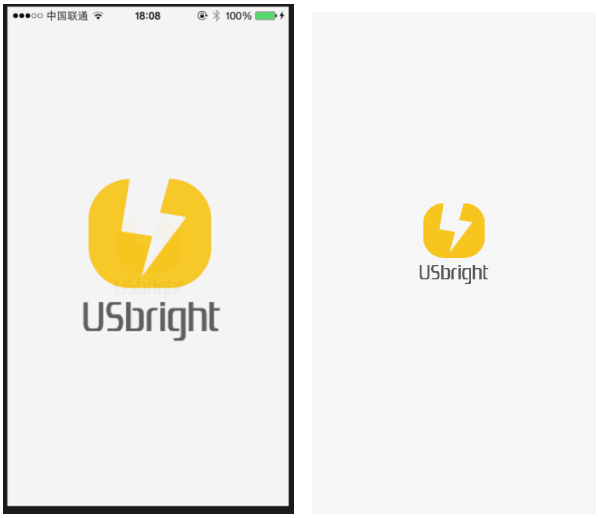

Figure 74. Brand logo on App (Left) and designed layout (Right)

However, “pop-up” was the only animation, in other words, all user experience related animations were overlooked. “Developer only do what asked”, GD commented, and explained “Flash (An animation software of Adobe) is popular tool for communicating with developers”, to tell them what animation transfer the “correct” experience. Consequently, an animation contains all required experience was prepared for communicating the required experiences.

Beside, fonts were bolder than required, similar to those issues in metal parts

prototyping process, they hard to identify the differences between fonts. Owing to the required font is Apple default font; mistakes only took place on font size. In terms of gesture functions, GD asked to activate “return” use “slide from left to right”, regardless of slide from the screen edge or the middle of the screen. Moreover, one of the most important application functions, the data of battery charge was inaccurate. GD pointed that the difference of using normal computer USB2.0 port and power adapters.

6.3.3 Second Application prototype bugs and comments

Although the requirement document and animation were provided to the software development company, aside from little mistakes such as wrong explanation sentences, some significant flaws also appeared in the second prototype. Firstly, the current output and input animation (Figure 75), which required being a smooth animation and the data was asked to be updated every 2 seconds. The representative of software development company (RepS) mentioned that those “current data is generated by memory calculation, it requires at least two second to obtain a new data, and therefore the animation only can be displayed after every two seconds, consequently it cannot be a smooth animation”; additionally, “the data of charging current is also using memory calculation, it cannot be specifically accurate as using professional devices”.

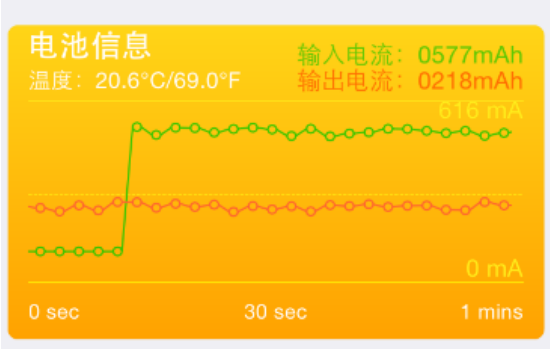

Figure 75. Animation area screen shot

For solving the first difficulty, GD proposed to have “a two seconds delay” while displaying the animation, consequently, the animation can then be smooth, but those data was not real-time data, but two seconds before. However, he mentioned that “people cannot perceive those differences on data, but can obviously know those imperfections of animation”. In terms of the inaccuracy issue while displaying the input current, GD asked technology specialist, who in charge of PCB board development, to provide a diagram with li-on battery charging and consuming details (Figure 76) and differences of charging Apple’s iOS devices (Table 42).

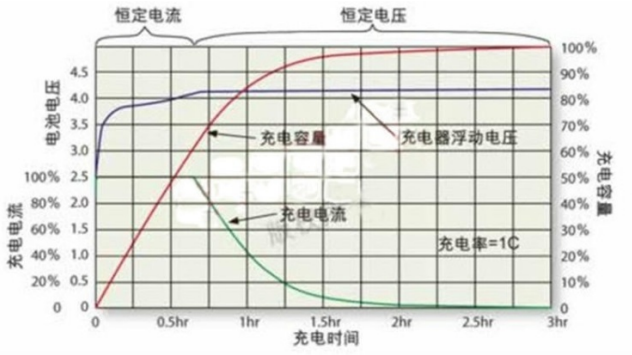

Figure 76. Li-on Battery charging and consuming diagram

The provided battery charging and consuming diagram displayed the relationships between charging voltage, current, and battery capacity clearly. However, RepS complained that the software development is far from hardware, the real current input on iOS devices is forbidden to be accessed. Consequently, those provided diagram and differences of devices and adopters have no meaning on software development.

Table 42. Different adaptors and charging capability on different devices

	USB2.0/3.0	iPhone 标配充电器(5W)	2.1A （ 10W ） iPad 充电器	2.4A (12W) iPad Air 充电器
D+,D- 设置	其他	2.0V,2.7V 或短接 (0V,0V)	2.7V,2.0V	2.7V,2.7V
Iphone 5	最大 0.5A	最大 1.0A	最大 1.0A	最大 1.0A
Iphone 5s/5c	最大 0.5A	最大 1.0A	最大 1.0A	最大 1.0A
Iphone 6	最大 0.5A	最大 1.0A	最大 1.4A	最大 1.4A
Iphone 6 plus	最大 0.5A	最大 1.0A	最大 1.6A	最大 2.0A

GD reported this inaccurate issue to team, and obvious a simulated current data was not satisfied. “The meaning of having this mobile application is to help our users to understand the true capacity of our car products”, PM expressed anxious of the spent on software development. However, IDb suggested to deal with it by using “mathematical approach”, “calculate the time for charging one per cent battery, and according to the time cost and device battery, it able to calculate the true current input”. This suggestion was internally agreed and transferred to RepS.

6.3.4 Continuous bugs and solutions

Within a week, the third prototype was provided, animation was smoothed and input current was relatively accurate. However, the touch sensitivity issue remains owing to conversations in former communications were highlighted on input accuracy and animation issues. Moreover, while touch the “option” icon, those data in “charging page” will be reset. RepS provided a solution that using a different way of navigation, remain gesture left and right slide functions and remove those top navigation (Figure 77).

Figure 77. Top navigation bar (Orange)

RepS also expressed worries of losing this client, and promised to optimise this application till it satisfied and also downloadable on Apple’s App Store. Therefore, GD agreed to permit them longer time to fix those discovered bugs and optimise the experience, and turned to produce the “big” App, which the “battery management” is just a part of it. RepS was responsible to remove those discovered bugs, texts errors and optimise the application performance and compatibility before submission.

6.3.5 Review feedbacks from Apple

However, in about a month, although there are complains on the application performance, the developed application finally accepted to be submitted, but the review process was also not smooth. At the first and second reject feedbacks, application reviewer from Apple included following words:

> We have begun the review of your app but aren't able to continue because we need additional information about your app.
>
> At your earliest opportunity, please review the following question/s and provide as detailed information as you can in response. The more information you can provide upfront, the sooner we can complete your review.
>
> What is the purpose of the app?
>
> Who are the target uses?
>
> Is this an existing service? If yes, where?
>
> How does the user obtain an account?
>
> What are some features, services, or privileges associated with an account?
>
> Is additional software or hardware required?
>
> Is there additional charge for mobile access?
>
> While you iTunes Connect Application State is displayed as Metadata Rejected, it is not necessary to upload a new binary. Once you reply to this message in the Resolution Center, we can proceed with your review.

RepS mentioned that is normal while receiving "metadata rejected", only additional information was required for them to understand the purpose of this application. However, while required information was given to RepS, such as

basic company information, and the rough purpose of this app in Chinese, consequently, the second time “metadata reject” took place. RepS then asked GD to explain the purpose of this app in details, and used both Chinese and English replied the second “metadata rejected”. GD delivered this rejection information to team, and it caused worry of the whole team, especially GD who proposed this concept and was in charge of application development. The team and GD believe that while this “smart function” application is rejected, also means the “big” App will be rejected as well. And in contrast, RepS consoled, and explained that it is a normal situation according to his experience, owing to the strict review process of especially Apple. Table 43 displays the detailed date and content in application review process.

Table 43. Application review process

Date	14th Jan, 2015	24th Jan, 2015	3rd Feb, 2015	10th Feb, 2015
Content	submission	Metadata rejected	Metadata rejected	Pending developer release

In result, the review success information was cost 27 days. The final result greatly encouraged the team, and to some extent, re-constructed trust with the selected external software development company. According to the result, the team decided to invest more on developing the “big” App, and keep working with the selected software development company.

6.3.6 Continuous development

During the process of developing the “battery management”, the development required document of “big” App was in progress. Similar to the “battery management”, GD prepared 30 user interface pages, with 20 normal pages and 10 notification pages (Figure 78). However, there was only three main pages in bottom navigate bar, represents the three main functions, “genuineness verification”, “smart function” and “warranty management”.

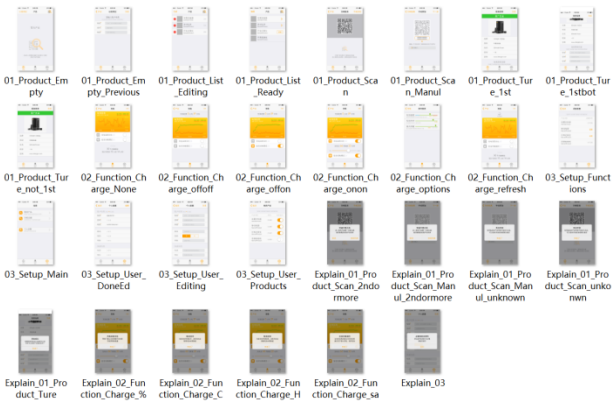

Figure 78. Prepared images for the “whole app” development

The first main page is a list for displaying scanned genuine products, and a “+” mark on the right top is used activate the camera for scanning the QR code. If the QR code was from the genuine product, the “genuine product” page will appear, with detailed product information, and the texts, “genuine product” in large and bold font, is displaying on the top of the page, and the other product related information follows, such as brand, product name, warranty and official

website (Figure 79).

Figure 79. The succeeded verified “genuine product” page

While one genuine QR code is scanned, the product name will be added into the list, click the name of the listed product, it will turn to the second main page and launch the product associated “smart function” (Figure 80). “Battery management” was the only developed “smart function”, therefore GD used the designed UI of “battery management” to display the logic of the “big” App.

Figure 80. “Smart function”, the developed “battery management”

The third page is mainly used for product “warranty management” (Figure 81),

and also able to choose display or not display verified products. It is available to review the detailed information of scanned products, and also send texts and images to consumer service. The warranty status is also displayed to indicate whether the purchased product in warranty or not.

Figure 81. The “option” page, for product “warranty management”

The above pages were modified few times while the “battery management” application was in its reviewing process, it firstly started with using the name of company “USbright” as the name of this “big” App; however, GD commented that the company logo leans too much on power adaptors, and this “big” app goes beyond it, and then produced a new app icon which he explained it is a combination of “verification”, “smart” and “quality” (Figure 82).

Figure 82. First edition Logo (left), an eye represents “verification” (mid left), a Wi-Fi icon represent “smart” (mid right), a Magnifier icon represent quality products (right)

Moreover, icons on the bottom navigation bar was also modified, from using the “infinity” icon (bottom image, Figure 83) to the “combination” one (top image, Figure 83). Additionally, the application system colour was also changed, from using the former “orange” to the Apple suggested “blue”. GD commented that would have the consistency of the original Apple applications.

Figure 83. The “combination” icon (top), the “infinity” icons (bottom)

On the other hand, GD perceived the “metadata rejected” feedbacks from Apple was mostly his fault, because he perceived that he raised the idea to have a mobile application, and felt guilty if it fails to be accepted. Therefore, he spent both working days and weekend to optimise the application. And the final team agreed application name, “MrCarer” was proposed by him. He mentioned that the company strategy is to develop car accessories, and he added “er” after “car”, to express the user of this application was also a car owner. The words then become “carer”; He also added a “Mr” before “carer”, the “big” then named “MrCarer”, means a carer to take care the products of car owners. He designed a smile graphic with bow tie (Figure 84), to emotionally shorten the gap between technological devices and users.

Figure 84. Designed smile graphic with bow tie

GD embedded the smile face with bow tie in most interaction interfaces, and the bow tie, consequently became the application icon (Figure 85), contains also the figure of signal, he commented that “smart devices” requires “signal”.

Figure 85. Mobile application “MrCarer” icon

6.3.6.1 ”MrCarer” development document

GD redesigned the former produced development document, replaced the former company logo to the smile face as launch screen (Figure 86). In the development document, he explained the application in the angle of application users.

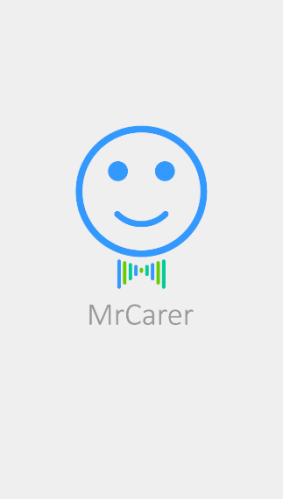

Figure 86. Launch screen of “MrCarer”

In figure 87, it displays the launch screen, while touch the “+” mark on top right, it able to activate the scan and verification function. The bottom navigation icons remain the former designed application icon. And in scan and verification page, the torch function was embedded.

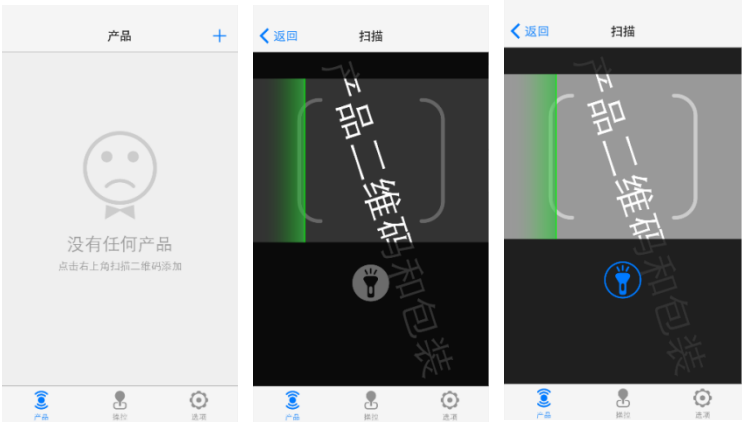

Figure 87. Firstlaunch(Left),scanwithtorchoff(middle),scanwithtorchon(right)

GD also included four possible failed notifications after scanning (Figure 88). Firstly, the QR code is not recognisable. He said the QR code is hidden inside

the package, this notification only appears while the code is not the genuine one. Second possible notification is internet connection issues, “while there has no internet access, scanned information cannot be sent to server for verifying”. The third possibility is for the case of repeat actions, “while a user scans same code more than one time”, this notification will tell “this code has been scanned by you”. He claimed that each code is designed to be correctly scanned only once, and while the counterfeiters copied the same code that other one has scanned, a notification will appear “this is a fake product”.

Figure 88. Possible notifications of scanning

GD mentioned that those four notifications covered almost all situations while scanning an abnormal code. Meanwhile, a normal genuine code contains two situations, he thought one product could be used by more than one people, firstly one is the user, and the others family members or friends of the user could also use the same product. Therefore, he designed two types of successful pages (Figure 89). First one is for the user, who scanned a genuine

product code that included in the product package, and all product related information with product photo will be displayed (Left image, Figure 89). The product information includes brand, and is represented by the logo of product brand. “Product category” is the general name of a product, such as “car charger”. And the specific name of the product, in the given designed layout, he used “Ultimate Power” as example, hence the specific product name is “Ultimate Power”. Product warranty was also included as part of displayed information, he mentioned, since the first scanning of the genuine product code, the warranty timer automatically started. The last information was the official website of product producer. On the second type of successful page, the coloured decorated large texts will be different, it clearly explains the type of scanned code (shared) and meanwhile, the warranty information displays “not available”.

Figure 89. Genuine product (left), shared from friend (right)

Once a code was successfully scanned, the code information associated

product will be added into the product list on the main page (Figure 90). “Shared” product has a blue mark on the top right of the product profile figure. GD also included explanations of gesture actions, “hold and draw” to reorder those added products, “slide to left” displays product options, such as “detailed information” and “not display”. He explained that “not display” not means “remove” or “delete” all product information, but just disable to display that product in main page.

Figure 90. added product list (Left), reorder(mid), editing(right)

In terms of the “detailed information” (Figure 91), he introduced two types of pages to distinguish the different origins of product. These pages were similar to “success page” in figure 89, but added extra options. “Contact consumer service”, “function setup” and “feedback”. “Contact consumer service” was direct send product related queries to product producer; “function setup” is for reset some functions for products that required firstly “paring” with mobile

phone. “Feedback” was used for sending messages that irrelevant to products.

Figure 91. Product detailed information, original scanned genuine product (left), shared from friend (right)

The default “smart function” page was a sad faced while there was no product in the list (Left image, Figure 92). However, while a genuine product was scanned, touch the name of a verified product, it will launch the linked “smart function”. In the designed layout, GD used the “battery management” as

example (Right image, Figure 92).

Figure 92. Touch “smart function” while have no product in list (Left), touch “car charger” while it in product list (right)

He also enclosed that the “smart function” button always activate the last used “smart function”, it is a pathway for activate frequent used function.

On the “option” page, which formerly named “warranty management”, four items are listed. These are “my products”, “function setup”, “personal setup” and “feedbacks” (Left image, Figure 93). “My products” is used for displaying all scanned products regardless those products were displayed in main page or not. On the right of each product name, a switch button to rapid control whether displaying this product on main page (Right image, Figure 93). Furthermore, the warranty status was included between the product name and its switch. While the product name was clicked, it will redirect to product

detailed information page which given in Figure 96. Similar to “my product” option, “function setup” was also used to display products, but only those ones that require additional setup, such as paring and password setup etc.

Figure 93. Option page (left) and product management (right)

GD tried to remove the registration process, replaced by using an automatically generated random user name, while user want to keep those scanned products, they are able to register accounts in “personal setup”, register an perminant account and save the product list onto server (Figure 94). GD also commented that while users change their mobile phones, they can use the same key information to retrive those saved product list. This similar to most user account registration solutions; however, GD gave the registration rights to users.

The last option was “feedbacks”, for sending message that irrelevant to

prdoucts. It includes three choices, “reporting counterfeit product”, “reporting dispute” and “other issues” (Mid image, Figure 94). The function of it similar to “Consumer service” (Left image, Figure 94), users are permitted to send texts and photos to explain their affairs.

Figure 94. Personal information viewing (left), editing (mid), retrieving (right)

Only users with appropriate “personal” information were permitted to user “consumer services” or giving “feedbacks”, which means users have to register before using these two functions (Right image, Figure 95), for the consumer service team to know whom to contact with.

Figure 95. Consumer service (left), feedbacks (mid), not registered (right)

Those designed layout images were given to the outsourced software development company. They pointed that those asked functions cannot be fulfilled until a server is built. They also presented two solutions, first one is to purchase a computer with all days on and internet connection, and then they can help on built firewalls for data safety, IDEs (Integrated Development Environment) for server software development. Second solution was bought a cloud server, no need for building any firewalls or IDEs, but has to pay by using time. GD communicated with PM and finally selected the later choice, to use the cloud server. This comparatively saved a considerable amount of server hardware costs and reduced most data loss or discloses risks, because those cloud server providers are promising almost 100 per cent data safety and full functional runtime with free data backup.

In terms of the server side, the outsourced company required no development

document, but only a choice of given options. It was about the control system on server-side, to develop the control software on Windows system, or having a website system that can be remotely operated online. Owing to the server was told runs on cloud server, and the cloud server provider offer online data management access as well, consequently, to have a website alike server-side control system was agreed to be the required data system.

Similar to the process of developing “battery management” application, bugs appeared frequently owing to the complicate logical architecture of “MrCarer”. The most critical one was on the “smart function” page (Left image, Figure 96). While user activates a “smart function”, changes pages (touch icons at the bottom navigation bar) will cause re-launch the “smart function”, and this was a flaw that cannot be solved by re-writing the application codes.

Figure 96. “smart function” page (left), re-designed “smart function” navigation with “back” button on top left (mid), re-designed layout (right)

Consequently, the “GD” re-designed the software architecture, as well as the user interfaces: while user touches the name of a product in the product list, instead of displaying bottom navigations, “back” button was displayed on top left, with no bottom navigation (Mid image, Figure 96). He also replaced the former “smart function” icon to the “discover” icon in bottom navigation bar, and left a smile face on that page (Right image, Figure 96), and commented the detailed content in that page need to be discussed with team.

6.4 Ninth Review meeting: the top manager involvement

The unusual time cost and fund spent aroused top manger’s attention. Team members prepared a PowerPoint file and presented recent in progress works.

Figure 97. Infinity Energy car charger CAD images

Figure 97 displays the presented CAD images with various “Infinity Energy” car chargers. PM indicated that “different colours and materials collocation would help on product variation and consequently the number of sales”. And also the

“breathe light” and “width adjustable” function was introduced to the top manager (Figure 98).

Figure 98. Patented lighting USB ports with breath light and screw alike metal dots

Top manager praised the ideas of “breathe light” and “width adjustable”, and commented that the appearance of the new designed car charger could bring the brand to high-end consumers. In terms of the mobile application, those encountered difficulties and potential risks were not communicated, and also the first developed “battery management” was not mentioned. The mobile application, “MrCarer”, was firstly presented by a previous designed layout by the graphic designer (Figure 99).

Figure 99. Whole app UI that included in presentation

Dislike given direct praise on those hardware ideas, the top manager spends quite a time on trying the given “MrCarer” prototype, and mentioned about his understanding of “internet thinking”. He explained that many IT companies, such as Google and Baidu, they were offering free service for searching online, and benefit from displaying advertisement to the users (Figure 100). And he also pointed that this business model can be integrated with the mobile application.

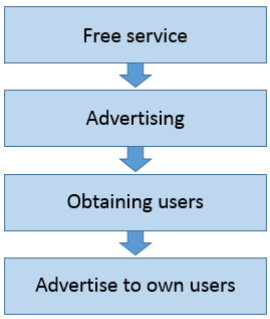

Figure 100. The top manager’s understanding of “Internet thinking”

He suggested to add a launch screen while use activating any “smart function”, with only the brand logo on it. And he wanted to offer the application to other companies; the purpose was obtaining their hardware users.

Moreover, he also asked to prepare to develop some vehicle related functions, owing to his personal connections are mostly car accessories producers, hence an application with added value for potential users could be attractive

for at least his personal connections. He also included future development advices, “stranger social networking”, those strangers in this application can see not only people nearby, but people who is using same products. He named this type of social networking was “Same Products Based Social Networking”, and aimed on the market of car owners.

Table 44. Different views between NPD team and the top manager

	NPD team	The top manager
Purpose	Add value on own tangible products	platform
Benefits	Smart functions	Smart functions free for other brands
Long-term	Nothing	Social Networking
Business model	Selling own products	Selling own products, advertising

Table 44 summarised those different views in terms of mobile application development. The NPD team’s view mostly rely on products, and current existing business model, gaining profit by selling own products. The top manager’s view was on company strategic level, not restricted by current business model and suggested to adopt “internet thinking”, rather than only using this application for adding value to own products, but have the vision of building a platform for others. For company long-term survive, the NPD team gave no comments, but the top manager proposed a new way of “social networking”, subsequently, profit by “advertising”. The top manager engagement was fruitful especially on company’s long-term development.

Members in NPD team were consistently agreed those suggestions proposed by the top manager.

6.5 Accomplishment of hardware

There are approximately ten meetings till the top manager intervention since the NPD project started, includes the initial meeting and the top manager review meeting. The new product was constructed by ideas and concepts discussed in those meetings. Table 45 summarise the ideas and concepts communicated in each meeting. It can be seen that the first three months were mostly spent on producing fragmental ideas, and those ideas were constructed to a whole in end the fourth month, since then, the confirmed hardware concept was progressed faster owing to their proficiency and experience of producing similar products. However, owing to the top manger intervention, the former planed and developed mobile application was assigned new meaning, to be the platform of carrying rather than only one brand. Therefore, further development of the software part became to the key task of this NPD.

Table 45. Meetings, dates and contents

Meeting	Approximate Date	Hardware	Software
Initial meeting	30th Jul, 2014	Metal appearance	\
1st review meeting	22nd Aug, 2014	Diamond idea	Application concept
2nd review meeting	19th Sep, 2014	Width adjustable idea Animation idea	App UI
3rd review meeting	21st Nov, 2014	"Smart Energy" concept	Requirement document
4th review meeting	26th Nov, 2014	Hardware solutions	Initial outsourcing
5th review meeting	28th Nov, 2014	Detailed design	Architecture of "big" App
6th review meeting	19th Dec, 2014	prototypes	Prototypes and revision
7th review meeting	9th Jan, 2015	Production solutions	More revisions
8th review meeting	14th Jan, 2015	Package and PCB solutions	Submission
9th review meeting	6th Feb, 2015	Strategic suggestions	Document of "Mrcarer"

In comprehensive perspective, the ideas that construct this NPD outcome were made by different team members. The origin of ideas is mainly from three aspects. Firstly, their understanding of the current market; in the process of having the metal appearance, the two industrial designers in team both agreed and presented their initial concept that with metal decorates. And it evolves to the final agreed "infinity energy". Secondly, feedbacks from distributors and users, to some extent construct the "width adjustable" concept, a solution of dealing the "too tight" issue. Thirdly, the "diamond", "breathe LED", "mobile App", "shorter USB", "PCB solutions" and "mechanical structure", more associate with the expertise of contributors. The production related tasks mostly carried by the project manager, owing to his familiarity of production

process and former built connections with representative of each detailed tasks. Figure 101 summarise the key ideas, and the main contributors and the origin of each idea.

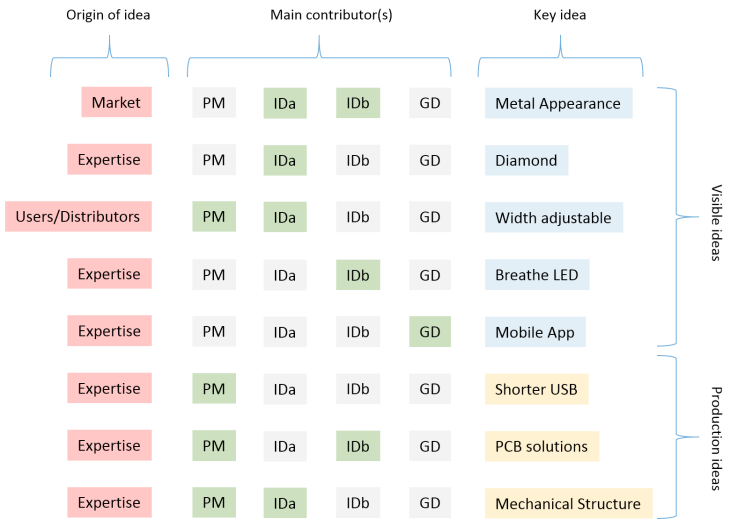

Figure 101. Ideas and its contributors and origin

This NPD project is different to a large extent in comparison of previous ones in the company, and performs a different NPD behaviour in comparison of most Chinese SMEs. The differences are represented in mainly three aspects. Firstly, the unusual time cost and fund spent. Most previous NPD projects were set in a fixed period, maximum three months. This NPD project started since Later-July 2014, till 10th Feb 2015, six months' development time, and the project is still in progress. Subsequently, the cost of this NPD project was largely increased includes costs of prototyping, expenditure of using external sources, purchasing new production tools etc. Secondly, the complexity of this NPD project was greatly increased. This can be reflected by the integration of

hardware and software development. It starts from hardware development and delivered a product that is recognised more complicate than any former developed ones. In terms of the software side, owing to the zero experience, they have to involve an external software development company, and learn how to cooperate with external resources. Thirdly, the impacts of this NPD project were ever important. They started to engage designers in NPD ideation, and according to the outcome, they benefited from it; moreover, the top manager involvement enriched the meaning of the mobile application. It integrated the “Internet thinking”, and shifted the company strategy from selling products to also be a platform provider, and accordingly, fixed the company long-term development plan.

Owing to the complexity of this NPD project, the NPD process was far different of previous NPD process, and also different from the introduced designer-led NPD process. It is a dynamic process with rich flexibility. At very beginning stage, four people was assigned to a team for ideation, those three designers were in the position of competing. Project manager who previously take all the job of ideation, at this time turned to be an assistant and advisor to aid designers for producing ideas, and realise ideas. After several concepts were communicated, a final idea was combined all team members’ contributions. The hardware and software development to some extent were separated, it seems one NPD project was decomposed to two. However, reviews still took

places with mostly all team members' participation. In terms of software development, the level of engagement of other three of four people was low, it to some extent turned to three people in charge of hardware, and the graphic designer and the external software development company were responsible for software development.

Hardware part of this NPD project was mostly accomplished. Because their previous experience and familiarity on developing similar hardware. However, the software part, "MrCarer" still in its development process. Owing to the long-term strategy made by the top manager, it seems the mobile App cannot be accomplished in short time.

6.6 Continuous development

The hardware part has been accomplished in about six months' time. In terms of the software, the first in app "smart function", the "battery management" was mostly accomplished, and it was already embedded in the "big" App, which was latterly named "MrCarer". According to the top manager's opinion, "MrCarer" was separated from the company brand "USbright", then he was able to invite his friends, owners of many other brands, to join and benefit from this software. He proposed to carry the mission of persuading the other brands to join and also expressed requirement of adding more social network related functions, such as instant message, posts and comments etc., therefore, the

top manager asked the graphic designer to deal with it and report back to him. Owing to the top manager's intervention, the meaning and function of the mobile application was significantly changed, accordingly, the required development time extended. It seems this NPD project has been moved to another level and became a part of company development strategy. User involvement, is claimed important by former reports, was missed from both the experimental process, and also in the evolved-NPD.

6.7 Summary

An explicit and detailed investigation on their continuous NPD project was conducted. According to their expressed NPD activities, they neither followed their former NPD behaviours, nor exactly adopted the suggested design-oriented NPD strategy, but self-evolved by combining their practical knowledge and the introduced design-oriented NPD strategy. They cost more funds and time on the development of a new product, and even started to engage external resources. They were asked to give comments toward their new way of doing NPD, the up-to-date knowledge from participants, and also the top manager of the selected company, have consensus on the positivity of the introduce of design-oriented NPD strategy.

The involved three designers and the project manager, claimed the key merits of the new way NPD is released them from repeating on doing something to

communicating and thinking on something more interesting. According to the top manager, it helped firstly, find a way for company survive in nowadays competitive environment. He mentioned that the the decrease on pricing is not valid owing to some internet company access to the hardware market. He pointed that especially Xiaomi, known as an internet company and a smartphone manufacturer, starts to manufacture products in a wider range, including car chargers, power banks etc. Their products were premium designed but sold at very low price. In this circumstance, they were able to price the product higher and survived by targeting different clients. Secondly, the top manager disclosed that a few large brands, were trying to contact and requiring for ODM service, for marking their labels on the new developed product. He therefore, planned to offer more colours combination for these ODM buyers, and pointed this could be a new way for company development. The members in the evolved NPD team were combined to a key team for NPD, all of them were mentioned about their role is interesting and challenging. The project manager claimed he was previously more on handle relationships with OEM buyers and communicate manufacturing techniques, but now on discussion of production solutions with designers and become a buyer of other OEM suppliers.

Chapter 7. Discussion

This chapter revisits the changes of the company NPD behaviour at different stages, and according to the detailed executive process of their following NPD, a model that reflect key points of the evolved NPD process is given. The main characteristics of design-oriented NPD in Chinese SMEs is summarised according to the evolved NPD. The success of the introduce of design-oriented NPD is reflected by the changes their following NPD behaviours, and it opens a way of team working by strength the importance of design. Advantages and disadvantages of adopting design-oriented NPD in companies are also discussed.

7.1 Process Journey Map

Chinese SMEs are normally conduct NPD by using “copy-cat” or “attribute listing”, in the experiment process, the conventional NPD team did follows the approach of “attribute listing” to NPD (tiny changes were made on shape of the product, LED lights was increased from one to two). The introduced design-oriented approach with optimisation offered opportunities for designers able to work with the engineering designer closely, therefore had an improved moulding technique to achieve the “gapless” appearance; moreover, the designer in the experimental design-oriented NPD also able to have voice with

the technology specialist, and concluded the “dual-core” idea and obtained the “patent”. The experimental design-oriented NPD to a large extent increased the ambition of producing high quality product, therefore in the follow-up NPD project (evolved NPD), they were able to focus on ideation (a team for idea) and combined all available resources to achieve both hardware (the new car charger) and software (the big app).

The three NPD projects perform differently in various dimensions. Firstly, team assembling and decision making are different. Although in the experimental process, the “Conventional NPD” and “Designer-led NPD” held the same team setting, but the differences lie in the decision making. In the “Conventional” NPD process, only the project manager of the team pays attention to ideation, the other team members playing a passive and supportive role to accomplish the ideas initiated by the project manager. Consequently, the project manager has full decision making rights and performs serious autocratic characteristics. In the “Designer-led NPD”, the importance of designer is emphasised, and therefore the ideation and decision making were constructed by the project manager and one designer in the team. In the “Evolved NPD”, the team setting was changed; the team was constructed by four members, three of them having design backgrounds. In the implementation process, all of them have has opportunity to contribute their talent to have an idea, and are also free to make comments to value others concepts. The differences in team setting and

decision making are summarised in table 46, team members who share decision making rights are highlighted in italic and bold texts.

Table 46. Differences of team assembling and decision making

Conventional NPD	Designer-led NPD	Evolved NPD
Project Manager B	***Project Manager A***	***Project Manager B***
Industrial Designer B	***Industrial Designer A***	***Industrial Designer A***
Engineering Designer B	Engineering Designer A	***Industrial Designer B***
Technology Specialist B	Technology Specialist A	***Graphic Designer***

Secondly, the detailed practical NPD implementation processes are different. All NPD projects are progressed generally in a similar way from having an idea, develop the idea to market the idea (Kahn, 2001). However, the detailed implementation process was different, it closely linked with the team settings. In the process of having the idea, the project manager in the “Conventional NPD” is the main contributor, but in the “Designer-led NPD”, the key idea is raised by the industrial designer. In the “Evolved NPD”, ideas are proposed by designers in the team, but integrated by the project manager. Furthermore, the reviews were taking place differently. Review in the “Conventional NPD” means to satisfy the project manager and only takes place once; in the “Designer-led NPD”, the purpose of review was to optimise the concept, but collected limited feedback. In contrast, the “Evolved NPD”, reviews were in loops and to some extent, a battlefield for ideas. Moreover, the impacts are different. There were almost no post NPD tasks in the “Conventional NPD” but

package design; in the “Designer-led NPD”, post NPD work were concentrated on solving defect issues; and in the “Evolved NPD”, the post NPD work was to make further development of an idea, likely generating another NPD project. These differences are summarised in table 47.

Table 47. Differences in practical application process

	Conventional NPD	Designer-led NPD	Evolved NPD
Having the idea	PM Setting goal Concept design	Internal knowledge review Setting goal	Core team Concepts
Review	PM review	feasibility / Feedbacks	Review loops
Development	Technical solutions Engineering Design Prototyping	Concept design Engineering design Technology development Prototyping	Engineering solutions Technical solutions Software solutions Prototyping
Confirmation	Top manager review	Top manager review	Top manager review
Post NPD	Package design	Defect issue	Further development

Those differences in team settings and implementation processes, resulted in the differences in development time cost. In figure 102, it can be seen that the time cost of having an idea, the “Conventional NPD” takes 2 weeks, and the “Designer-led NPD” costs double, more seriously, the “Evolved NPD” spends about 16 weeks and accounts for 8 times the time cost of “Conventional NPD”. The time cost of developing the idea, the differences are not as large as having the idea, 3 weeks for the “Conventional NPD”, 6 weeks for the “Designer-led

NPD", and 8 weeks for the "Evolved NPD". And the overall time cost for the "Conventional NPD" is 5 weeks, the "Designer-led NPD" doubled this number, and the "Evolved NPD" reaches almost 5 times of it.

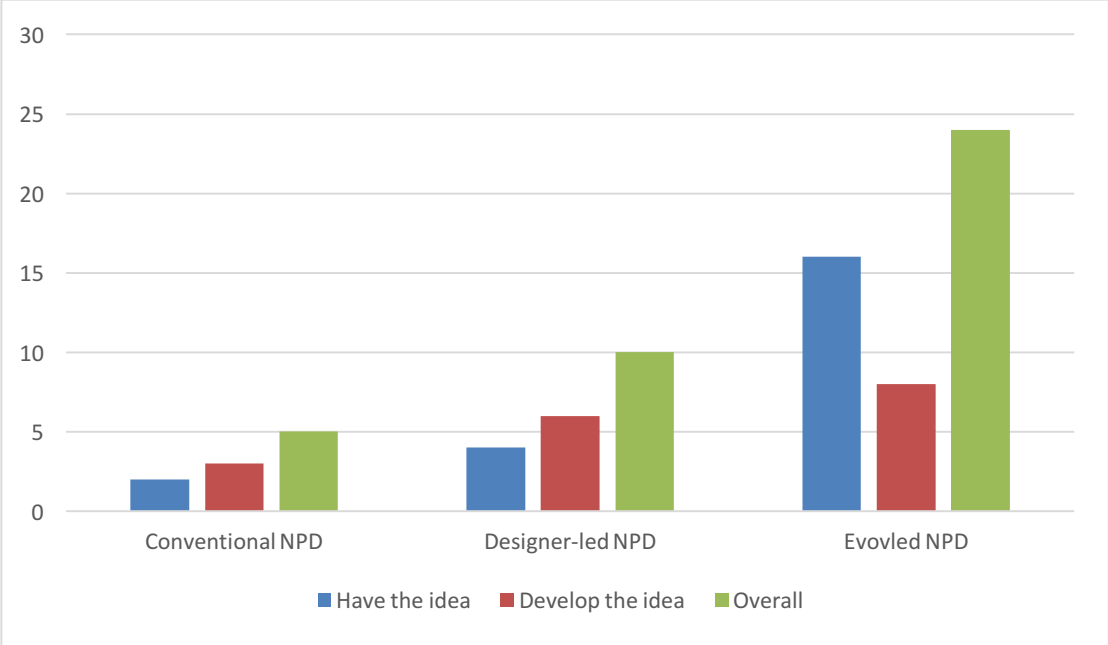

Figure 102. Differences of time cost at different stages

7.2 The evolved NPD process model

While the design-oriented NPD was introduced in a way of experiment, the process of the new started NPD project afterwards was evolved according to their practical knowledge and understanding of the design-oriented NPD. Chapter 6 explicitly displays the overall executive progress. Figure 103 summaries the overall evolved-NPD process in the way of NPD process model. It started from having a core team with members have equal rights but different

expertise for ideation (line one, Figure 103). The concepts presentation and confirmation was built in the follow-up phase, with various team reviews took place (line tow, Figure 103). Different from the former experimental “Designer-led NPD” process, there was no technical feasibility validation process beforehand. This implied this “Evolved NPD” project gave less weight to product functionality but exploration. A final team agreed concept was moved to development stage, engaged not only internal resources, but external resources as well, various team reviews took place, until proper prototypes were ready to be reviewed by team (line three, four and five, Figure 103). A presentable prototype of the new product can then be reviewed by the top management, for obtaining strategic feedbacks from the perspective of company development (line six, Figure 103), and then the further development stage started before production (the last line, Figure 103). In the practical application process, development and prototyping (line three, four and five, Figure 104) were almost run in loops.

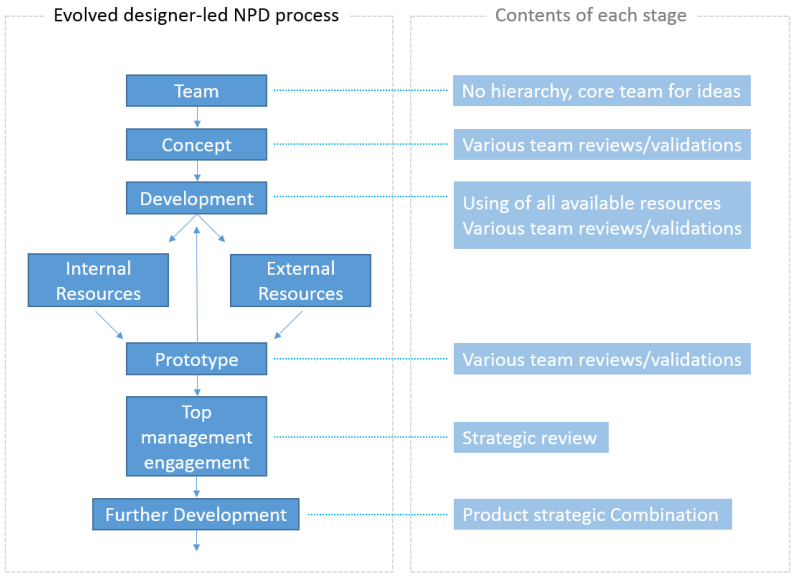

Figure 103. The Evolved NPD process model and its contents

In the evolved-NPD progress, the team was assembled with three designers and one project manager, there was no engineering designers nor technology specialist for becoming a team with full functions. However, this built a core team for idea generation and development, engineering designers and technology specialists were only required on their functional expertise. In this stance, the boundary between internal resources and external resources were blurry. This setting was able to solve the limitation of resource availability, while the company internal lacks on one resource, the external resources can be the substitution, and consequently, the company was sitting in the same chair of large ones, who were able to interact and benefit from all available social resources.

7.3 Main characteristic of design-oriented NPD in Chinese SMEs

In this research, the design-oriented NPD was firstly introduced by using the optimised designer-led NPD process model, a model that contains design-oriented aspects to represent the importance of design in a very detailed execution process, the process of developing new product. Firstly, the introduced NPD process model emphasises the importance by assigning the management rights to engaged designers. Designers in the process of the experimental “Designer-led NPD” and the “Evolved NPD”, were given opportunities to make vital impacts on the outcomes, those impacts were previous solely owned by the project manager. Secondly, a certain degree of flexibility was given to the NPD team; the process of having “UP” and the “Infinity Energy”, schedule and fund limits were set to relatively flexible. Thirdly, communications were suggested in the NPD process; in the experimental “Designer-led NPD” implementation process, three validations took place, to determine whether the development actions could be moved to the next phase, and about 10 review meetings happened in the “Evolved NPD” process because of the engagement of internal competition.

7.4 The Success and Merits

The success of the introducing design-oriented NPD to the selected Chinese SME, owing to the long term fact of obtaining and various variables on financial

evidence, therefore was reflect by NPD process facts, such as changing the previous hierarchical “autocratic” culture to “democratic”. And during the evolved NPD process, the content of “design-oriented” was shifted to encourage team working, and potentially “challenge large competitors”.

7.4.1 Company NPD culture building

According to the “Evolved NPD”, their NPD behaviour appears to change, from developing new products led by one project manager autocratically, to developing new products by the team, and thanks to the engagement of more designers in one team, designers with different backgrounds and expertise could make more contributions than they were in their functional roles. Designers and the project manager can share their knowledge with less interference than the previous hierarchy culture. The introduction of designers with similar backgrounds (two industrial designers) in the same team can potentially produce a high quality idea by internal competition and knowledge combination. It seems that having more designers with difference expertise is beneficial, the mobile application idea for example, was proposed by the graphic designer, and therefore the top manager’s “internet thinking” can be practically integrated into the company’s long-term strategy. Moreover, Staffs in the former “autocratic” NPD process were mostly passive, only undertaking tasks that were asked and assigned. Distinctly, design-oriented NPD

encourages team members to express their own voices and ideas; it changes the passive staff behaviour, to actively presenting their own ideas, competing and learning from each other. In terms of schedule behaviour, the former fixed schedule policy was also changed to maximise flexibility.

7.4.2 Benefit for long-term branding and survival

Design-oriented NPD can be recognised as beneficial for Chinese SMEs' long-term branding and survival. Firstly, owing to the high development cost, and the higher quality of outcomes, the unit price can be set higher to serve mid to high-end users, this helps on broadening the brand's market capability in comparison of former products. Secondly, the experience of having high quality products are transferrable, which means the future low price products are able to have better quality than competitors'. In terms of company development, the use of external resource, enriched the company's experience and broadened the vision for further NPD projects. And also investment in design-oriented NPD can potentially bring new ways for company development in the future. Such as the mobile application, it evolves the NPD to build a platform, to extend the company's business model from selling own products to being a platform that benefits from selling products from themselves and competitors.

7.4.3 “design-oriented” is a way of team working

Industrial design was recognised as the most relevant “design” in the NPD context (IDSA, 2010). Therefore, both in the process of generating the designer-led NPD process model and understanding of design-oriented NPD, the industrial designer was suggested to be included in the team and to be assigned the leading role. However, in the “Evolved NPD” process, according to their understanding of “design”, one graphic designer was assigned to the core team. The engagement of the graphic designer also incorporated his vision and experience. It broadened the team’s understanding of new product, and therefore, introduced software development to the team and company. Furthermore, the intervention that made by the top manager, contributed to his vision for the new product, and enriched the business model of the company. All those changes were made and contributions came not only from the industrial designer, but a combination of knowledge from different areas. The meaning of “design” in this NPD goes beyond only industrial design, but more about knowledge exchange and combination. Designer-led, design-led, or design-oriented NPD means not only set highlights on industrial designers, but an approach of integrating knowledge from individuals with different expertise, and give designers the opportunity to express opinion and influence direction.

7.4.4 Challenging large competitors

According to the “Evolved NPD”, it displays the company to have new a product based neither on former mature solutions nor experience, but bravely discover and try new solutions, even areas that they have no experience in (e.g. software). This change brings the company behaviour in line with many other large competitors, who dare to adventure and take risks. And thanks to their lower labour cost, the outcome of those changes, could be produced with lower unit price in comparison with large competitors’ ones.

7.5 Risks and Disadvantages

Associated with those benefits, risks are obvious. In terms of the experimental “Designer-led NPD”, the comparatively complicated process and its longer time cost, and higher cost on making tests, and solving mass production issues, results in the overall NPD costs growing, much higher than former “autocratic” NPD method. Moreover, in the “Evolved NPD”, owing to the engagement of the core team, the internal competition increased, consequently cost extra time, as well as the development budget. In the experimental implementation process, the outcome of “Designer-led NPD” team was internally considered better than the other outcome from the “Conventional NPD”; however, the market results in six months proved that

neither the numbers of delivery nor profitability was positive. The main cause of this fact was concluded as pricing policy. Therefore, a better balance of pricing a product is also important before product launch. Furthermore, the development process did not engage users, feedback from users and distributors proves hard to collect before the product comes to market. This restricts the internal ideas to be disclosed to competitors. On the other hand, the robustness of those ideas cannot be verified objectively. Once the developed new product did not fit into the market, the extra time cost and fund invested could get no return.

Chapter 8. Conclusion

This chapter concludes this research. The answers to each identified research question are stated, analysed and the contributions of this research are summarised. Reliability and limitations of this research are listed; Implications for practitioners, researchers, and suggestions for further research are given at the end.

8.1 Research questions

According to research in recent decades, design-oriented NPD strategy is considered beneficial for company development and survival, thus the initial objective of this research sought to investigate design-oriented NPD strategy in Chinese SMEs. A sequence of questions were identified to reach the objective. The initial question was “Can a bespoke design-oriented NPD model be created tailored for Chinese SMEs?” This question was divided and answered by two steps, firstly, to understand whether Chinese SMEs accept and want to make changes; a scoping study of three companies positively confirmed their aspiration. Secondly, to produce an instrument to carry design-oriented NPD strategy; knowledge from literatures concluded that a customised NPD process model with design-oriented aspects was the best tangible instrument, therefore a conceptual designer-led NPD process model

was constructed. While the initial question was answered, the following research turned to answer the second question “How can a design-oriented NPD strategy be introduced into Chinese SMEs?” Experimental approaches were selected to answer this question by exploring applicable research methods; a Chinese SME was selected to perform the experiment with parallel implementation of two NPD projects with different NPD process models. A metrics tool was built with practitioners to obtain internal subjective feedback, and six months’ sales data was collected as external objective evidence; the internal feedbacks firstly confirmed the introduction of design-oriented NPD was succeeded. Then the research moved to answer the last question “What are the impacts of a design-oriented NPD model adoption in Chinese SMEs?” Continuous investigation was made on their follow-up NPD project (evolved NPD), the researcher detached from making impacts on their NPD process. According to their NPD executive process, it confirmed the success of the introduction of the design-oriented NPD strategy to a Chinese SME, and was recognised mostly positive. Table 48 summarise all the questions, approaches and answers to each question.

Table 48. Summary of answer of the objective and questions

Objective	Understanding design-oriented NPD strategy in Chinese SMEs		
Main Question	Can a bespoke design-oriented NPD model be created tailored for Chinese SMEs?"	How can a design-oriented NPD strategy be introduced to Chinese SMEs?	What are the impacts of a design-oriented NPD model adoption in Chinese SMEs?
Approach	scoping study, analysis and synthesis of reviewed literature	Company selection Model optimisation Parallel experiment	New NPD project Detached observation
Answer	Feasible, customised NPD process model	Metrics tool: positive Sales data: negative Overall: positive	Changes take place mainly positive but with risks
Overall	Positive with risks		

8.2 Contribution to knowledge

Design-oriented NPD strategy mostly takes place in large companies, and limit efforts are spent on investigating design-oriented NPD strategy in especially Chinese SMEs. This research presents the full process of three NPD projects in a small Chinese company and the complete process from team building to final product, it displays the step by step approach for turning a conventional Chinese SME to a design-oriented company. According to the evolved NPD process, the definition and characteristics of design-oriented NPD in Chinese SMEs can be concluded as a strategy to incorporate team working on ideation, especially on widen designers' actions and give the opportunities for ordinary designers to interact and contribute their knowledge to NPD.

According to this research, the introduced design-oriented NPD process model, and even the conventional NPD process model, to some extent, were not strictly followed while in the NPD implementation process, but some suggestions they perceived as “inspiring” were progressed, such as award participation, assigning management rights to the designer, team reviews etc. This because they were proficient in production processes and well experienced in NPD, also the complexity of the projects in Chinese SMEs mostly remain mid to low level, their knowledge was constructed by practice and sufficient to cover all phases without following models. In this instance, those theoretically built NPD process models become a constraint to innovation, and therefore have limited impacts on simple NPD projects. To introduce design-oriented NPD strategy to Chinese SMEs requires preliminary analysis of their current process of NPD, and the level of NPD complexity (represented by the length of recent NPD project). The NPD process model is only in the role of guidance and reference, to infuse key design-oriented aspects to their NPD process, such as having a key team for ideation, engaging and offering equal rights to designers for voice and ideation; frequent idea reviews with team members; actively searching and using all available social resources and engaging top management for strategical suggestions.

In comparison of known design-oriented NPD, for example, researchers (Perks et al., 2005; Roper et al., 2012) indicate that design-oriented NPD is

used with “design as process leader”. However, according to discovery in the “Evolved NPD” process, the process leader was the team, and able to combine all members’ contribution. Jang et al. (2009) suggests securing expert designers, and let other functions of company support design; differently, in this research, design works were taken by ordinary designers, and designers were actively support other functions of the company (engagement in production, engagement of marketing etc.).

Owing to the various factors that are able to impact on sales, the success of using design-oriented NPD hardly to be reflected by financial return in short term. For example, although the outcome from the experimental design-oriented NPD was internally recognised as an improvement on the other one, but had a poor marketing performance according to the six months’ sales data. This was concluded mainly on the high pricing policy. Hence, the performance of design-oriented NPD strategy cannot be calculated by only highlight the sales data, because of the importance of management factors, such as pricing. The subjective data, such as simply questioning practitioners, would obtain a relative correct data that in relation to the NPD outcome.

In terms of NPS factors, user involvement in product development is a comment research approach for obtaining users’ suggestion and feedbacks towards an idea; however, there were no user involvements in those three

NPD processes, therefore, immediate data users' comments cannot be obtained for the reason of saving cost. Cross-functional teamwork is another important NPS factor, but was partly removed in the "Evolved NPD" process, those functional roles such as engineering designer and technology specialist, were not included in the evolved NPD process, but they still made contributions in the prototyping process. It implies that a team for ideation in Chinese SMEs are not necessarily to involve the other functional roles. Firstly, the marginal benefit of having a multi-disciplinary team is unpredictable. In the experimental process, the "designer-led NPD" team was constructed by people with diverse backgrounds; however, they made less contribution in comparison of the team setting in the "Evolved NPD" process, a team has more designers. Secondly, building a formal multi-disciplinary team is costs. For many Chinese SMEs, to have staff in relation to production and tangible tasks is understandable and acceptable; psychologist, anthropologist etc. are to some extent hard to be set in a proper position in Chinese manufacturing SMEs, and to involve engineering and technology specialist, decreased their time for doing other tangible tasks. Thirdly, the staff in senior management roles expressed their comprehensive knowledge and skills in relation all dimension. For instance, in the "Evolved NPD" process, the project manager expressed their diverse skills from obtaining information from the distributors, collecting outsourcing resources and managing production; and the top manager explained his understanding of internet thinking etc.

In terms of designers, it partly confirmed the findings of Perks et al. (2005), their skills remain the same, but their action range was raised in the evolved NPD process. This change offers them opportunities to contribute their ideas and evaluate others' concepts. Additionally, their perceptions on engineering design and technology solutions positively impacted on the outcome.

8.3 Reliability and limitation

Due to the short history of industrial design in China, many Chinese SMEs rarely adopt or even know design-oriented NPD strategy. On the other hand, in comparison to large companies, they have fewer resources for taking risks, this result the company selection progress, only one small company are accepted and cooperate with this research. This research is built upon investigating real-world business processes, therefore the reliability of the given data is in the most reliable form and the outcomes of these NPD project were already on market, it applicable for this kind of company within the manufacturing industry. However, result of this research is constructed by a single site study in a small Chinese manufacturing company, and owing to the limitation of research schedule, only one NPD project data after introducing the design-oriented NPD is referred, whether and how they can continuously develop outstanding products and obtaining increased profit are still awaiting to be discovered.

8.4 Implication and suggestion

This research proves that the design-oriented NPD strategy is an appropriate way for Chinese small or medium sized manufacturing companies. Design is able to be used as access for team working, and opened the door for actively interacting with external resources. Competing on product price is not the only way for Chinese SMEs to grow and survive. The “evolved NPD” process in this research is an example for Chinese SMEs to learn and absorb the methods of developing original new products.

In this research, the proposed models were not followed exactly, owing to the simplicity of the NPD project. Relatively, key factors in those proposed models expressed more significance. Such as the “co-management” setting brought “democratic” to the company, design engagement in other functions delivered the new PCB board solution and enriched the moulding method, and also the “democratic” generated the courage of using of external resources. Those little changes together were able to shift a company’s NPD culture, and therefore resulted the evolved NPD project.

In the “evolved NPD” process, a core team that was constructed by mostly designers and aimed for ideation, internal and external resources were in supportive positions. Designers in the team made the most contribution. This implies that designers, who trained to be innovative, are able to have their own

companies to develop new products by utilising external resources. Therefore, the design education system appears requirement of courses in relation to business and management, to support those potential design entrepreneurs.

According to the final consensus of the participants and the top manager of the cooperated company, the design-oriented NPD strategy is worthy to be disseminated in a wider range of Chinese SMEs. However, the detailed process of implementing design-oriented NPD strategy may differ from company to company, it requires the use of quantitative and qualitative approach to learn, test and refine. The genes of design-oriented NPD strategy, according to this research, is not about investing more on design nor designers, but providing an equal platform for voices, for combining knowledge of each possible creative member. To some extent, design-oriented NPD strategy in this stance is not set against market-oriented NPD strategy nor technology-oriented NPD strategy, but rather a way to combine them.

More implementations of the design-oriented NPD strategy, and tests of the “evolved NPD” process model in a wider range of companies are required, and suggested to investigate as many as NPD projects. This task cannot be fulfilled by only one or two researchers but a range of researchers in years’ investigations for obtaining quantitative and qualitative data. Chinese SMEs and SMEs in many other nations have lower risk tolerance; therefore, in future

study, quantitative approach is firstly suggested for obtaining feedbacks toward the key factors of design-orient NPD strategy and interests of practical implementation, and then use action research approach to test and refine in a loop for gaining long-term facts of companies with design-oriented NPD strategy. This research and the outcomes of the three NPD projects are able to be used as evidence for conducting further quantitative questions, and further qualitative implementations.

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Appendix 1 Definition of SME

Name of industry	Index name	Large	Medium	Small	Micro
Agriculture, forestry, husbandry, fishery	Revenue(Y)	Y≥20000	500≤Y＜20000	50≤Y＜500	Y＜50
Industry (mining, manufacture, electricity, heat, gas, water producing & providing)	**Employee(X)**	**X≥1000**	**300≤X＜1000**	**20≤X＜300**	**X＜20**
	Revenue(Y)	**Y≥40000**	**2000≤Y＜40000**	**300≤Y＜2000**	**Y＜300**
Construction	Revenue(Y)	Y≥80000	6000≤Y＜80000	300≤Y＜6000	Y＜300
	Total Assets(Z)	Z≥80000	5000≤Z＜80000	300≤Z＜5000	Z＜300
Wholesale	Employee(X)	X≥200	20≤X＜200	5≤X＜20	X＜5
	Revenue(Y)	Y≥40000	5000≤Y＜40000	1000≤Y＜5000	Y＜1000
retail	Employee(X)	X≥300	50≤X＜300	10≤X＜50	X＜10
	Revenue(Y)	Y≥20000	500≤Y＜20000	100≤Y＜500	Y＜100
Transportation (road transport, water transport, air transport, pipeline transport, load & carry, transport agency)	Employee(X)	X≥1000	300≤X＜1000	20≤X＜300	X＜20
	Revenue(Y)	Y≥30000	3000≤Y＜30000	200≤Y＜3000	Y＜200
storage	Employee(X)	X≥200	100≤X＜200	20≤X＜100	X＜20
	Revenue(Y)	Y≥30000	1000≤Y＜30000	100≤Y＜1000	Y＜100
Postal service	Employee(X)	X≥1000	300≤X＜1000	20≤X＜300	X＜20
	Revenue(Y)	Y≥30000	2000≤Y＜30000	100≤Y＜2000	Y＜100
accommodation	Employee(X)	X≥300	100≤X＜300	10≤X＜100	X＜10
	Revenue(Y)	Y≥10000	2000≤Y＜10000	100≤Y＜2000	Y＜100
restaurant	Employee(X)	X≥300	100≤X＜300	10≤X＜100	X＜10
	Revenue(Y)	Y≥10000	2000≤Y＜10000	100≤Y＜2000	Y＜100
Information transmission (telecom, radio, television, satellite transmission, internet access)	Employee(X)	X≥2000	100≤X＜2000	10≤X＜100	X＜10
	Revenue(Y)	Y≥100000	1000≤Y＜100000	100≤Y＜1000	Y＜100
Software and Information Technology	Employee(X)	X≥300	100≤X＜300	10≤X＜100	X＜10
	Revenue(Y)	Y≥10000	1000≤Y＜10000	50≤Y＜1000	Y＜50
Real estate	Revenue(Y)	Y≥200000	1000≤Y＜200000	100≤Y＜1000	Y＜100
	Total Assets(Z)	Z≥10000	5000≤Z＜10000	2000≤Z＜5000	Z＜2000
Estate management	Employee(X)	X≥1000	300≤X＜1000	100≤X＜300	X＜100
	Revenue(Y)	Y≥5000	1000≤Y＜5000	500≤Y＜1000	Y＜500
leasing	Employee(X)	X≥300	100≤X＜300	10≤X＜100	X＜10
	Total Assets(Z)	Z≥120000	8000≤Z＜120000	100≤Z＜8000	Z＜100
Other (research & professional service; water, environment, public utility management; resident service, repair and other service industry, social work, culture, PE & entertainment; estate agency & service etc.)	Employee(X)	X≥300	100≤X＜300	10≤X＜100	X＜10
Unit for Revenue: 10,000 RMB (Chinese Yuan)					

Source: Stats.gov.cn, (2013). *统计上大中小微型企业划分办法*. [Online] Available at:

http://www.stats.gov.cn/statsinfo/auto2073/201310/t20131031_450691.html [Accessed 7 Aug. 2013].

Appendix 2 Agreement

Agreement of Research Project

The purpose of this research is to optimise and investigate the practical effectiveness of a former established designer-led New Product Development (NPD) process model. Company manager would give rights to researcher to access all data that may involve in this research, and actively cooperate with research activities such as interviews, discussions and related recording methods (voice recording, photo taking etc.). Also give permission to key staff to actively engaging in discuss, criticize, modify, and practically apply the constructed mode

Company manager agrees to cooperate with researcher and accepts relevant research methods. to apply the optimised designer-led NPD model and their current NPD model in two separate NPD projects. And all data in terms of these two NPD projects from plan, develop process will be permitted to be recorded by researcher, and outcomes of these two NPD project (e.g. financial performance of new products) will be reported to researcher continuously by remote communication methods (E-mail etc.).

All data and research process are able to be checked by manager and key stuff who engaged in this research to assure the accuracy and reliability. Company will give permission to researcher to analyse, transcript and publish the collected data in academic purpose.

研究项目同意书

本次研究目的为优化一个已经建立的设计师主导的新产品开发流程模型并研究它在实践中的效率。公司主管将赋予研究员获得一切研究所需数据的权利，并且在研究活动中积极地与研究员合作，例如采访，讨论以及相关的数据记录（录音，拍照等等）。并且允许主要员工积极参与到研究活动例如对研究目标的讨论，评论，修改及在实践中的应

公司主管同意配合研究员并接受相关的研究方法，同时开展两个新产品开发项目，一个使用现有流程模型，一个使用优化过的设计师主导的流程模型。以上两个新产品开发项目相关的数据包括最初计划，开发过程等允许研究员进行相关记录，新产品开发项目的成果（例如开发的新产品在财务方面的表现）将被不间断的通过邮件的方式汇报给研究员。

参与本次研究的人员有权利核对所收集数据，以确保其准确性和可靠性。公司赋予研究员对所收集数据进行以学术为目的的分析，记录和发表的权利。

Researcher (研究员):

Representative of Company (公司代表):

Appendix 3 the NPS pool

Category	Sub-category	Approach	Research Tool	Description	Form of Data
General					
Adaption time		Ethnography Grounded theory Case study	Observation Conversations	Use varies media to record events Recorded dialogue	Photos, videos, texts Audios
Flexibility		Ethnography Grounded Theory Case study	Observation Conversations	Use varies media to record events Recorded dialogue	Photos, Videos, texts Audios
NPD Process Factors					
Product Characteristic	Product Advantage Meets Customer needs Product price Technological sophistication Product innovativeness	Case study Grounded theory Ethnography	Observation Semi-Structured Interviews Focus Group Interviews	Use varies media to record events Prepared Open-ended questions Small group discussions	Photos, Videos, texts Audios, Texts Audios, Texts
Market Orientation	Competitor Orientation Consumer Orientation	Case study Grounded theory Ethnography	Conversations Semi-Structured Interviews Focus Group Interviews	Recorded dialogue Prepared Open-ended questions Small group discussions	Audios Audios, Texts Audios, Texts
Time Cost	Conceive Idea Development Prototyping & Marketing Commercialization	Case study Grounded theory Ethnography Phenomenology	Observation Conversations Semi-Structured Interviews Focus Group Interviews	Use varies media to record events Recorded dialogue Prepared Open-ended questions Small group discussions	Photos, Videos, texts Audios Audios, Texts Audios, Texts
Investment	Conceive Idea Development Prototyping & Marketing	Case study Grounded theory Ethnography	Observation Conversations Semi-Structured	Use varies media to record events Recorded	Photos, videos, texts

	Commercialization	Phenomenology	Interviews Focus Group Interviews	dialogue Prepared Open-ended questions Small group discussions	Audios Audios, Texts Audios, Texts
Risks & Iterations(validation)	1st Validation(concept) 2nd validation(performance) 3rd validation(experience)	Case study Grounded theory Ethnography	Semi-Structured Interviews Focus Group Interviews	Prepared Open-ended questions Small group discussions	Audios, Texts Audios, Texts
Engagement of launch	Production Marketing		Observation Semi-Structured Interview	Use varies media to record events Prepared Open-ended questions	Photos, Videos, texts Audios, Texts
Impacts (Learning)	Short term Impacts Long term Impacts		Focus Group Observation	Small group discussions Use varies media to record events	Audios, Texts Photos, videos, texts
Internal(internal)					
Internal Satisfaction	Satisfaction by department Overall	Grounded theory Ethnography	Semi-Structured Interview Focus Group	Prepared Open-ended questions Small group discussions	Audios, Texts Audios, Texts
Employee Productivity	Satisfaction by department Overall	Grounded theory Ethnography	Semi-Structured Interview Depth Interviews	Prepared Open-ended questions One-on-one interview with respondent	Audios, Texts Audios, Texts
Workload	Conceive Idea Development Prototyping & Marketing Commercialization	Grounded theory Ethnography	Focus Group Observation Semi-Structured Interview	Small group discussions Use varies media to record events Prepared Open-ended questions	Audios, Texts Photos, Videos, texts Audios, Texts
User (consumer)					
User satisfaction	Willingness to have	Ethnography	Group Discussion	Small group discussions	Audios, Texts

Distributors satisfaction	Willingness to sell	Ethnography	Questionnaires	Online distribute and collect questionnaires	Texts
New Product Performance					
Profitability(Profitability)			Statistic	Review internal statistical documents	
Invest On Return (Financial)					
Concept Effectiveness	Concept transfers to next step		Statistic	Review internal statistical documents	
Technical Effectiveness					
Objectives Achievement	Sales Profit		Statistic	Review internal statistical documents	
Versus Competitors	Units Shipment Profitability		Statistic		
Overall(Overall success)		Ethnography	Group discussion	Small group discussions	Audios, Texts

■Balanced scorecard ■Measure of New Product Performance