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A DESIGN METHODOLOGY INCORPORATING USER REQUIREMENTS AND PREFERENCES FOR A SUCCESSFUL PRODUCT

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FACULTY OF ENGINEERING
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KUALA LUMPUR

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Hassan Alli

ABSTRACT

The failure of most new products on the market is almost always caused by the inability to integrate user requirements and preferences in the development of a product. It has been proven that involving the user in the development of a new product results in the success of the product. This should be done in the product definition stages of the design process, particularly in the development of the specification and characteristics of the product. Involving the user opens up possibilities for new ideas, improves product innovation, decreases the product risks, prevents it from being irrelevant and makes it pleasurable for the product designer to verify the product requirements. The aim of this research is to develop a design methodology for identifying the product characteristics that satisfy the user requirements and preferences, and increasing the probability of its success. A survey was carried out in order to establish the relationship between the product designer and the user during the product development process. In particular, the study seeks to determine the role of the main stakeholders in the success of a new product. The survey consisted of a questionnaire and structured interviews to explore product development activities and decision-making practices during the product definition stages of the design process. Seven successful product characteristics were established from past successful products; namely, multi-function, advanced technology, good performance, good brand, good design, user-friendly and environmentally friendly. It was also found that there are twenty-seven requirements of product design that can be defined in a product design specification. Thirteen requirements are recognized as functional requirements followed by fourteen aesthetical requirements. Both of which contribute to the establishment of successful product design characteristics. In addition, these requirements serve as an indicator of the degree of user satisfaction. This was proven through a product user survey and technical

specification analysis. A case study was conducted in which factor analysis of sales performance through a correlation and regression test also showed that the seven characteristics have a strong influence on the success of a mobile smart phone.

ABSTRAK

Kegagalan beberapa produk baru di pasaran adalah disebabkan oleh ketidakupayaan untuk mengintegrasikan keperluan pengguna dan keutamaan dalam pembangunan produk baru. Ia terbukti bahawa penglibatan pengguna dalam pembangunan produk baru telah menyumbang kepada kejayaan produk. Ini perlu dilakukan pada peringkat definisi proses reka bentuk, terutama dalam pembangunan spesifikasi dan ciri-ciri produk. Penglibatkan pengguna telah menyumbang kepada penghasilan idea-idea baru, meningkatkan inovasi produk, mengurangkan risiko produk, mengelak daripada penghasilan produk tidak relevan dan memudahkan para pereka bentuk produk mengenalpasti keperluan produk. Tujuan penyelidikan ini adalah untuk membangunkan satu methodologi untuk mengenal pasti ciri-ciri produk yang memenuhi keperluan dan citarasa pengguna, dan meningkatkan kebarangkalian kejayaan sesuatu produk. Satu kajian telah dijalankan dalam usaha untuk mewujudkan hubungan antara pereka bentuk produk dan pengguna semasa proses pembangunan produk. Khususnya, ia bertujuan untuk menentukan peranan pihak berkepentingan utama dalam kejayaan produk baharu. Kaji selidik ini terdiri daripada soal selidik dan temu bual berstruktur untuk mengenalpasti aktiviti-aktiviti pembangunan produk dan amalan membuat keputusan diperingkat definisi proses reka bentuk. Tujuh ciri-ciri reka bentuk produk berjaya telah dikenalpasti berdasarkan kejayaan produk terdahulu iaitu pelbagai fungsi, teknologi canggih, prestasi yang baik, jenama yang baik, reka bentuk yang baik, mesra pengguna dan mesra alam. Terdapat juga dua puluh tujuh keperluan reka bentuk produk yang menentukan spesifikasi sesuatu produk. Tiga belas keperluan telah dikenalipasti sebagai keperluan fungsi diikuti oleh 14 keperluan estetika. Kedua-dua mereka menyumbang kepada pengukuhan ciri-ciri reka bentuk produk berjaya. Di samping itu, keperluan-keperluan ini adalah menjadi sebagai penunjuk kepada tahap

kepuasan pengguna. Ini terbukti melalui kajian produk pengguna dan analisis spesifikasi teknikal. Satu kajian kes telah dijalankan untuk menganalisa faktor prestasi jualan melalui korelasi dan ujian regresi yang juga telah menunjukkan bahawa tujuh ciri-ciri tersebut mempunyai pengaruh yang kuat terhadap kejayaan kepada telefon pintar mudahalih.

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LIST OF ABBREVIATIONS

Abbreviation	Description
NPD	New Product Development
R&D	Research and Development
SE	Simultaneous Engineering
CE	Concurrent Engineering
QFD	Quality Function Deployment
TRIZ	Theory of Inventive Problem Solving
DOE	Design for Experience
SPC	Statistical Process Control
KM	Knowledge Management
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CAE	Computer Aided Engineering
FMEA	Failure Model and Effect Analysis
DFEMA	Design Failure Model and Effect Analysis
DFX	Design for "X"
DFA	Design for Assembly
DFM	Design for Manufacturing
PDM	Product Data Management
VA	Value Analysis
VE	Value Engineering
TQM	Total Quality Management
SPSS	Statistical Package for Social Sciences
CAs	Customer Attributes
FRs	Function Requirements
DPs	Design Parameters
PVs	Process Variables
CPU	Consumer Product User
FU	Furniture User
AU	Automotive User
Fr	Functional Requirements
Ar	Aesthetical Requirements
PDS	Product Design Specification
SPC	Successful Product Characteristics
SPDC	Successful Product Design Characteristics
TS	Technical Specifications
XS	Success Factors
MH	Must Have
SH	Should Have
NNH	Not Necessary to Have
MNH	Must Not Have
W	Weight
Σ	SUM

LIST OF APPENDICES

CHAPTER 1 INTRODUCTION

1.1 Introduction

In this introductory chapter, the research background is described and discussed. The research background establishes the significance of this research. The aim, objectives, and scope and area of research are also presented. Finally, the structure of the thesis is summarized.

1.2 Research Background

A study by Kristensson et al. (2007) discovered that no matter how ingenious the invention, it will fail if the product developers do not satisfy the needs of the user. In addition, it is frustrating to see a product that has a great technical solution and a vast amount of investment, but fails to deliver any value to the user (Janhager, 2005; Su et al., 2006; Bruch, 2007). The users are thus recognized as an important factor in ensuring the success of a new product. They can support the product developers generating products, which are not only profitable (Saunder et al., 2009; Riedl et al., 2010; Cooper & Kleinschmidt, 2011), but also address social and environmental issues (Lundkvist & Yakhlef, 2004; Cooper, 2005; Warell et al., 2006). The users are also necessary to identify and establish the characteristics of the new product. However, understanding user needs is a major challenge and a burden to the product designer (Janhager, 2005; Su et al., 2006; Jiao & Chen, 2006; Bruch, 2007; Heiskanen & Repo, 2007; Holmdahl, 2007; Dieter & Schmidt, 2009; Ivandic et al., 2009; Awa, 2010). Although there have been various models and approaches employed to involve users in the product development process. They usually do not adequately represent its dynamics (Janhager, 2005; Almeida & Miguel, 2007; O'Hern & Rindfleisch, 2009; Hoyer et al., 2010),

which is essential for the success of a new product (Hauser et al., 2006; Owen, 2007; Schimmoeller, 2010). Furthermore, several researchers have also stated that the product development process has not been properly described and explained in the early stage of the design process in which product characterization is to be established (Takeishi, 2001; Araujo, 2001; Cross, 2001; Teravarunyon & Sato, 2001; Donaldson & O'Toole, 2002; Lopez-Mesa et al., 2002; Janhager, 2005; Lettl, 2007; Bluntzer et al., 2009; Riedl et al. 2010; Weber et al., 2010; Isaksson et al., 2011; Cooper & Kleinschmidt, 2011). There is thus a need for an approach that is able to identify and establish the successful product design characteristics from the users' early involvement in the product development process.

1.3 Aim

The aim of this research is to ***develop an approach to identify the product characteristics that will satisfy the user requirements and preferences, and increase the probability of its success in the early stage of the product development.***

1.3.1 Research Objectives

To attain this research aim, three objectives are laid out:

1. To investigate the extent of user involvement and contribution in product development that results in the success of a new product.

2. To identify the characteristics of a successful product and the requirements of product design.

3. To develop a design methodology that incorporates the requirements of the product designer and user with the successful characteristics of a product in the early stages of the design process.

1.3.2 Scope and Area of Research

The research investigates the perspectives of both the product designer and the user, who are the main stakeholders in determining the success of a product. It explores the work, design planning and decision-making of the product designer during product development in the product definition stage of the design process. In order to address the issue of product non-acceptance and increase the product success, this study specifically investigates the characteristics of a successful product. It explores the user involvement and contribution in the product development process, particularly in the development of the characteristics of a new product. In particular, the research is conducted to increase the effectiveness of product developers in Malaysia in incorporating user requirements and preferences as well as successful product characteristics during the product development process. This is because many of them are still facing difficulties with developing a product that meets the user expectations and is successful. An in-depth study of product characteristics development is conducted. The information gained is used to develop an approach to facilitate the product designers to develop a new product that satisfies user requirements and preferences, and incorporate the characteristics of a successful product in order to increase the probability of its success.

1.3.3 Research Contributions

The contributions of the study are expected to:

i) Provide a new approach for identifying the product characteristics that satisfy the user requirements and preferences, and the characteristics of a successful product.

ii) Provide theoretical and empirical evidence of user involvement and contribution in product development that results in the success of a new product and the characteristics of a successful product.

iii) Increase the effectiveness of involving the user in product development and incorporating the characteristics of a successful product.

iv) Minimize the possibility of creating an irrelevant design concept, reduce the operating cost and shorten the time frame for the product to enter the market.

1.4 Outline of the Thesis

This study consists of two parts: the empirical study and methodology development. There are eight chapters in total and each chapter is associated with each stage of the research progress, as illustrated in Figure 1.1 below.

Chapter 1: Introduction – The chapter presents an overview of the research background, the aim of the research, research objectives, scope of the study and thesis structure.

Chapter 2: New Product Development – This **c**hapter presents a review of significant issues in undertaking research. At the end of this chapter, the research gaps are identified and a new strategy is proposed.

Chapter 3: Research Methods – This chapter describes the methods undertaken in this research. The research plan, data collection, source of data and data analysis are explained.

Chapter 4: User Contribution to a Successful Product – The chapter reports on user involvement and their contribution to the success of a new product. The significance of user involvement and contribution in the early stages of the design process is further investigated. Several success factors are identified. An in-depth study is conducted to validate the involvement of the user and their contribution that has resulted in the success of a new product.

Chapter 5: Identifying the Successful Product Design – This chapter reports on the factors that influence the development of the characteristics of a new product. In particular, it focuses on the functional requirements and aesthetical requirements of the product design contributed by the user, which is a significant part of the product design specification and contributes to the success of a new product.

Chapter 6: Development of the Product Design Definition Method – This chapter deals with the development of successful product design characteristics, which integrates characteristics from the product designer (design requirements), user (user requirements) and successful product characteristics. A new design methodology is introduced to incorporate all these requirements in the product development process in order to establish successful product design characteristics. The focus of this new design methodology is to help the product designer to identify and verify the user requirements and preferences for a new product.

Chapter 7: Validation the Product Design Definition Method – This chapter presents the validation of product success through the Product Design Definition Method. The validation involves product users and detailed technical specification of the product design. Correlation and regression methods are used to correlate successful

product design characteristics and show their contribution in increasing the sales performance.

Chapter 8: Conclusion – This chapter is the conclusion and summary of the research contribution. Recommendations for further research are also highlighted at the end of this chapter.

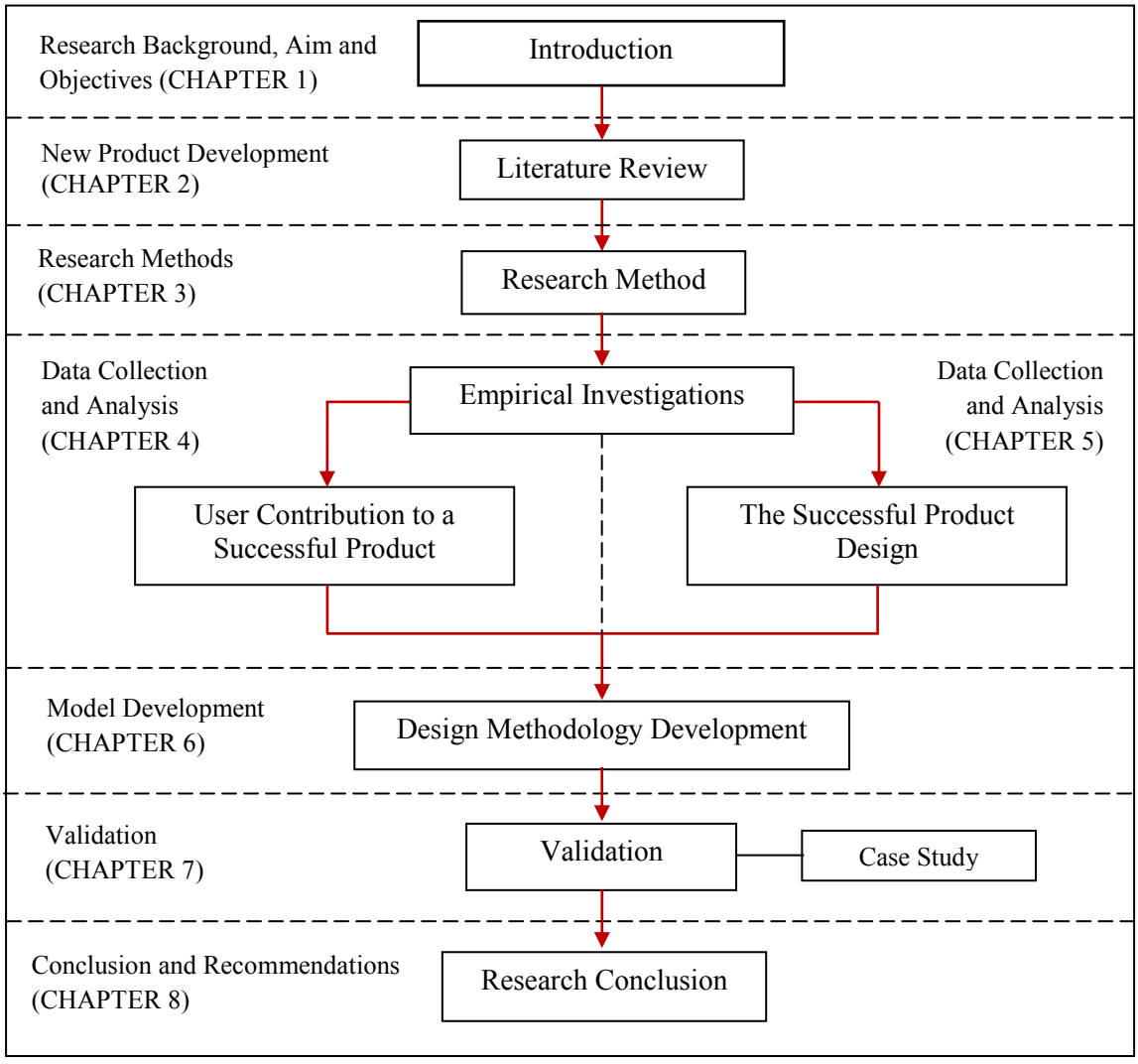

Figure 1.1: Research methodology and associated thesis chapters

CHAPTER 2 NEW PRODUCT DEVELOPMENT

2.1 Introduction

This chapter aims to review the literature to provide a clear view of the development process of a new product, which is related to several factors that influence the success of a product. It further discusses the role of the user and their contribution in the product development process. The following subsections provide a description of the requirements of the product design that are most likely to increase the success of a product. Several existing methods that involve the user in the product development process are explored. At the end of this chapter, a new strategy is highlighted and the research gaps are formulated.

2.2 New Product Development

New product development (NPD) is often defined as a process to produce a new physical product accompanied by its purpose or function while considering the aesthetic elements (Engwall et al., 2005; Ulrich & Eppinger, 2008; Senk et al., 2010; Isaksson, 2011). According to Ulrich & Eppinger (2008), the development of a new product is a sequence of activities that enterprises employ to conceive, design, and commercialize a product through intellectual and organizational involvement. It attempts to produce a product design specification and physical form based on the needs, wants and wishes of the user, and bring new technology into a product that is available for sale (Krishnan & Ulrich, 2001; Ottosson 2006; Holmdahl, 2007; Ulrich & Eppinger, 2008). Such activities may include the assessment of business opportunities, the generation of product ideas, conceptual and development, product engineering, product testing,

production and manufacturing, and launching in the marketplace (Nijssen & Frambach, 2000 and Ulrich & Eppinger, 2008).

Generally, the development of a new product passes through six stages; namely, product planning, design and development, product engineering, product testing and validation, production, and marketing. As shown in Table 2.1, Clark and Fujimoto (1991) classified five main stages in the development of a new product, which are product planning, concept generation, product engineering, process engineering and production engineering. Other researchers argue that the product development process varies depending on the product to be produced, such as size, type of product and component (e.g. Nijssen & Frambach, 2000; Ulrich & Eppinger, 2003; Ottosson, 2006).

Table 2.1: New product development process stages (Clark & Fujimoto, 1991)

	NPD Stage	Tasks or activities
1	Product Planning	Designers and product planners define the character of the product from a customer's perspective
2	Design and development	The design concept is translated into specifics for detailed design, including major specifications, technical choices and cost targets.
3	Product Engineering	Product plans are transformed into blueprints or CAD drawings then into prototypes, and, ultimately, into real parts and components
4	Process Engineering	The manufacturing tools that will realize the product are developed and material flows, plant layout, work organization and tasks are defined
5	Production Process	Final products are made and assembled for the end customer. The NPD process then ends with feedback into the product and process engineering steps from ramp-up production and pre-series

2.2.1 The Design Process

The design process also known as the design and development process of a new product, which is identified as an important stage for new product development. The design is defined as a process of converting an idea into information from which a product can be produced (Caldecote, 1986), which involves both designing and

communicating activities (Love, 2000). According to Baldwin & Clark (2000), design as a complete description of an artifact, can be broken down into smaller units, which are called design parameters (e.g. color, height and weight of the artifact, and the design task is to choose these parameters). The design process is considered a continuous logical sequence of actions or tasks that leads to the accomplishment of particular objective (Caulkin, 1995 and Martin, 1997). The process will provide a solution that can later be applied in the development of a specific product concept (Ottosson, 2006), and the concept can only start once the product requirements are well described and have met with approval (Dieter & Schmidt, 2009).

Typically, as described by Ulrich & Eppinger (2008), most NPD activities in manufacturing companies undergo a generic product development process, as shown in Table 2.2 below. The generic development is characterized by stages or steps with gates, indicating a division between each of stages. The stages of the design process through a generic product development process model can be divided into five stages that involve planning, concept development, system-level design, detailed design, testing and refinement, and finally production ramp-up. In addition, a generic product development process should also concurrently involve marketing, design, manufacturing and other functions, such as finance and sales (Ulrich & Eppinger, 2008). According to Braha & Reich (2003), the design process is a generic process in which product designers modify the current design based on new information and requirements that have become known. It starts from some abstract specifications or brief and terminates with the description of a product while gradually refining the product specification (Braha & Reich, 2003; Hatchuel & Weil, 2009; Razzouk & Shute, 2012).

Table 2.2: A generic product development process (Ulrich & Eppinger, 2008)

Stage 0: Planning	Stage 1: Concept Development	Stage 2: System-Level Design	Stage 3: Detail Design	Stage 4: Testing and Refinement
Marketing				
• Articulate market opportunity • Define market segment	• Collect customer needs • Identify lead users • Identify Competitive Products	• Develop plan for product options and extended product family • Set target sales price point(s)	• Develop marketing plan	• Develop promotion and launch materials • Facilitate field testing
Design				
• Consider product platform and architecture • Assess new technologies	• Investigate feasibility of product concept • Develop industrial design concept • Build and test experimental prototype	• Generate alternative product architecture • Define major subsystems and interfaces. • Refine industrial design	• Define part geometry • Choose material • Assign tolerances • Complete industrial design control documentation	• Reliability testing • Life testing • Performance testing • Obtain regulatory approvals • Implement design changes
Manufacturing				
• Identify production constraints • Set supply chain strategy	• Estimate manufacturing cost • Assess production feasibility	• Identify suppliers for key components • Perform analysis • Define final assembly scheme • Set target costs	• Define piece-part production processes • Design tooling • Define quality assurance processes • Begin procurement of long-lead tooling	• Facilitate supplier ramp-up • Refine fabrication and assembly processes • Train work force • Refine quality assurance processes
Other Functions				
• Research: Demonstrate available technologies • Finance: Provide planning goals • Management: Allocate project resources	• Finance: Facilitate economic analysis • Legal: Investigate patent issues	• Finance: Facilitate analysis • Service: Identify service issues		• Sales: Develop sales plan

2.2.2 Product Definition Stage of the Design Process

The early stage of the design activity is called the product definition stage. The product definition is an important stage in the design process through which the information gained from the user is translated into product specifications. According to Dieter & Schmidt (2009), product developers need to focus intensively in order to determine the full description of the product intended to be produced in the product definition stage. A number of researchers have their own interpretation of the product definition stage and its tasks. According to Zhang & Doll (2001), product definition should involve idea generation, market assessment, technology and competition, project justification and action plan. In Figure 2.1, Ulrich & Eppinger (2003) illustrated the front-end product development activities in the concept development stage. The concept development stage implies the activities from the mission statement to the development plan. The concept process is divided into seven processes - identify customer need, establish target specification, generate product concept, select product concepts, test product concept, set final specification and plan downstream development.

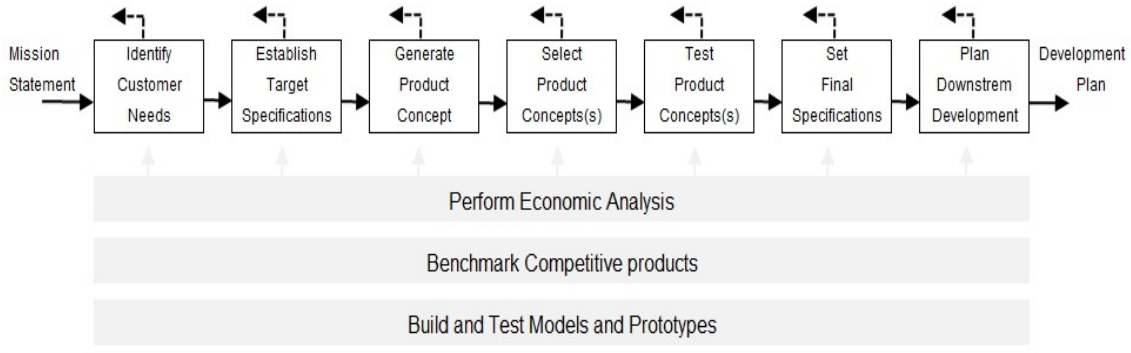

Figure 2.1: Concept development stage (Ulrich & Eppinger, 2003)

2.3 Successful Product Design

A successful product is a product that affords high performance, gives significant benefit and is more dominant compared to other products (Cooper, 2005; Janhager, 2005; Lettl, 2007; Saunder et al., 2009; Cooper & Kleinschmidt, 2011). The

dominance usually takes the form of a new product or set of features synthesized from the users (Utterback, 2007). This success is also dependent on the product development process in terms of implementation and completeness (Saunder et al., 2009 and Schimmoeller, 2010). The ability to develop new products that could compete successfully in new markets is a core competency of many successful companies (Meybodi, 2003; Cooper, 2005; Saunder et al., 2009; Riedl et al., 2010; Cooper & Kleinschmidt, 2011).

Product developers must be able to identify key factors that contribute to the success of a new product. However, there are many factors that influence a better product outcome, such as cost, quality, delivery, dependability, innovation and flexibility variations of demand (Givechi & Velasgrez, 2004; Warell et al., 2006; Lettl, 2007; Riedhl et al., 2010). Several researchers (e.g. Janhager, 2005; Bonner et al., 2005; Warell et., 2006; Pat & O'Toole, 2006; Ogawa & Piller, 2006; Lettl, 2007; Awa, 2010; Senk et al., 2010; Riedl et al., 2010; Schimmoeller, 2010) have suggested that a successful new product can be analyzed from four different viewpoints: a design that fulfills the technical requirements, increases the return on investments, delivers high performance, and fulfills user needs.

2.3.1 The Role of the Users in a Successful Product

The user has an important role in the development of a new product, particularly in determining the characteristics of a new product by offering their perspectives. The user perspective is a personal point of view that becomes information (Ottosson, 2006). When conveyed either in a tacit or explicit method, the point of view of the user becomes information that can help generate new product features (Margolin, 1997; Thomke & Hippel, 2002; Prahalad & Ramaswamy, 2004; Kujala, 2007). The ability of a product developer to extract and integrate user information into the product

development process is considered as a good design strategy (Glazer, 1991), could be one of a company's competencies (Li & Calantone, 1998), could provide considerable access to innovative ideas (Lundkvist & Yakhlef, 2004; Jangaher, 2005; Su et al., 2006; Heiskanen & Repo, 2007; Dieter & Schmidt, 2009), and contribute to the success of a new product (Kujala, 2003; Janhager, 2005; Heiskanen & Repo, 2007; Awa, 2010).

User information is essential to identify the specification of a product (Kujala, 2003). However, understanding the user information has been recognized as a pressing challenge for product developers (Jiao & Chen, 2006; Kristensson, 2007; Awa, 2010). The quality and type of information needed from the user is also difficult to determine (Elfving, 2007). In addition, it is critical that the information is extracted in the early stages of the product development process, when most of the knowledge is still resident in the mind of individuals (Boutilier & McNaughton, 2006). As a result, the product designer may make mistakes or misjudgments in several aspects of the product design (Bruch, 2007).

A study by Light Minds Ltd. (2005) suggested that there are three key elements to understand the user when developing a new product: 1) desirability – the new product must satisfy the person wanting to use it or meet user requirements, 2) purpose – the product must have useful functions, and 3) user experience – the product must provide user satisfaction. However, among these elements, desirability is regarded as a fundamental element for achieving a product that will subsequently be positively perceived and become successful in the market (Warell et al., 2006).

2.3.2 Understanding User Behavior

Warell (2001) defined users as *"individuals who, for a certain purpose, interact with the producer or any realized element (system, part, components, module, feature, etc., manifested in the software or as concrete objects) of the product, at any phase of*

the product life cycle". The product user is also described as the individual who uses the product repeatedly (Wieringa, 2006 and Ottosson, 2006). Users can be divided into three groups - primary users, secondary users and tertiary users. The primary user is often called the end user, which means the person for whom the product is intended for, whereas the secondary user is a user who only occasionally uses the product, and the tertiary user is a person who is likely to be influenced by the use of the product but eventually indirectly uses the product (Hansen, 1991). According to Eason (1988), the primary user is the "hands on" and perhaps full-time user of the product while the secondary user is the occasional user who has to work with the output from the product.

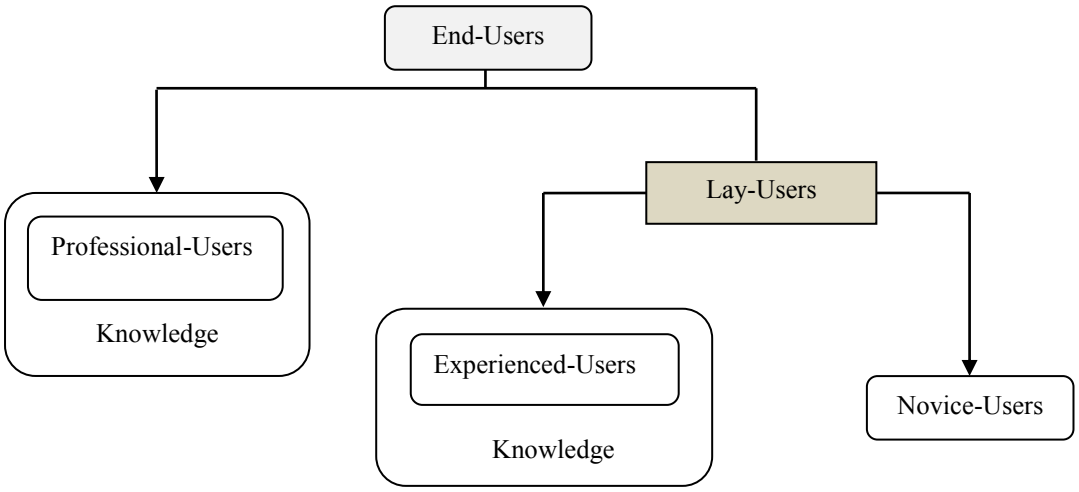

Figure 2.2: Type of end user (Cifter & Dong, 2008)

The end user is defined as the person who uses a product (Karlsson, 1996, Kujala, 2003 and Ottosson, 2006). Figure 2.2 above shows the different types of end user as classified by Cifter & Dong (2008). According to Cifter & Dong (2008), end users can be divided into three types: 1) professional-users – who possess a good knowledge of the product performance, 2) experienced-users – those who have some experience with the product and are compared with professional-users, and 3) novice-users – those who are new to the task or the product and who usually do not have enough information to perform the task with the device.

2.3.3 User Involvement in the Product Development

The involvement of the user in product development has contributed to product competency (Bonner et al., 2005), and has become an effective strategy in finding a solution to complex problems (Wrights, 2006). The purpose of user involvement in the product development process is to provide information about their needs, wants and desires. The information is valuable in order to establish the product design specification, which the product designer will take into consideration to establish the characteristics of a new product in the early stage of the design process.

Involving the user in product development is recognized as a good mechanism that enables the interests of both user and product developer to be sought, elicited and reflected for a better decision-making process by a company (Bae, 2005; Heiskanen & Repo, 2007; Awa, 2010). Furthermore, Gruner & Homburg (2000); Ernst (2002); Kujala (2003); Jeppesen & Molin (2003); Kristensson et al. (2007) also showed that user involvement in product development plays an important and valuable role in producing better product quality through enhancing the product designer's capability to design, increasing the product performance, and providing a guideline in the development stage. They can also help to reduce uncertainties and increase the innovation in developing new products (Gruner & Homburg, 2000 and Lilien et al., 2002).

Kujala (2003) indicated that the early user involvement in product development should produce a better quality product requirement, which fits the user needs and has better product usability. In addition, involving the user in the early stages of product development will also help to identify several elements of product design, such as effectiveness, reliability, durability, safety, ergonomic and others. Table 2.3 shows the customer or user roles in product development. According to Nambisan (2002), the role of the customer or user in the product development process can be divided into three

categories; customer as a resource, customer as a co-creator and customer as a user. In addition, the role of the customer or user is not only important in generating new product ideas during the product development process but also in testing the finished product, and in providing end-user product support.

Table 2.3: Customer or user roles in product development (Nambisan, 2002)

Customer / user Role	Product development Stage	Key Issues/Managerial Challenges
Customer Resource	Ideation	• Appropriateness of customer as a source of innovation • Selection of customer innovator • Need for varied customer incentives • Infrastructure for capturing customer knowledge • Differential role of existing (current) and potential (future) customers
Customer as co-creator	Design and development	• Involvement in a wide range of design and development tasks • Nature of the NPD context: Industrial/consumer product • Tighter coupling with internal NPD teams • Managing the attendant project uncertainty • Enhancing customers' product/technology knowledge
Customer as User	Product testing	• Time-bound activity • Ensuring customer diversity
	Product support	• Ongoing activity • Infrastructure to support customer-customer interaction

2.4 The Development of Product Characteristics

Product characteristics have been identified as an important element of innovation (Rogers, 1993; Flynn & Goldsmith, 1993; Steenkamp & Gielen, 2003). According to Janlert & Stolterman (1997), characteristics are a coherent set of characters and attributes that apply to both appearance and behavior alike, cutting across different functions, situations and value systems, such as an aesthetical, technical, ethical, and providing support for anticipation, interpretation and interaction. According

to Low & Yen (2006), product attributes are either tangible attributes or intangible attributes, which contribute to the final make up of a product, thus giving the product its own character. The product characteristics are also the distinctive characteristics of the products, which could differentiate them from other products, and, at the same time, fulfill the user's needs and wants (Kotler & Keller, 2006).

The development of the characteristics of a new product is a crucial task in product development, and is often required during the product specification stage. During the execution of this task, the designer not only needs to consider the engineering characteristics of a product but also the physical appearance. A number of studies indicated that determining the characteristics of a new product during the early stage of the design process would help the product designer to be mindful of the various issues and the interplay between them (e.g. Gruner & Homburg, 2000; Lilien et al., 2002; Kotler & Keller, 2006; Wieringa, 2006). According to Noble & Kumar (2008), functional and emotional attributes are considered as core essentials for the characteristics of product design. It should refer to its form, function, aesthetics and features and is usually accompanied as a set of product specifications (Ulrich & Eppinger, 2008).

2.4.1 Requirements of Product Design

The elements of product design are a collection of product requirements (Pahl & Beitz, 1996), and are also known as the product design specification (Pugh, 1991). The product design specification provides a categorization scheme for product requirement that make every product requirement in a specification belong to one requirement group (Pahl & Beitz, 1996), which is always considered during the design stage (Cespedes, 1995).

Product requirements are unique attributes that have their own characteristics providing good value for money and optimizing user needs and quality (Cooper, 1993). They should provide a differential concerning the appearance of a product that will influence user choice (Creusen & Schoormans, 2005). According to Hofstede (2001), the requirements of product design are referred to as functionality, manufacturability, usability, creativity, and styling aesthetics. Figure 2.3 shows an approach to driving value through design by Noble & Kumar (2008). They indicated how functional differentiation and emotional value creation are two additional factors that strategize the design and are closely related to the user requirements. In addition, the processes are divided into three categories in order to identify the functional and emotional value of product design; namely, utilitarian design, kinesthetic design and visual design.

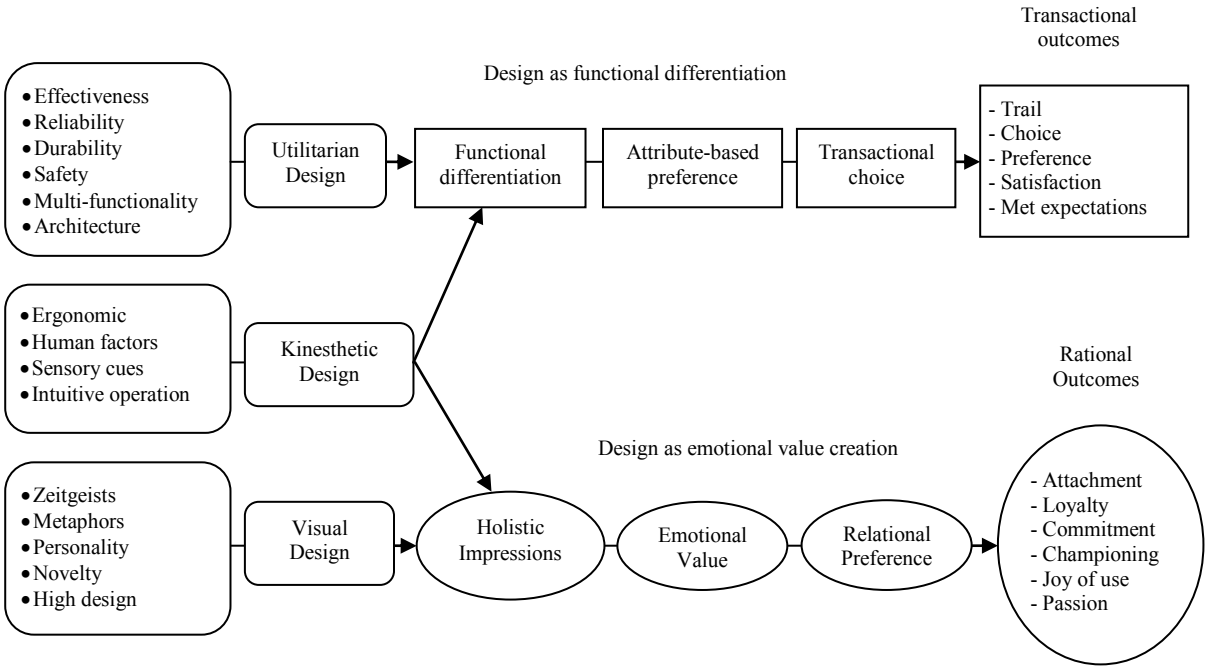

Figure 2.3: Approach to driving value through design (Noble & Kumar, 2008)

2.4.2 Functional and Aesthetical Requirements of Product Design

Product requirements can be divided into two distinguished characters, which can be identified through functional and aesthetical requirements. Functional can be

classified as physical character, while aesthetical is classified as the non-physical character of a particular product. According to Jordan (2002), the requirements of product design can be divided into two categories; firstly, from the product's functionality, and, secondly, through the product's aesthetics.

Functional requirements are a description of functions that should be offered to the user. According to Hubka & Eder (1988), the functional requirements are content elements - systems, parts, components, modules and features - to support a certain purpose. The functional requirements are also the individual operations that contain functional properties and transform into the overall performance of a product (Ulrich & Eppinger, 2003), such as weight, safety and reliability, aesthetics, manufacturability, testability, environmental friendliness, assemblability and cost of the product (Suh, 1990). Therefore, the functional requirements can be measured through the observation of product performance, which refers to the primary operating characteristics. The product performance is frequently associated with product quality and has been recognized as being of primary importance in achieving user satisfaction, such as features, reliability, and conformance to requirements, durability, the product-related serviceability, the aesthetics and perceived value (Garvin, 1988; Warell, 2001; Kuang & Jiang, 2008).

Aesthetical requirements are broadly used to describe the characteristics of the appearance of a product. According to Hertenstein et al. (2005), products gain their high reputation through aesthetics, which is one of the most significant factors that ensure the success in the competitive market. A study by Dieter & Schmidt (2009) showed that aesthetics refer to the sense of beauty and concerns how the product is perceived by a user in terms of its shape, color, surface, texture, and such factors as balance, unity and interest. They are also related to the emotional or feeling responses and the personal character (Bamossy et al., 1983). The aesthetical requirements are also perceived

through how the product looks, how the user feels when looking at the product, and how it sounds, tastes or smells (Garvin, 1988).

2.4.3 Preferences of Product Design

According to International Communication Research (2010), preference is defined as the power or ability to choose one thing over another with the anticipation that the choice will result in greater satisfaction, greater capability or improved performance. In product design, preference is defined as appreciative word to classify objects by the user (Kotler & Keller, 2006), and refers to safety and well-being, functionality, usability and the pleasure of the user (Bonapace, 2002). It is also described as a distinction between the essential properties of what the product must have, and the desired properties of what the users like to have. The product preferences have become significant in the continuing search for reducing time to market (Venkatamuni & Rao, 2010), and it is an important reality that can lead to the success or failure of a product (McDonald, 2008). Product preferences are often referred to as user perception or preference.

Research in user preference has drawn considerable attention from marketing, economics, psychology, and management science. It studies both the internal and external influences on user preference (Wang & Tseng, 2008). According to Lin & Wei (2012), the existing research indicated that user preference is quite difficult to describe clearly, and involves factors, such as product attributes, alternatives and competitive products. In addition, Cooper (2005) and Kujala (2007) stated that, nowadays the product positioning in the market is crucial, in that the development of a new product often requires producing a brilliant product that meets user preference. To realize the vision in order to produce better product outcome, and develop product success in the market, it is necessary to integrate product designers and user opinions during the

product development (McGregor, 2003; Cooper, 2005; Lin & Wei, 2012). Then, to address these issues, a systematic and efficient product development process is required for an effective outcome and to increase the success of the product. It necessary for the product developer to ensure that their product performs well, and is pleasurable and functional (McGregor, 2003; Cooper, 2005; Heiskanen & Repo, 2007).

2.5 Incorporating Product Designer Decisions and User Requirements

According to Tien-You (2012), the product designers have to know what the requirements for the product design are and integrate user preference with the design, so that their product may be competitive in the market (McDonald, 2008; Wang & Tseng, 2008; Tien-You, 2012) and successful (Lin et al., 2007; Kujala, 2007; Cooper & Kleinschmidt, 2011). It can also be beneficial to increase the productivity, quality of work and minimize support, operating cost, and results to improve the user satisfaction (Maguire & Bevan, 2002; Kristensson et al., 2007; Awa, 2010). However, the process for understanding the requirements and preferences of users are poorly developed (Goellner, 2005; Warell et al., 2006; Ivandic, et al., 2009; Bluntzer et al., 2010; Weber et al., 2010; Hoyer et al., 2010).

2.5.1 The Product Designer-User Collaboration

The product designer provides a product specification that contributes as a competitive advantage for a product (Kotler & Rath, 1984; Hertenstein et al., 2005; Kotler & Killer, 2006), and a better role for the success of the product (Srinivasan et al., 1997; Dahl & Moreau, 2002; Hertenstein et al., 2005). Collaboration between the product designer and user during the product development is increasingly in demand to solve many contemporary issues in the design practice. This exercise has become essential as a way to elicit new knowledge for a new product development, whereby, the

product designer will often analyze and synthesize all the information gained from the user, and use it as their consideration and guidance for product development (Margolin, 1994). Several researchers also indicated that it is necessary for product developers to have contact with the user and learn about their needs (Gould, 1995; Ganzalez & Palacious, 2002; Ulrich & Eppinger, 2003; Janhager, 2005). According to Gonzalez & Palacious (2002), the product has more significant value, or in other words becomes more successful, if the product developers have a comprehensive picture of the user. As pointed out above, a lack of collaboration between the product designer and user causes conflict, and the failure of new product ideas (Janhager, 2005; Wright, 2006; Lee, 2008). Collaboration is required in the early stage of the design process to identify and transfer the user knowledge into the new product characteristics.

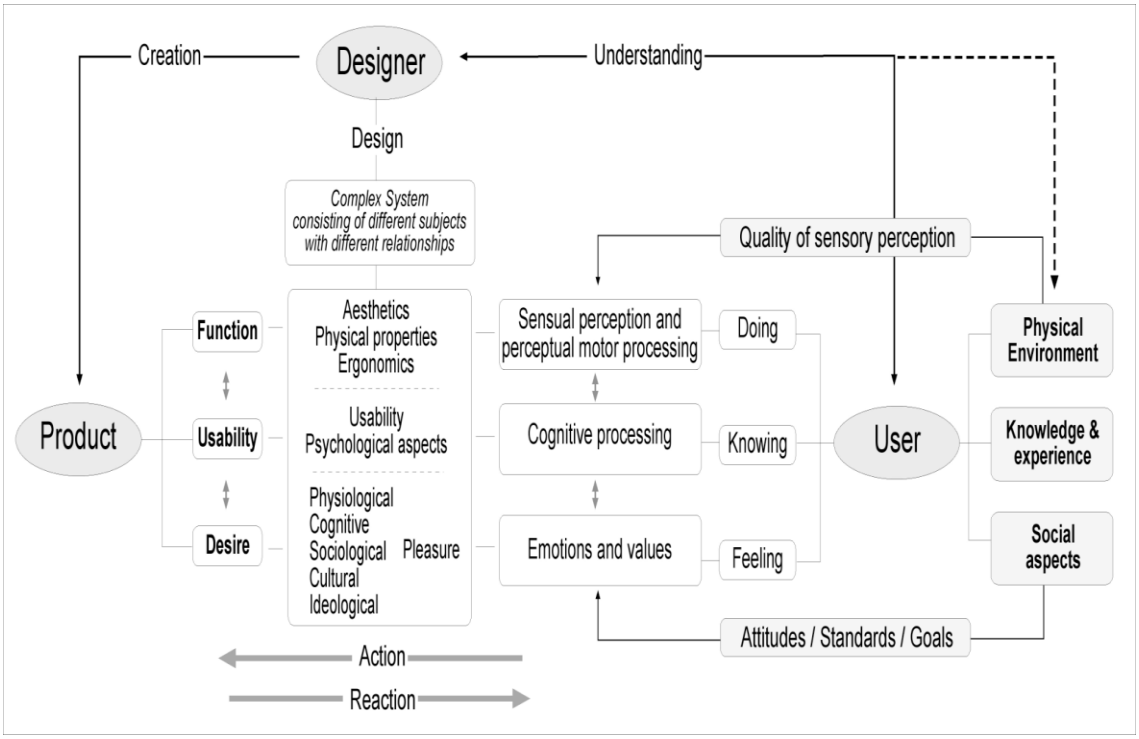

Figure 2.4: Multiple levels of user-product-designer interaction (Goellner, 2005)

Goellner (2005) indicated that the product designer needs to holistically understand and address the user needs in order to create and produce a new product, and system, as

shown in Figure 2.4 above. In addition, she also suggested that the process of creating a new product and system is determined by the product designer's understanding of the multi levels of user-product interaction. It can help the product designer to identify the requirements of a product.

2.5.2 Existing Methods in the Product Development Process

According to Ulrich & Eppinger (2003), the method is important to support coordination and planning of all development activities and elements in the product development process. Numerous methods in product development have been used over the years to make the product process more manageable (Thia et al., 2005 and Ching-Chaw et al., 2006), ensure product quality, help to identify possible problems or improvements (Ching-Chaw et al., 2006), and increase the performance of the product development process (Eriksson, 2009). Therefore, numerous different methods have been developed to assist the product developer in understanding the end user (Goellner, 2005). Most were introduced from areas, such as operations management, marketing, engineering and organization such as the product development approach, Concurrent Engineering, Kansei Engineering, Four Pleasure Framework, Sensorial Quality Assessment Method and Simultaneous Engineering (Bonapace, 2002; Krishnan & Ulrich, 2001; Ulrich & Eppinger, 2003; Ching-Chaw et al., 2006).

2.5.3 Existing Methods to Involve the User in the Design Process

According to Kujala (2003), user involvement has a positive effect on user satisfaction. However, direct interaction with the user does not guarantee a successful outcome if the product developer does not know how to involve the user in product development. User involvement needs to be thoroughly considered and efficiently applied in order to gather user requirements and preferences from the real product

development contexts. A good understanding of the design methods and the choice of method depends on the required novelty of the solution (Lopez-Mesa & Thompson, 2002) and its suitability for developing revolutionary or evolutionary products.

A study by Kaulio (1998) identified three types of design method that can be used to involve users in the design process, – design for customer or user, design with customer or user and design by customer or user. The author indicated that methods, such as QFD, user-oriented product management, led user method, consumer idealized design and participatory ergonomics, are often used in product development in order to identify and establish the specification of a product, concept development, detailed design, prototyping and final outcome. A study by Yang & El-Haik (2003) also confirmed that QFD is often used in the customer and business requirements study stage of the product development process, while methods, such as Taguchi, Robust Design, TRIZ, Axiomatic Design, DOE, Reliability-based Design and Simulation/Optimization, are often employed in the concept development stage of the product development process. Hence, only the QFD method is useful for gathering user information and purposely designed to ensure that the new product concept comes up with the right functional requirements (Kaulio, 1998; Yang & El-Haik, 2003; Ching-Chaw et al., 2006). The study by Kujala (2003) also indicated that user-centered design, participatory design, ethnography and contextual design are successful methods to gather information of user needs, wants and requirements for product design. However, the author also indicated that different methods are used for obtaining different kinds of information and often focus on specific decisions or aspects during a specific stage in product development process, as shown in Table 2.4 below. In addition, these methods are also expensive and provide limited product developers-user interaction (Hoyer et al., 2010), and are often applied in marketing research (Janhager, 2005 and Light Minds Ltd, 2005).

Table 2.4: User involvement methods (Kujala, 2003)

	User-Centered Design	Participatory Design	Ethnography	Contextual Design
Emphasis	Usability	Democratic participation	Social aspect of work	Context of work
Typical methods	Task analysis Prototyping Usability Evaluations	Workshops Prototyping	Observation Video-analysis	Contextual inquiry prototyping

Involving users in product development employs a range of design methods that attempt to facilitate communication between the product designers and users. However, many product developers have not been able to integrate theory and practice into the product development process because they lack a means by which to match their unique problem situations and activities with the available design theories and methods including Axiomatic Design, QFD, Robust Engineering, Structured Analysis and Design Technique, Theory of Inventive Problem Solving, and Total Design (Araujo, 2001; Owen, 2007; Johansson et al., 2011; Benedicic et al., 2012). Recently, many new design methods were proposed based on concurrent function deployment, such as System Engineering (SE), Concurrent Engineering (CE), Integrated Product Development (IPD), Lead User and Stage-gate (Ho & Lin, 2009), to define and produce a product in which user relation comes in as "establishing requirements" (Johansson et al., 2011). Although design methods have also been developed to support product designers, in particular, during decision-making process (Poulikidou & Bjorklund, 2013), many of them did not emphasize capturing information related to the success factors that could influence the sales performance of the products.

2.6 Successful Factors of New Product

There are many things that make products successful in the market-place (Ljungberg & Edwards, 2003 and Cooper, 2005). From a product designer perspective,

the success of a product depends on the acceptance of a user for a variety of reasons, some of which are technical and some non-technical. A product not only must fulfill a user satisfaction, but also attract more users (Barclay, 2002), and must also feel good to use and have an appealing design (Ljungberg & Edwards, 2003). Ultimately, the quality of a product is related to the user experience and personal taste, and not the opinion of the product designer or someone else in the manufacturing company. A study by Cooper & Kleinschmidt (2011) found that successful new products were strongly determined by eight factors, as shown in Table 2.5 below.

Table 2.5: Key factors underlying product success (Cooper & Kleinschmidt, 2011)

1	A superior product that delivers unique benefits to the user
2	A well-defined product and project prior to the development phase
3	Technological synergy
4	Quality of execution of technological activities
5	Quality of execution of pre-development activities
6	Marketing synergy
7	Quality of execution of marketing activities
8	Market attractiveness

However, only the first two factors significantly contribute to a product's success in the product definition stage: 1) a superior product that delivers unique (design and features) benefits to the user, and 2) a well-defined product in the product definition stage. Additionally Cooper & Kleinschmidt (2011) also stated that a product with strong definition in the early stage of the design process is likely to be successful, with a success rate of 85.4 percent. This stage requires critical information: 1) user needs, wants and preferences, 2) the brief of product concepts, 3) the target market, and 4) the product specification and requirements.

There are also numerous characteristics that product developers may simply not know how they affect the success of their new product, such as low cost, high quality,

superior performance (Ernst, 2002), competition, economy, lifestyle, environmental (Carpinetti et al., 2003 and Senk et al., 2010), and newness of the technology or technological sophistication (Binnur, 2002; Carpinetti et al., 2003; Langerak et al., 2004). According to Binnur (2002), although the newness of the technology increasingly influences the success of a new product, it depends on the right or appropriate technology that being selected by the product developer and the way a new product is accepted by users. In addition, implementing the latest technology in the product design will assist the product developers to stay ahead of competitors.

2.6.1 Strategies for a Successful Product

It has been clearly recognized that a successful product depends on a deep understanding of user needs (Kujala, 2003; Janhager, 2005; Bonner et al., Hauser et al., 2006; Wright, 2006; Heiskanen & Repo, 2007; Awa, 2010). However, this process is often rather difficult because these needs are often complex and are not always identified (von Hippel, 2005; Elfving, 2007; O'Hern & Rindfleisch, 2009; Hoyer et al., 2010), and often a reason for the failure of a new product (Ogawa et al., 2006; Kristensson, 2007; Hoyer et al., 2010; Schimmoeller, 2010). There is many of the design methodologies developed attempt to support the development process of a new product. However, limited numbers of methodologies focus on the early stage of the design process, which enables the product designer to employ them into their practice (Araujo Jr., 2001 and Janhager, 2005). Furthermore, the design method to assist the product designer during the product development process is often limited to the identification of user needs, lacks specific guidelines and does not explicitly relate to an increase in the product success (Janhager, 2005; Goellner, 2005; Ching-Chaw et al. (2006); Owens, 2007; Randall & Rouncefield, 2007; Ho & Lin, 2009; Senk et al., 2010; Isaksson et al., 2011). In addition, although many holistic methodologies have been

introduced and implemented, they do not adequately represent the dynamics and are limited to incorporating the user requirements and preferences in the product definition stage of the design process and do not clearly relate to the probability of a successful product.

2.6.2 Proposed New Design Methodology

The question that many product developers could be asked is "what is the best process that could identify all the key factors including user requirements and preferences in the product definition stage of the product development of a successful product?" The purpose of this section is to lay out an approach for a successful new product.

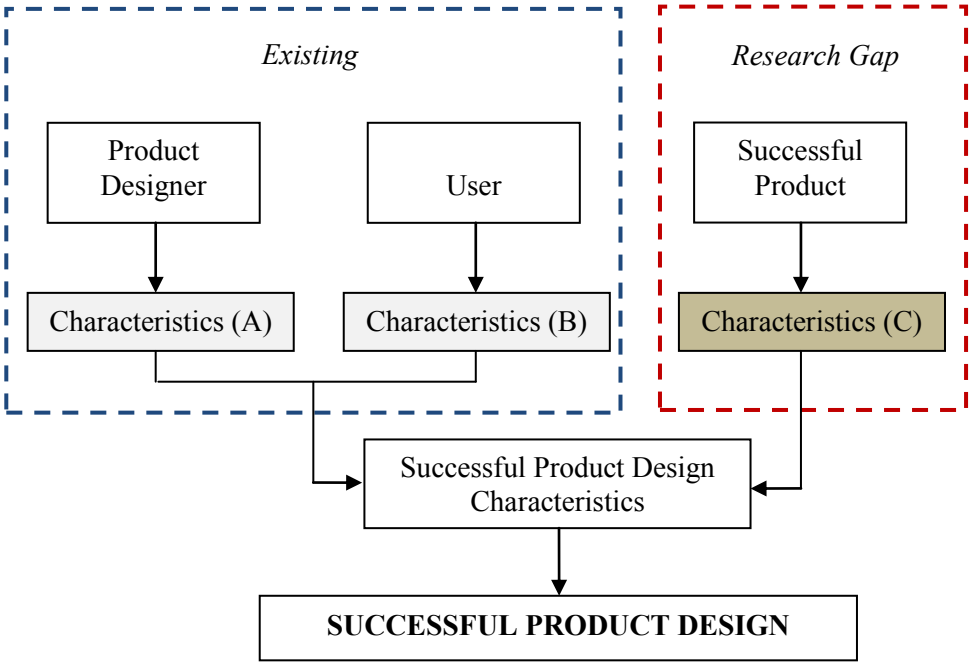

Figure 2.5: Successful product design characteristics

Figure 2.5 above shows the approach for the successful product design characteristics for new design methodology. Essentially, it incorporates characteristics from the product designer (design requirements), user requirements and past successful products.

The proposed new approach is called the Product Design Definition Method (PDDM). The PDDM is purposely designed as a decision support tool that assist the product designer to identify successful product characteristics and verify the product design specifications that will result in a successful design in the product definition stage of the design process. Based on available information, this has never been studies, and the new design methodology introduced is deemed to be novel.

2.7 Conclusion

Involving the user in product development is the most effective strategy in helping product designers to meet information pertaining to their requirements and preferences. It provides better product quality and competition in the market. The product definition stage of the design process is a crucial stage in the design process, in which the user information should be defined as a product specification in order to establish the characteristics of a new product. Various requirements of product design have been found and identified for product design specifications, particularly those that meet user requirements and preferences. However, this does not guarantee the success of the product. In addition, there are a large number of design methods that can be used in the product definition stage of the design process in order to assess and fulfill user needs, but none of them incorporate the successful product characteristics. Hence, a new strategy is proposed that identifies the successful product design characteristics by incorporating the product designer, user and past successful product characteristics in order to increase the probability of product success. The next chapter in this thesis will discuss the research method considerations undertaken in order to develop the proposed the design methodology.

CHAPTER 3 RESEARCH METHODS

3.1 Introduction

This chapter explains the strategic choices concerning the selection of the research methods and how the research was conducted. It presents the research considerations in selecting the methods of study. In particular, this chapter describes how the author carried out the research work, specifically concerning data collection and analysis. The techniques employed to ensure the quality of research are discussed at the end of this chapter.

3.2 Research Plan

An understanding of the research aim, objectives and research questions is required in order to organize and select an appropriate research method for conducting any piece of research work. This understanding plays an important role in providing an accurate result and to prevent poor research findings. In this research work, a descriptive research approach has been chosen in order to achieve all the research objectives. Descriptive research is a specific approach that can provide an accurate picture of a situation and increase the understanding of the phenomenon by presenting data in the form of a numerical picture and creating a set of categories (Neuman, 2007). The data are important for a better understanding of the topic under investigation, and in identifying earlier research previously carried out by other researchers. The information from the previous research is significant for the researcher to understand how similar topics have been researched and identify relevant issues, and to meet new expectations (Hart, 1998 and Marshall & Green, 2004).

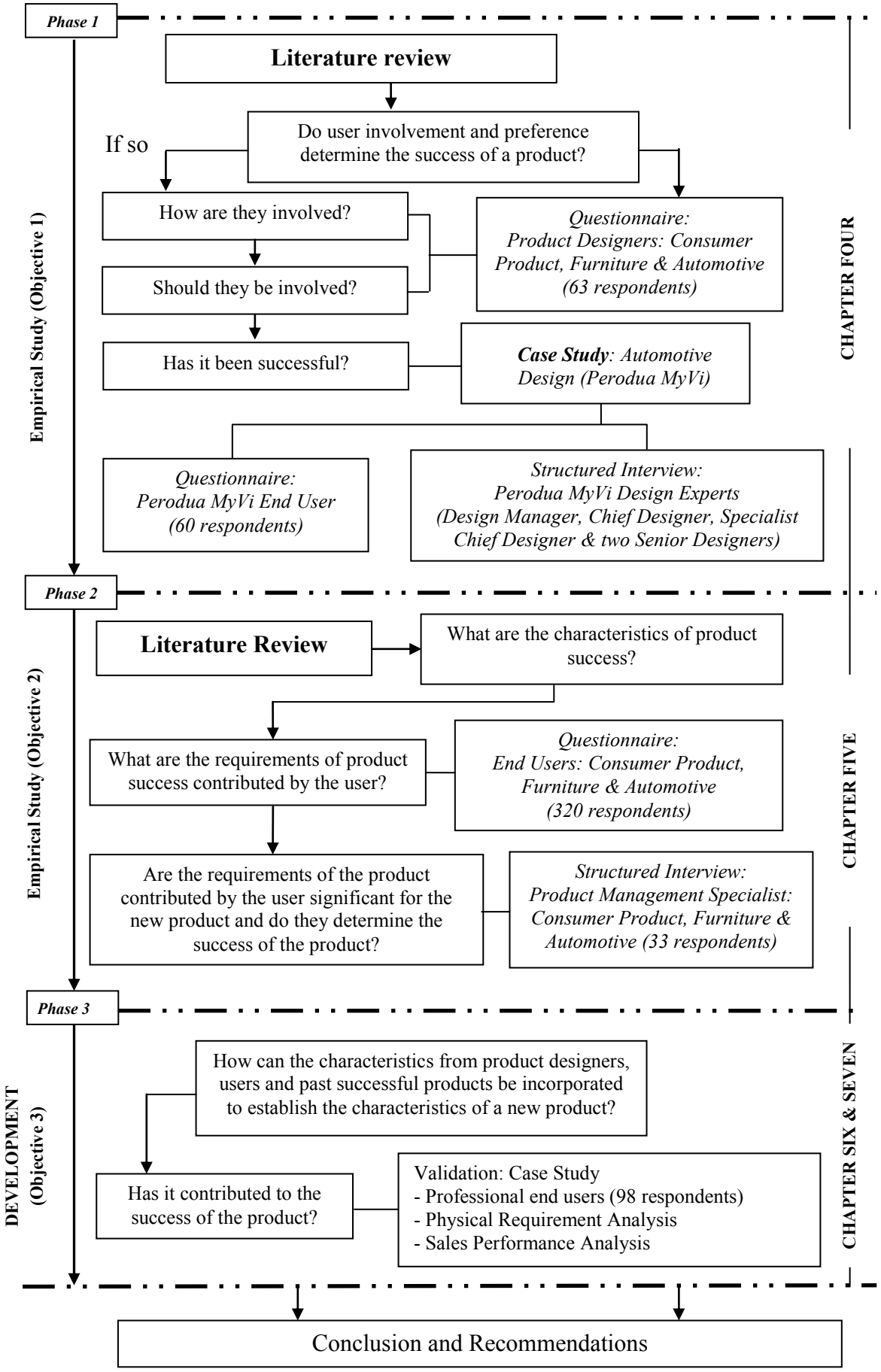

Figure 3.1: Research Framework

Figure 3.1 above presents the research method employed by the researcher to conduct the research work. The fieldwork during this study was divided into two parts: 1) Empirical study – this study was an attempt to identify the successful product characteristics and the requirements of product design contributed by the users, which is significant for the success of a product. 2) Develop a new design methodology – to establish the successful product design characteristics, which incorporate the characteristics from the product designer (design requirements), user requirements and past successful products in the product definition stage of the design process in order to increase the probability of product success. Subsequently, the new design methodology developed was tested to ensure it will fulfill the research aim.

3.3 Data Collection

Quantitative data collection was used to gain an in-depth understanding of the issues and problems identified. It has become a fundamental approach to explore and provide a clear picture of the research issues and to utilize the data as a resource so some problems could be understood and tackled. The quantitative data are also strongly recommended to provide accurate statistical results during the research by using the survey (den Hertog & van Sluijs, 1995 and Ottosson, 2006).

Primary data are needed for this research and are most appropriate for collection through a survey. A survey is important as the backbone of research data that can be used to collect information by asking a set of pre-formulated questions in a predetermined sequence in a structured questionnaire to a group of individuals drawn from a defined population (Hutton, 1990), and is often conducted by product designers as a reference that helps them to ensure the effectiveness of their innovation (den Hertog & Van Sluijs, 1995). Two types of instrument for data collection have been implemented questionnaire and structured interviews.

3.3.1 Questionnaires and Structured Interviews

Questionnaires and structured interviews are good data collection techniques to present better quantitative data (Kuter & Yilmaz, 2001). A questionnaire is a powerful instrument that can help the researcher generate findings that can be used to answer each of the research questions and to obtain specific information for a defined problem. A questionnaire can be useful as a data collection tool when the following conditions are met: 1) the target respondents can be clearly defined and identified, 2) the respondents know what is asked of them, and 3) the focus of the analysis is numerical, i.e. the questionnaire yields quantitative data (Marshall, 2004). However, it is not that easy to implement a questionnaire survey without great skill to produce an effective outcome. In order to capture the greatest results from the participants and to ensure they give an appropriate answer, the questionnaires should: 1) be easily understood by the respondents, 2) who must be able to provide the information requested, and 3) be willing to provide the information. In addition, the questions should not be too complex, the questionnaire should not to be too long, and the questions should be concise and straightforward (Eaden et al., 1999 and Edwards et al., 2004).

Structured interviews are also known as closed type questionnaires. Structured interviews include a set of questions that use the same wording and order of questions as specified to gather information from the respondents (Kumar, 2005). The objective of structured interviews is to follow specific questions that focus on defining the purpose of the research target. According to Robson (2002), structured interviews have predetermined questions with fixed wording, usually in a pre-set order. In addition, the questions are written according to a closed-ended question approach, prepared for usage during a person-to-person interaction. In this research, structured interviews are useful to define the specific answers relating to the phenomenon being investigated.

3.3.2 The Questionnaire Design

The systematic design of research questions is an important aspect in order to provide the quality and validity of the output (Kumar, 2005). According to Rubin & Babbie (2011), every questionnaire should contain clear instructions to be completed by the respondents who should be in the proper frame of mind to answer the question. In addition, self-administered questionnaires should have basic instructions to be followed for their completion. Thus, in this research, the questionnaires were developed on the basis of information from two sources: 1) the literature and 2) several design experts comprising academics and practitioners (refer to Appendix A and Appendix B). In addition, the respondents were also used as sources of information in the questionnaire design. In this research, the Perodua MyVi design expert survey was designed based on the findings generated from the Perodua MyVi end-user survey. The Perodua MyVi design expert survey attempts to extend the knowledge and identifies the relevant data through the perspective of Perodua MyVi design experts.

In order to provide a good questionnaire, each question in the questionnaire was evaluated through pretesting the questions and a pilot test. For pretesting, the draft of four questionnaires and two structured interviews were first sent to academics and design experts in this area, who were asked to comment on the content, clarity and scaling of the instruments. The questionnaires were distributed to three design experts currently working within a consumer product company (Design Manager, Panasonic (M) Sdn. Bhd), furniture company (Managing Director, Redahjaya Sdn. Bhd) and automotive company (Specialist Designer, Perodua (M) Sdn. Bhd), as well as to two academic researchers (Professor and Associate Professor) for input concerning the content validity of the questions. The questionnaires were initially designed and revised many times in order to improve the wording, grammar, and specific item contents. The

questionnaires were carefully written to ensure that the content and the definitions were delivered to the participants in an appropriate manner.

The pilot test for the end-user survey was conducted by sending questionnaires to actual respondents in order to identify the specific focus of the content, design and usability of the instrument. According to De Vos (1998), the purpose of a pilot study is to improve the success and effectiveness of the questionnaire through which modifications can be made before the actual questionnaires are distributed to many respondents. The pilot testing of the instrument could involve a minimum of ten (10) respondents per instrument item to evaluate the survey for its content validity (Rubin & Babbie, 2011). In addition, a pilot test on a minimum of 10 subjects is usually sufficient to capture many large problems in a questionnaire before accomplishing the main study (De Leo et al., 2010 and Leroy, 2011). After the pilot test was conducted, several minor changes were made before the final questionnaire was sent to a large number of respondents, e.g.; 1) the length of questions was shorted formulating short simple questions, 2) complex questions where simplified so that they focused on what was relevant to the main subject, 3) good use of arrows and boxes was made in the answer part, and 4) an introduction briefly explaining the purpose of the survey was provided.

3.4 Sources of Data

The data collection specifically focused on the product development process and product success. The information collected was used to achieve the research aim and objectives. The selection of participants to be involved in this research was important in order to obtain accurate results that would achieve the research objectives. Six groups were selected as respondents: 1) product designer, 2) Perodua MyVi design experts, 3) Perodua MyVi end user, 4) end users of the three products (consumer product, furniture and automotive), professional end user, and 5) product management specialists. Only

data from the professional end user survey were used in the evaluation of the developed theories and method in chapter seven. The questionnaire was applied in this survey through face-to-face, telephone, recruitment and email involving product designers, Perodua MyVi end users, end users of three product types and professional end user, while the structured interview involved 15-minute face-to-face interviews with Perodua MyVi design experts and product management specialists in order to obtain the necessary knowledge from them. The questionnaires were divided into two categories: Part A: the respondent's background and Part B: to identify the respondent's point of view pertaining to the required answers. The measurement scales employed a five-point Likert scale with 1=Not important, 2=Less important, 3=Neutral, 4=Important and 5=Strongly important.

Non-probability sampling was used to gather information from the individuals in the population. The decision to use this type of sampling is essential when the number of elements in a population is either unknown or cannot be individually identified (Kumar, 2005). According to Babbie (2009), and Rubin & Babbie (2011), social research is often conducted in situations that do not permit certain kinds of probability sampling. Consistently, most researchers resort to the use of non-probability sampling as it is the only way to obtain the data (Sekaran & Bougie, 2009). Thus, in this study, three types of non-probability sampling technique were used judgment sampling, quota sampling and snowball sampling. Table 3.1 briefly describes the significance of the non-probability sampling selected from the viewpoints of several authors.

Table 3.1: Types of non-probability sampling used

Type of non-probability sampling	Significance of sampling
Judgment sampling	Judgment sampling is method for obtaining the type of information that required from very specific pockets of people who alone possess the needed facts and can give the information sought (Sekaran & Bougie, 2009), and appropriately select the sample on the basis of the researchers' own knowledge of the population (Rubin & Babbie, 2011).
Quota sampling	Quota sampling is a form of proportionate stratified sampling, in which a predetermined proportion of people are sampled from different groups (Sekaran & Roger, 2009) and selected from a convenient location (Kumar, 2005 and Sekaran & Bougie, 2009)
Snowball sampling	Snowball sampling is a technique for sampling (or selecting) the cases in a network (Neuman, 2011 and Kumar, 2005). The researcher collects data concerning a few members of the target population, then asks these individuals to provide the information needed to locate other members of that population whom they happen to know (Babbie, 2009 and Rubin & Babbie, 2011)

The sample size is the number of subjects used for a study estimated from a given population. According to Neuman (2011), sample size depends on the population characteristics, the type of data analysis to be employed, and the degree of confidence in the sample accuracy needed for research purposes. It also relates to how many respondents to invite for the research and consists of the elements of analysis of the population. However, the target size for a survey depends on three main factors: 1) the resources available, 2) the aim of the study, and 3) the statistical quality needed for the survey (Kelly et al., 2003). Mitra & Lankford (1999), and Nieswiadomy (2008) indicated that, for a survey, a minimum of 10 percent of the total population or response rate is sufficient in order to analyze the data. Consistently, a sample size of 25 or 30 is generally considered to be sufficiently large for most situations (Howell, 2002). According to Cohen (1988), a minimum of 30 participants is enough for an ordinary study. Many researchers in product design study have used small sample sizes. Lai et al. (2006) used 15 respondents; Yang & Shieh (2010), and Yang (2011) used 30

respondents; Kuang & Jiang (2009) used 40 respondents; Chen & Chung (2008) and Lin et al. (2012) used 60 respondents.

3.4.1 Empirical Study

In this research, the empirical study provided new data and points of view for the research. It is valuable to answer several questions, which were highlighted in phase 1 and phase 2 in Figure 3.1 (details in section 3.2 in Chapter 3). Hence, five groups of respondent were selected and involved in this survey: 1) product designer, 2) Perodua MyVi end user, 3) Perodua MyVi design expert, 4) end user, and 5) Product management specialist.

3.4.1.1 Product Designer

The product designer survey was purposely done 1) to determine whether user involvement and preference determine the product success, 2) to identify at which stage the product designer should involve the user the most in the NPD process, 3) to identify the roles of the user in the product development process, 4) to identify the product information source of the new product, and 5) to identify methods to involves users in product development process. The respondents who were involved in this survey were selected based on their understanding of the importance of user involvement in product development. Thus, the survey was carried out among a number of product designers working in design development activities or product development from three representative design companies, namely, consumer product, furniture and automotive.

A total of three hundred and eighty (380) product designers are registered with the Industrial Design Association of Malaysia (PEREKA). For this survey, only seventy-five (75) respondents were identified based on three selection criteria of the

respondents: 1) the respondents must work in product development activities or R&D, 2) a maximum of five respondents representing each design company, and 3) professional product designer with minimum of a degree in product design or equivalent. The judgment sampling technique is employed in this survey. At the end of the survey, sixty-three (63) responded or an 84 percent response rate was achieved. Thus, the total number of the respondents are more than sufficient to analyze the data (Cohen, 1988; Mitra & Lankford, 1999; Howell, 2002; Nieswiadomy, 2008).

3.4.1.2 Perodua MyVi End User

The Perodua MyVi end-user survey aims 1) to identify user preference for the Perodua MyVi, and 2) to identify the design characteristics that contributed to the success of the Perodua MyVi. The new Perodua MyVi car was selected as the product of study. The selection was based on the sales reputation of the first generation MyVi in the market and its popularity in the compact car category in Malaysia since its launch in May 2005. According to Power Asia Pacific (2010), the Perodua MyVi was ranked highest in the compact car segment in 2009 in Malaysia and was awarded the prestigious best model 2010 from the Frost & Sullivan Asian Automotive Award. A total of eighty-eight (88) potential respondents along with their details were obtained from several branches of Perodua Sales and Service Centers in Selangor, Kuala Lumpur and Putrajaya. The respondents' characteristics were classified as purchasers of the new Perodua MyVi model launched in June 2011. The questionnaire was employed through face-to-face, telephone, recruitment, and email. The judgment sampling technique was employed in this survey. At the end of the survey, sixty (60) respondents were obtained. This number of respondents was adequate for analysis (Cohen, 1988; Mitra & Lankford, 1999; Howell, 2002; Nieswiadomy, 2008). Many other researchers have used smaller

sample sizes, e.g. Lai et al. (2006), Yang & Shieh (2010), Yang (2011), Kuang & Jiang (2009), Chen & Chung (2008) and Lin et al. (2012).

3.4.1.3 Perodua MyVi Design Experts

The survey of design experts was conducted in an automotive company. The empirical investigation involved the design experts from the R&D department of Perusahaan Otomobil Kedua Sdn Bhd (PERODUA). The survey of design experts was conducted for the purpose of 1) to know whether user involvement contributes to the success of a product, 2) to identify when to involve the user in the product design and development stage, and 3) to identify the factors for the success of the Perodua MyVi. The selection of the five respondents was based on their experience and involvement in the development of the new Perodua MyVi model, which was launched in June 2011. The Delphi method was employed in this survey. According to Sackman (1975), Delphi is an attempt to elicit expert opinion in a systematic manner for useful results. Sackman (1975) stated that the Delphi method could be a structured questionnaire, in which a quantitative or qualitative scale may be used and the process consists of two or more rounds of survey. In this survey, the Delphi process consisted of two rounds in which, in the first round, the questionnaire was distributed to the respondents, and then returned to the researchers, while, in round two, the respondents had the opportunity to verify their responses from round one and the opportunity to change or expand their response. A total of five (5) respondents were selected and participated in the face-to-face interviews. They are categorized as the design manager, chief designer, specialist chief designer, and two senior designers. Clayton (1997) reported that only 5-10 experts are needed. Other studies indicated that Gustafson et al. (1973) used four respondents in two rounds of the Delphi process, while three respondents were used in three rounds of the Delphi process by Lam et al. (2000). The number of respondents is usually small

because the Delphi do not or are not intended to produce a statistically significant result or response of a larger population and the data can be displayed using the mode, median or interquartile range (Gordon, 1994).

3.4.1.4 End User

The end-user survey was purposely conducted: 1) to determine user preference for three different product types, 2) to identify the characteristics of three different successful product types, and 3) to identify and differentiate user requirements for the three different product types. This survey is an important tool to generate the list of functional and aesthetical requirements that are considered important to them; for example, the design, function, technology, brand, price and safety (refer to section 2.4.2 and section 2.4.3 in Chapter 2). The product for each design cluster analyzed was mobile phone for consumer product, living room sofa for furniture product and privately owned car for automotive product. The mobile phone was selected based on its availability with many features and various design offers. The development of the mobile phone has been very fast, and has changed in a very short period of time. In addition, the mobile phone is not just a tool but has become part of our fashion and status. The living room sofa was selected as an example of a product from the furniture design cluster. The selection of a living room sofa is important to show the preference of the user in order to identify the design selection based on the room environment and to ensure the comfort of the user. The passenger car was chosen as an example of a product from the automotive design cluster. The passenger car was selected based on its purpose as something being used by people in their daily activities for an extended period. It can also show and identify user preference concerning car design. In addition, the development of a vehicle is also of great concern to the user in respect of the perceived quality.

A total of three hundred and sixty (360) respondents or one hundred and twenty (120) respondents from each product type (consumer product, furniture and automotive) were invited to participate in this survey. They were designed as end user of the product (professional user, experienced user and novice user). The quota sampling technique was employed in this survey. At the end of this survey, three hundred and twenty two (320) responded of which one hundred and four (104) respondents were for consumer product, one hundred (100) respondents were for furniture and one hundred and sixteen (116) respondents were for automotive. The total respondents are deemed sufficient for analysis of the data (Cohen, 1988; Mitra & Lankford, 1999; Howell, 2002; Nieswiadomy, 2008). Many other researchers in almost similar studies have a smaller sample size (Lai et al., 2006; Chen & Chung, 2008; Kuang & Jiang, 2009; Yang & Shieh, 2010; Yang, 2011; Lin et al., 2012).

3.4.1.5 Product Management Specialists

The product management specialist survey was an attempt 1) to categorize the product requirements into functional and aesthetical requirements, 2) to identify the source of product characteristics development in the design process, and 3) to find the contribution of the user for product characteristics development. These involved a number of product management specialists who were currently leading the product design activities in the field of consumer product design, furniture design and automotive design. The list of respondents was obtained based on data provided from the Industrial Design Association of Malaysia (PEREKA). Thirty-five (35) respondents were identified as potential respondents based on the following requirement: 1) the project leader has a minimum working experience of 10 years in research and development (R&D) projects in design or manufacturing companies, and 2) is the key decision-maker in the final product development stage. The personnel interviewed

included highly trained designers, prominent executives and people who were well versed in the design process. The judgment sampling technique was employed in this survey. In the end, thirty-three (33) respondents participated in the face-to-face interviews. The response rate was 94 percent; thus the total number of respondents is more than sufficient to analyze the data (Cohen, 1988; Mitra & Lankford, 1999; Howell, 2002; Nieswiadomy, 2008).

3.4.2 Development of the Design Methodology

The data gained from the empirical studies were valuable and useful for the development of a new design methodology in an attempt to establish new successful product design characteristics. Three main processes were involved in the new design methodology: 1) developing the successful product design characteristics (SPDC) map, 2) prioritizing the product success through the successful product characteristics (SPC) matrix, and 3) verifying the product specification through the product design specifications (PDS) matrix. All these are essential to establish the successful product design characteristics. The mapping process, prioritizing analysis, clustering analysis was motivated from the Project Prioritization Performance Metrics and Evaluation Matrix. According to Edgett (2011), the project prioritization performance evaluation metrics are divided into four levels ranging from priority 1 to priority 4. Therefore, the Evaluation Matrix is often used to evaluate an idea in accordance with several factors or criteria, and allows for 1) specifying and prioritizing needs, 2) evaluating, rating and comparing different solutions, and 3) selecting the best matching solution. The percentage score or rates are used on a ratio scale, e.g. 0-5, 0-10 or 0-100.

In this study, the establishment of the successful product design characteristics (SPDC) Map consisted of three main steps (details in Figure 6.2 in Chapter 6): Step 1: Identify successful product characteristics (PDC). Step 2: Identify product requirements.

In this step, several design requirements and user requirements were identified from both the product designers and the user. Step 3: Mapping process for successful product design characteristics (SPDC) Map. Both the PDC and PDS are important to establish the successful product design characteristics. After the successful product design characteristics (SPDC) Map was established, the next process focused on the development of the product design definition method process and procedure. This was essential to enable the product designer to use the Product Design Definition Method (PDDM). The process was divided into four steps (details in Figure 6.5 in Chapter 6): 1) user input is required according to SPDC Map, 2) prioritizing successful product characteristics through SPC Matrix (details in Table 6.4). Step 3: verifying product design specification through PDS Matrix (details in Figure 6.6 in Chapter 6). In this step, the product design specifications were clustered based on Must Have (MH), Should Have (SH), Not Necessary to Have (NNH) and Must Not Have (MNH). Toward the end, several specifications were identified as significant for new products. Step 4 was building the SPDC into the success factors (XS) Detailed Description. The XS-Detailed Description is a worksheet to facilitate the research and development team to identify the technical specification for each specification (example shown in Table 6.5 in Chapter 6).

3.4.3 Validation of a Successful Product

The validation of a successful product was conducted purposely to validate the success of a new product using the proposed design methodology (details in Chapter 7). This validation survey involved the professional user end of a successful product, detailed technical specification analysis and sales performance analysis.

3.4.2.1 Professional End User

The professional end-user survey was performed to validate the significant successful product characteristics and product design specification, which contributed to the success of a product. The respondents involved in this survey were users of BlackBerry Bold, Apple iPhone4 and Samsung Galaxy Tab 7.0 plus. These products were selected based on their leading edge technology reputation and volume of sales. A set of questionnaires was distributed in order to investigate the factors that could influence the success of the product (refer to Appendix A-4). The snowball sampling technique was employed in this survey. A total of ninety-eight (98) respondents participated in data collection. There were thirty-one respondents for Apple iPhone4, thirty-two respondents for BlackBerry Bold and thirty-five respondents for Samsung Galaxy Tab 7.0 Plus in the survey. The total respondents were deemed sufficient for analysis (Cohen, 1988; Mitra & Lankford, 1999; Howell, 2002; Nieswiadomy, 2008). Many other researchers in similar studies have smaller sample size, e.g. Lai et al. (2006), Chung (2008), Kuang & Jiang (2009), Chen & Yang & Shieh (2010), Yang (2011) and Lin et al. (2012).

3.4.2.2 Technical Specification Analysis

After the factors that influenced the success of a product were identified from the user, the technical specification was conducted in order to determine the detailed specification of a product that could contribute to the success of the product. The successful product characteristics were used as a product indicator and correlated through the product design specification. The XS-Detailed Description (example shown in Table 6.5 in Chapter 6) was used in order to identify the detailed technical specification of a product.

3.4.2.3 Sales Performance Analysis

Sales performance analysis was conducted using correlation and regression methods in order to provide evidence of successful product characteristics that have a strong influence sales performance. The Apple iPhone was selected as a case study. The Apple iPhone was selected based on its sales performance and user satisfaction (e.g. Change Wave Research, 2012). The factor analysis was carried out through correlation and regression methods using the SPSS software. The correlation result is accepted if the correlation is significant $p<.05$. The strength of a correlation can be defined through Pearson Correlation (r), as shown in Table 3.2.

Table 3.2: The strength of correlation (Piaw, 2012)

Correlation Coefficient size (r)	Correlation strength
.91 to 1.00 or -.91 to -.1.00	Very Strong
.71 to .91 or -.71 to -.90	Strong
.51 to .70 or -.51 to -.70	Average /medium
.31 to .50 or -31 to -.50	Weak
.01 to .30 or -.01 to -.30	Very Weak
.00	No Correlation

The regression analysis was used to analyze the relationship between the interval variables. It contained two values - dependent variable (Y) and independent variable (X). The regression analysis of the variable in this analysis can be identified through the formula below:

$$Y = a + bX \quad (3.1)$$

$$Y = a + b_1X_1 + b_2X_2 + \ldots\ldots b_kX_k \quad (3.2)$$

Note: Y = sales, X = variable of product

3.5 Data Analysis

In this research, the data from the empirical investigation were analyzed using the Statistical Package for Social Sciences (SPSS) version 19.0 software for windows. The SPSS software is a major tool for data analysis in social sciences (Nachmias & Nachmiss, 2008). It is useful to process data from a questionnaire due to its flexibility and convenience of use (Piaw, 2012).

3.5.1 Quality of the Research Instrument

The research quality in quantitative approach is associated with the reliability and validity of the research. Reliability is the degree of accuracy or precision in the measurements made by a research instrument (Kumar, 2005). It can be divided into longitudinal reliability (e.g. the consistency of the result validity – the same person is asked the same question on multiple occasions) and cross-sectional reliability, i.e. the consistency of the results across similar questions. While, the validity can be divided into a correlation validity, i.e. the degree to which a given response can be used for predicting other similar responses and discriminate validity, i.e. the degree to which a response can be used for differentiating dissimilar attitudes. Thus, before the data were analyzed, all the questions were tested for reliability using SPSS. The validation must result in a Cronbach's Alpha α between .65 and .95 (Piaw, 2012).

3.6 Conclusion

This chapter describes the systematic research plan that was designed to answer the research objectives and to achieve the research aim. The study was divided into two stages; the empirical study and the development of a new design methodology. For the empirical study, a quantitative research method was employed in order to provide an accurate result in the form of statistics. Therefore, descriptive research was used as a

specific approach to achieve the first two research objectives. The data was collected using four (4) questionnaires and two (2) structured interviews, for which the purpose of each is summarized in Table 3.3 below. The data for the empirical study from this process were analyzed and used for the new methodology development stage. The empirical study is explained in chapter four and chapter five, while the new design methodology development is explained in chapter 6. The validation of this new proposed design methodology is presented in chapter seven.

Table 3.3: The empirical study and validation survey

	Target group	Data collection methods / sampling types	Number of respondents	Purpose of survey	Data & Results
Empirical Study	Product Designer	Questionnaire / Judgment sampling	63	1) To determine whether user involvement and preference determine the product success. 2) To identify at which stage the product designer should involve the user the most in the NPD stage. 3) To identify the roles of the user in the product development process. 4) To identify the product information source of the new product. 5) To identify methods to involves users in the product development process.	Section 4.2.2.2 & Section 4.2.2.3 Section 4.2.2.4 Section 4.2.2.5 Section 4.2.2.6 Section 4.2.2.7
	Perodua MyVi End User *(professional, experienced and novice user)*	Questionnaire / Judgment sampling	60	1) To identify user preference for the Perodua MyVi. 2) To identify the design characteristic that contributed to the success of the Perodua MyVi.	Section 4.3.2.2 Section 4.3.2.3
	Perodua MyVi Design Expert	Structured Interview / Delphi Method	5	1) To know whether user involvement contributes to the success of a product. 2) To identify when to involve the user in the product design and development stage. 3) To identify the factor for the success of the Perodua MyVi.	Section 4.4.2.2 Section 4.4.2.3 Section 4.4.2.4
	End User of three product group *(professional, experienced and novice user)*	Questionnaire / Quota sampling	320	1) To determine user preference for three different product types. 2) To identify the characteristics of successful of three different successful product types. 3) To identify and differentiate user requirements for the three different product types.	Section 5.2.2.2 Section 5.2.2.3 Section 5.2.2.4

	Product Management Specialist *(Experienced product designers who lead design team)*	Structured Interview / Judgment sampling	33	1) To categorize the product requirements into functional and aesthetical requirements. 2) To identify the source of product characteristics development in the design process 3) To find the contribution of the user for product characteristics development.	Section 5.3.2.2 Section 5.3.2.3 Section 5.3.2.4
Validation	Professional End User	Questionnaire / Snowball sampling	98	To validate the significant successful product characteristics and product design specification, which contributed to the success of a product	Section 7.3.2.2 & Section 7.3.2.3

CHAPTER 4 USER CONTRIBUTION TO A SUCCESSFUL PRODUCT

4.1 Introduction

This chapter describes the data analysis and results obtained from three empirical studies in order to achieve the first objective which, was *to investigate the extent of user involvement and contribution in product development that results in the success of a new product*. The first empirical investigation involved the product designer in an attempt 1) to determine whether user involvement and preference determine the product success, 2) to identify at which stage the product designer should involve the user the most in the NPD process, 3) to identify the role of the user in the product development process, 4) to identify the product information source of the new product, and 5) to identify methods to involves users in the product development process. The second empirical investigation involved Perodua MyVi end users 1) to identify user preferences for the Perodua MyVi and 2) to identify the design characteristics that contributed to the success of the Perodua MyVi. The third empirical investigation involved Perodua MyVi design experts. The aim of this survey was 1) to know whether user involvement contributes to the success of a product, 2) to identify when to involve the user in the product design and development stages, and 3) to identify the factors for the success of the Perodua MyVi. The questionnaire was distributed to the product designers and Perodua MyVi end users, while, the structured interview approach was applied for the Perodua MyVi design experts.

4.2 Data Analysis and Results of Product Designer Survey

4.2.1 Reliability of the Research Instrument

A list of 23 items was used in this survey and to ensure the reliability of the instrument, all the questions were thoroughly tested in the reliability analysis. The reliability of a particular research instrument is defined by the capability of a research to obtain identical values. The reliability of the instrument result will be valid if the Cronbach's Alpha shows an α value between .65 and .95. Table 4.1 shows the reliability of the research instrument statistic from the product designer survey. The results indicate that the Cronbach's Alpha reliability coefficient is .73. The reliability of .73 indicates 73 percent consistency in the score produced by the instrument. Hence, the research instrument is satisfactory.

Table 4.1: Reliability of research instrument statistic for product designer survey

Cronbach's Alpha	N of Items
.73	23

4.2.2 Results of Product Designer Survey

4.2.2.1 Characteristics of Respondents

A total of 63 respondents working as professional product designers took part in this survey. Table 4.2 shows the designation of the respondents. The results indicate that the respondents consist of professional product designers with N=28 (44.4 percent), senior designers with N=18 (28.6 percent), design managers with N=12 (19.0 percent), and directors with N=5 (7.9 percent).

Table 4.2: Designation of respondents

Designation	Frequency N	Percentage
Designer	28	44.4%
Senior Designer	18	28.6%
Manager	12	19.0%
Director	5	7.9%
Total	63	100.0%

All the respondents have a great deal of experience in product development. Table 4.3 shows the experience of the respondents. The results show that 17.5 percent of the respondents have less than two years' experience in product development followed by 33.3 percent respondents with between 3 and 5 years working experience, 12.7 percent respondents with between 6 and 10 years working experience and 36.5 percent with more than 11 years working experience.

Table 4.3: Experience of respondents

Years of Experience	Frequency N	Percentage
<2 years	11	17.5%
3-5 years	21	33.3%
6-10 years	8	12.7%
>11 years	23	36.5%
Total	63	100.0%

Table 4.4: Type of company of respondents

Type of Company	Frequency N	Percentage
Product Design	21	33.3%
Furniture Design	21	33.3%
Automotive Design	21	33.3%
Total	63	100.0%

Table 4.4 shows the type of company of the respondents. The results indicate that 33.3 percent of the respondents work in consumer product design, followed by 33.3 percent in furniture design and 33.3 percent in automotive design.

4.2.2.2 User Involvement and Preference in Product Development

It is observed that user involvement and preference are widely accepted and practiced in the product development process. Table 4.5 shows user involvement and preference in product development. The results indicate that 60.3 percent of the respondents agree with user involvement and preference in new product development, followed by 33.3 percent strongly agreeing and only 6.3 percent preferring to be neutral.

Table 4.5: User involvement and preference in product development

Product Designers	Frequency N	Percentage
Strongly Agree	21	33.3%
Agree	38	60.3%
Neutral	4	6.3%
Total	63	100.0%

Table 4.6 shows the user involvement and preference in the product development for the three types of product. The results show that the product designers for both automotive and furniture, comprising 95.3 percent of the respondents, agree and strongly agree compared to 90.5 percent of the respondents from the consumer products. Only 4.8 percent of the respondents from both the automotive and furniture opted to be neutral compared with 9.5 percent of the respondents from the consumer products.

Table 4.6: User involvement and preference in product development for the three types of product

Product group/ Company		*The Categorical Scale*			Total
		Neutral	Agree	Strongly Agree	
Consumer Product	N	2	13	6	21
	% for company	9.5%	61.9%	28.6%	100.0%
	% for user involvement	50.0%	34.2%	28.6%	33.3%
	% of Total	3.2%	20.6%	9.5%	33.3%
Furniture	N	1	14	6	21
	% for company	4.8%	66.7%	28.6%	100.0%
	% for user involvement	25.0%	36.8%	28.6%	33.3%
	% of Total	1.6%	22.2%	9.5%	33.3%
Automotive	N	1	11	9	21
	% for company	4.8%	52.4%	42.9%	100.0%
	% for user involvement	25.0%	28.9%	42.9%	33.3%
	% of Total	1.6%	17.5%	14.3%	33.3%
Total	N	4	38	21	63
	% for company	6.3%	60.3%	33.3%	100.0%
	% for user involvement	100.0%	100.0%	100.0%	100.0%
	% of Total	6.3%	60.3%	33.3%	100.0%

4.2.2.3 User Contributes to Product Success

The user and their strong acceptance have made them one of the most influential decision-makers in the success of a new product. Table 4.7 shows user contribution to product success. The results indicate that 88.9 percent of respondents stated that they agree and strongly agree that the user contributed to the success of a new product followed by 7.9 percent of respondents who chose to be neutral and 3.2 percent of respondents stated they disagree.

Table 4.7: User contribution in product success

Product Designers	Frequency N	Percentage
Strongly Agree	18	28.6%
Agree	38	60.3%
Neutral	5	7.9%
Disagree	2	3.2%
Total	63	100.0%

Table 4.8: User contribution in product success from designers' experience

Product designers' experience		*The Categorical Scale*				Total
		Disagree	Neutral	Agree	Strongly Agree	
<2 years	N			9	2	11
	% for respondent experience			81.8%	18.2%	100.0%
	% for product success			23.7%	11.1%	17.5%
	% of Total			14.3%	3.2%	17.5%
3-5 years	N	1	3	11	6	21
	% for respondent experience	4.8%	14.3%	52.4%	28.6%	100.0%
	% for product success	50.0%	60.0%	28.9%	33.3%	33.3%
	% of Total	1.6%	4.8%	17.5%	9.5%	33.3%
6-10 years	N		1	7		8
	% for respondent experience		12.5%	87.5%		100.0%
	% for product success		20.0%	18.4%		12.7%
	% of Total		1.6%	11.1%		12.7%
>11 years	N	1	1	11	10	23
	% for respondent experience	4.3%	4.3%	47.8%	43.5%	100.0%
	% for product success	50.0%	20.0%	28.9%	55.6%	36.5%
	% of Total	1.6%	1.6%	17.5%	15.9%	36.5%
Total	N	2	5	38	18	63
	% for respondent experience	3.2%	7.9%	60.3%	28.6%	100.0%
	% for product success	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	3.2%	7.9%	60.3%	28.6%	100.0%

Table 4.8 shows the user contribution in a product's success based on designers' experience. The results indicate that 43.5 percent of respondents who have more than 11

years of experience in product development strongly agree with the level of importance of user contribution in product success followed by 47.8 percent respondents agreeing. The respondents with 6-10 years of experience show that 87.5 percent of the respondents agree, while 12.5 percent of the respondents chose neutral. In addition, 28.6 percent of the respondents with 3-5 years of experience strongly agree, whilst 52.4 percent of respondents agree, and 14.3 percent chose to be neutral. Only 4.8 percent respondents disagree. Finally, 18.2 percent respondents with less than 2 years of experience strongly agree whilst 81.8 percent agree.

4.2.2.4 User Involvement in NPD Stages

In this study, it was found that user involvement in NPD is significant throughout the whole product process. Table 4.9 shows the overall user involvement in the NPD stages. The results indicate that user involvement in NPD stages is significant at the product introduction, followed by product planning, product testing & validation, and product concept. However, their involvement is not required so much in the product engineering and production stages.

Table 4.9: User involvement in NPD stages

NPD Stages	N	Median	Mode	Min	Max	Sum
Product Planning	63	4.00	4.00	1.00	5.00	248.00
Product Design & Development	63	4.00	4.00	1.00	5.00	235.00
Product Engineering	63	3.00	3.00	1.00	5.00	194.00
Product Testing & Validation	63	4.00	4.00	1.00	5.00	236.00
Production	63	2.00	3.00	1.00	5.00	148.00
Product Introduction	63	4.00	4.00	1.00	5.00	251.00

However, slightly different results were obtained when the data were separated and compared for the three different product groups. Figure 4.1 shows the user involvement in the new product development stage for the three product groups. The results indicate

that the respondents in consumer products are highly desirable in the product introduction with 76.2 percent, followed by 71.4 percent in product planning and product testing & validation, 66.7 percent in product design & development, 28.5 percent in product engineering, and 9.6 percent in production. For the furniture group, 80.9 percent of the respondents stated that user involvement is highly desirable during the product design and development followed by 71.4 percent in product planning, 66.7 percent in product introduction, 61.9 percent in product testing and validation, 28.5 percent in product engineering and 14.3 percent in production. For the respondents in the automotive group, 85.7 percent of the users were highly involved in product planning, followed by 80.9 percent in product introduction, 61.9 percent in product testing and validation, 52.7 percent in product design & development and 42.8 percent in product engineering. While, only the respondents for automotive group was identified as not being involved the user in the production stages.

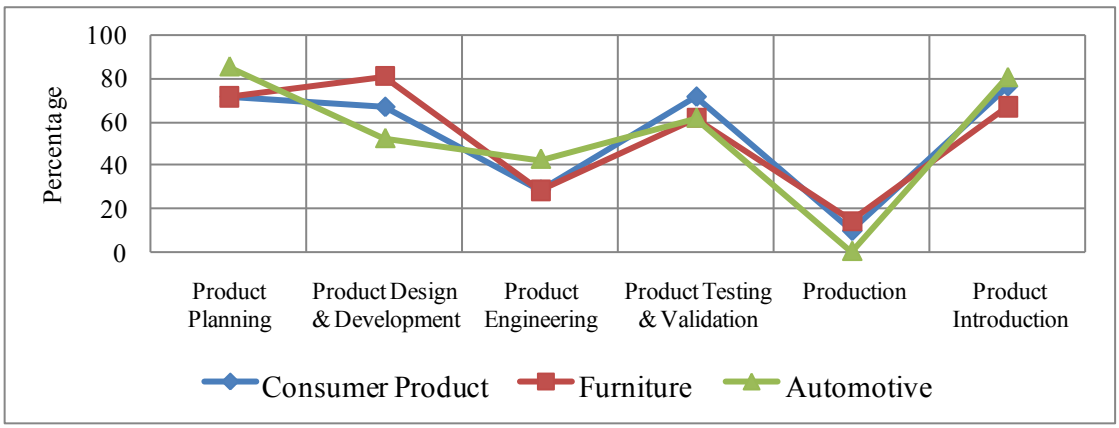

Figure 4.1: User involvement in NPD stages for three product groups

4.2.2.5 Role of User in Product Development Process

The user is regarded as an important source from whom information for producing a new product can be elicited. It is also important in order to facilitate the product designer during the establishment of the product characteristics. Table 4.10 shows the role of users in the product development process. The results indicate that

users play an important role in the product development as user-product testing followed by as resources-ideation, as creator-design development and as a part of the design decision.

Table 4.10: Role of users in product development process

Role of users	N	Median	Mode	Min	Max	Sum
As Resources-Ideation	63	4.00	5.00	1.00	5.00	249.00
As Creator-Design Development	63	3.00	5.00	1.00	5.00	216.00
As User-Product Testing	63	4.00	4.00	2.00	5.00	262.00
As Part of Design Decision	63	3.00	3.00	1.00	5.00	199.00

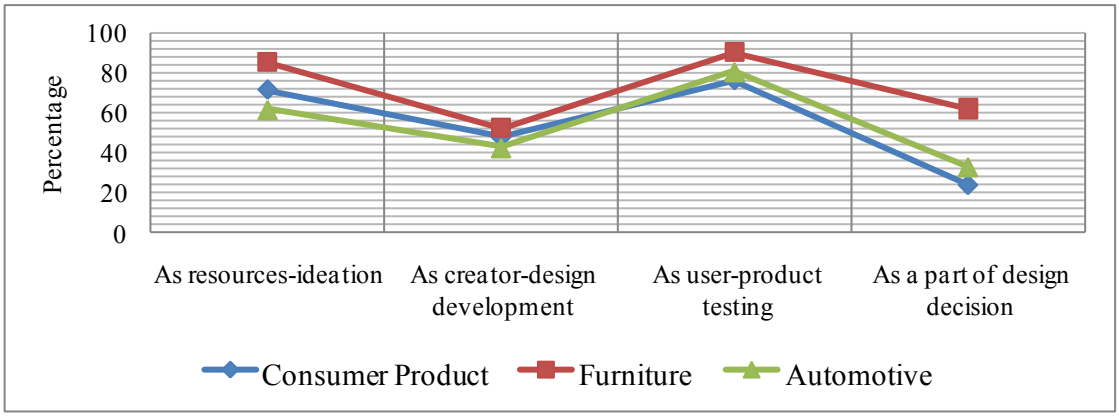

Figure 4.2: Role of users in product development process for the three product groups

Figure 4.2 shows the role of users in the product development process for three product design groups. Respondents in the consumer product group indicate that user involvement in product development is highly important as user-product testing with 76.2 percent, followed by 71.5 percent as resources-ideation, 47.6 percent as creator-design development and 23.8 percent as part of the design decision. In the furniture group, the user plays an important role in user-product testing with 90.4 percent followed by 85.7 percent as resources-ideation, 61.9 percent as a part of design decision and 52.4 percent as creator-design development. In the automotive group, the user is employed as user-product testing with 80.9 percent, followed by 61.9 percent as

resources-ideation, 42.8 percent as creator-design development and 33.3 percent as a part of the design decision.

4.2.2.6 Source of Product Information for a New Product

Product information is important for a new product. It is considered as part of the product strategy and increases the opportunity for success. Table 4.11 shows the sources of product information in product development. The results indicate that the development of a new product is more concerned with user requirements followed by problem identification, market needs and demand, technology and function, lifestyle and culture, and environment and lifecycle.

Table 4.11: Source of product information in product development

Product Information	N	Median	Mode	Min	Max	Sum
Problem Identification	63	5.00	5.00	2.00	5.00	282.00
User Requirement	63	5.00	5.00	2.00	5.00	285.00
Market Need & Demand	63	5.00	5.00	2.00	5.00	278.00
Lifestyle & Culture	63	4.00	4.00	1.00	5.00	262.00
Technology & Function	63	4.00	4.00	1.00	5.00	262.00
Environment & Lifecycle	63	4.00	4.00	2.00	5.00	248.00

Figure 4.3 shows the sources of product information for the three product groups. In consumer product, problem identification and user requirement with 90.5 percent is occasionally required as product information, followed by 85.7 percent in technology and function, 81.0 percent in market needs and demand, 71.4 percent in lifestyle and culture and 66.6 percent in environment and lifecycle. In the furniture, problem identification with 95.3 percent is required as main product information, followed by 90.5 percent in user requirement, 85.7 percent in technology and function, 81.0 percent in lifestyle and culture, market need and demand, and 76.2 percent in environment and lifecycle. The respondents in the automotive group mostly required user requirement,

market needs and demand, and lifestyle and culture with 95.3 percent, followed by 90.5 percent in problem identification, 85.7 percent in environment and lifecycle, and 81.0 percent in technology and function.

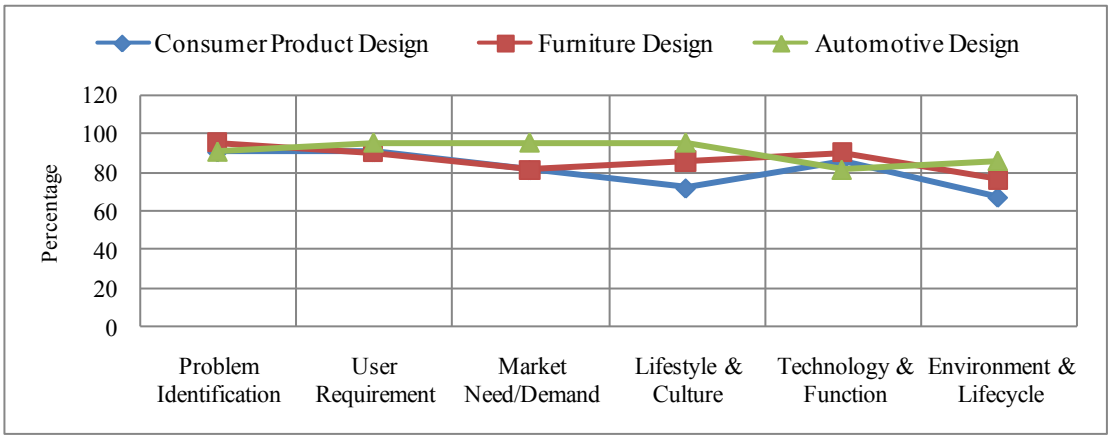

Figure 4.3: Source of product information for the three product groups

4.2.2.7 Methods for Involving Users in the Product Development Process

It was found that five methods are widely used by product designers to involve the user in order to obtain information; namely, interviews, questionnaires, observation, sales analysis and product complaint.

Table 4.12: Methods for involving users in the product development process

Methods	N	Median	Mode	Min	Max	Sum
Product Complaints	63	5.00	5.00	2.00	5.00	282.00
Observation	63	5.00	5.00	3.00	5.00	280.00
Sales Analysis	63	4.00	4.00	1.00	5.00	274.00
Interviews	63	4.00	5.00	2.00	5.00	262.00
Questionnaires	63	4.00	4.00	2.00	5.00	239.00

Table 4.12 shows the methods for involving users in the product development process. The results indicate that the product designers strongly identified product complaints as high priority for information to gain user knowledge concerning the new development of product characteristics. This is followed by observation, sales analysis, interviews

and questionnaire. Figure 4.4 shows the methods for involving users in the product development process for the three product groups. The results indicate that respondents for the consumer product strongly perceived sales analysis with 95.2 percent to provide information for new product development, followed by 90.5 percent in product complaints, 85.7 percent in observation, 80.9 percent in interviews, and 52.4 percent in questionnaires. In furniture, the respondents perceived observation with 95.2 percent as the major source for product information, followed by 90.5 percent in sales analysis and interviews, 85.7 percent in product complaints, and 66.7 percent in questionnaires. The respondents in automotive perceived product complaints with 95.2 percent as the major source of information, followed by 85.7 percent in observation and sales analysis, 76.2 percent in interviews and 60.3 percent in questionnaires.

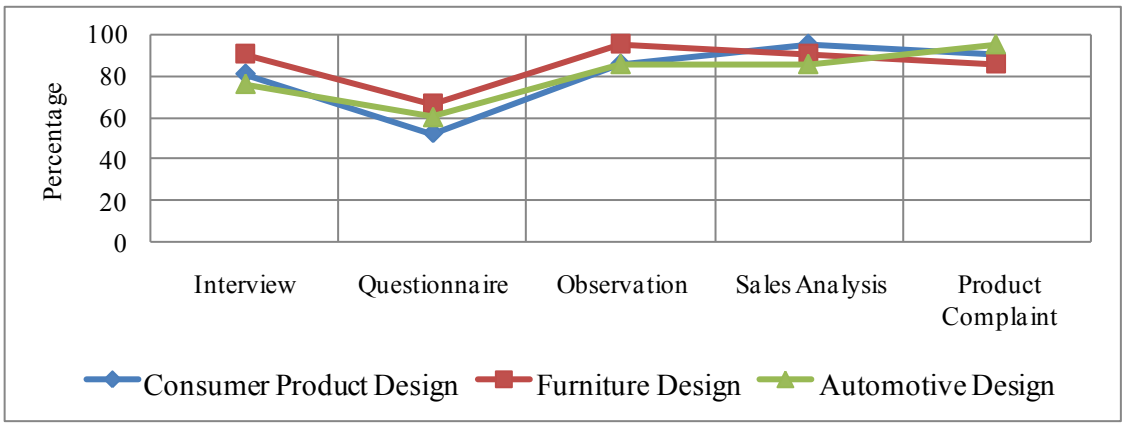

Figure 4.4: Methods for involving users in product development process for the three product groups

4.3 Data Analysis and Results of Perodua MyVi End-User Survey

4.3.1 Reliability of the Research Instrument

A total of 12 items from the Perodua MyVi end-user survey were analyzed. Before the data were analyzed the reliability of the instrument was tested by conducting a reliability analysis. Table 4.17 above shows the reliability of the research instrument for the survey of end users for the Perodua MyVi. The results indicate that

the Cronbach's Alpha reliability coefficient is .89. A reliability of .89 indicates 89 percent consistency in the score produced by the instrument. Thus, the research instrument is satisfactory.

Table 4.13: Reliability of the research instrument statistic for the end users of the Perodua MyVi survey

Cronbach's Alpha	N of Items
.89	12

4.3.2 Results of Perodua MyVi End-User Survey

4.3.2.1 Characteristics of Respondents

A total of 60 respondents participated in this survey. All the respondents had very good experience of using the product. Two different groups were identified as contributing in the survey – primary and secondary users. The primary user is defined as a person who uses the car as a first car, whereas the secondary user is a person who uses the car as a secondary car.

Table 4.14: The Perodua Myvi owner

User Status	Frequency N	Percentage
Primary User	40	66.7%
Secondary User	20	33.3%
Total	60	100.0%

Table 4.14 shows that N=40 (66.7 percent) respondents use the Perodua MyVi as their first car followed by N=20 (33.3 percent) of respondents using it as a secondary car. Table 4.15 shows the respondents' choice of Perodua MyVi. The results indicate that N=30 (50 percent) of respondents own a Perodua MyVi as their first choice car and N=30 (50 percent) of the respondents had it as a second choice car.

Table 4.15: Respondent's choice of Perodua MyVi

User selection	Frequency N	Percentage
1st Choice	30	50.0%
2nd Choice	30	50.0%
Total	60	100.0%

4.3.2.2 User Preference of Perodua MyVi

User preference has become a key indicator of resources allocation, product planning and marketing decisions. There are three foremost user considerations in buying a new car; namely, design, price and brand. Figure 4.5 shows the user preference of the Perodua MyVi. The results indicate that for 55.0 percent, design is highly considered by the user compared to only 35.0 percent for price and 10.0 percent for brand.

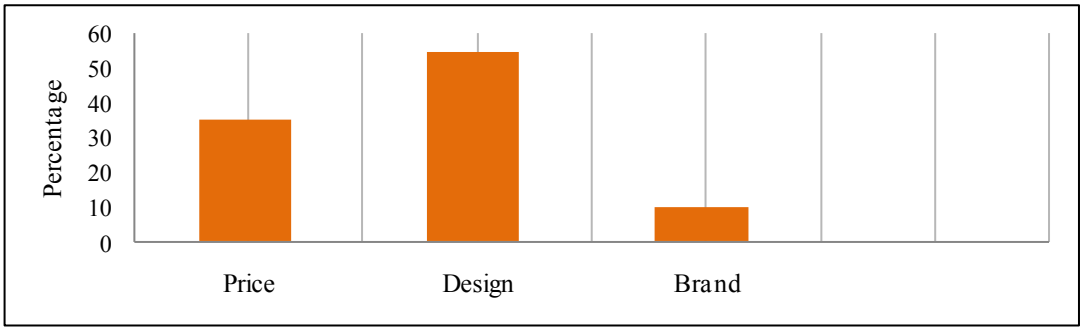

Figure 4.5: User preference for Perodua MyVi

4.3.2.3 Design Characteristics for the Success of the Perodua MyVi

The design characteristic is a key indicator of product selection decision that made the product more competitive in the marketplace. The success of a new product is not only dependent on being functionally attractive, but also aesthetically pleasing to the user. Table 4.16 shows the design characteristics of a Perodua MyVi. The results indicate that easy to operate is the highest priority in the design characteristics of the Perodua MyVi followed by simple & compact, aesthetical design, contemporary style,

user friendly and driving performance, driving comfort, technology, environmentally friendly, own identity, image, and safety.

Table 4.16: The design characteristics of the Perodua MyVi

Design characteristics	N	Median	Mode	Min	Max	Sum
Easy to Operate	60	4.00	4.00	2.00	5.00	251.00
Simple & Compact	60	4.00	4.00	1.00	5.00	250.00
Aesthetical Design	60	4.00	4.00	1.00	5.00	235.00
User Friendly	60	4.00	4.00	1.00	5.00	231.00
Contemporary Style	60	4.00	4.00	1.00	5.00	230.00
Driving Performance	60	4.00	4.00	1.00	5.00	230.00
Driving Comfort	60	4.00	4.00	1.00	5.00	227.00
Technology	60	4.00	4.00	1.00	5.00	224.00
Environmentally Friendly	60	4.00	4.00	1.00	5.00	218.00
Own Identity	60	4.00	4.00	1.00	5.00	217.00
Image	60	4.00	3.00	1.00	5.00	216.00
Safety	60	4.00	4.00	1.00	5.00	214.00

Table 4.17: Five key design characteristics of the Perodua MyVi

Design Characteristics	User	*Categorical Scale*				
		Not Important	Less Important	Neutral	Important	Strongly Important
Easy to Operate	Primary		3.3%	6.7%	43.3%	46.7%
	Secondary			23.3%	50.0%	26.7%
Simple & Compact	Primary		3.3%	13.3%	40.0%	43.3%
	Secondary			20.0%	50.0%	30.0%
Aesthetical Design	Primary		3.3%	10.0%	56.7%	30.0%
	Secondary	3.3%	3.3%	26.7%	53.3%	13.3%
Contemporary Style	Primary		6.7%	13.3%	60.0%	20.0%
	Secondary	3.3%	6.7%	23.3%	46.7%	20.0%
User Friendly	Primary			16.7%	50.0%	33.3%
	Secondary	3.3%	6.7%	36.7%	40.0%	13.3%

Table 4.17 shows five design characteristics based on the primary and secondary users of the Perodua MyVi. The results indicate that easy to use (90.0 percent) is the highest

priority design characteristic by the first choice user of Perodua MyVi followed by aesthetical design, simple & compact, user friendly (83.3 percent), and contemporary style (80.0 percent). The secondary user of Perodua MyVi put high priority on simple & compact (80.0 percent) followed by easy to use (76.7 percent), contemporary style (66.7 percent), aesthetical design (66.6 percent), and user friendly (53.3 percent).

4.4 Data Analysis and Results for the Survey of Perodua MyVi Design Experts

4.4.1 Reliability of the Research Instrument

Data from a total of 14 Perodua MyVi design experts were analyzed. Before the data were analyzed, the reliability of the instrument needed to be tested by conducting reliability analysis. Table 4.18 shows the reliability of the research instrument from the Perodua MyVi design expert survey. The results indicate that the Cronbach's Alpha reliability coefficient is .69. A reliability of .69 indicates 69 percent consistency in the score produced by the instrument. Hence, the research instrument is satisfactory.

Table 4.18: Reliability of the research instrument statistic for design experts' of Perodua MyVi survey

Cronbach's Alpha	N of Items
.69	14

4.4.2 Results of Survey of Perodua MyVi Design Experts

4.4.2.1 Characteristics of Respondents

Five representatives from Perusahaan Otomobil Kedua Sdn Bhd (PERODUA) were selected as participants in this survey consisting of Design Manager, Chief Designer, Specialist Chief Designer and two Senior Designers. The respondents have more than 6 years experience in car design and development. Table 4.19 shows the length of the design experts experience in product development. The results indicate

that three of the respondents have 6-10 years' experience in product development followed by two respondents with more than eleven years' experience.

Table 4.19: Design experts' experience in product development

Years of experience	Frequency N	Percentage
6-10 years	3	60.0%
>11 years	2	40.0%
Total	5	100%

4.4.2.2 User Contribution to the Success of a Product

In this study, the user is recognized as a central source to accelerate product development to reduce development cost, and enhance new product value. Table 4.20 shows the user involvement that contributes to the success of the product. The results indicate that the respondents strongly recognize the importance of user involvement and contribution in car development, and contribute to the success of the product.

Table 4.20: User contributes to product success

User involvement	N	Median	Mode	Min	Max	Sum
B1. The importance of involving user in car design	5	5.00	5.00	4.00	5.00	23.00
B2. User involvement contributes to the success of car design	5	5.00	5.00	4.00	5.00	23.00
B3. The importance of user contribution in the success of car design	5	5.00	5.00	4.00	5.00	23.00

4.4.2.3 Involving the User in the Product Design and Development Stage

It was found that the user is highly involved in the early stages of the product development process. Figure 4.6 shows that the user is highly involved in the product definition stage with 80.0 percent, followed by 40.0 percent in the product concept stage and 20.0 percent in the product testing and validation. The results also show that the user is not involved in the product specification stage of the design process.

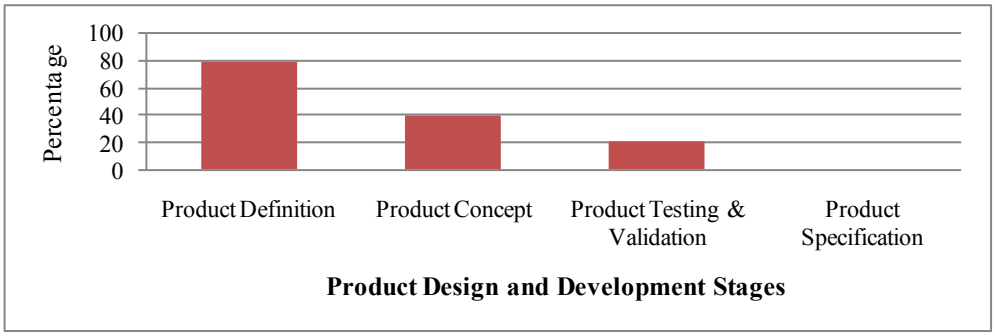

Figure 4.6: User involvement in the product design and development stages

4.4.2.4 Success Factors of Perodua MyVi

User involvement has a positive impact on improving the effectiveness of new products introduced by the manufacturers. It also increases the value of the product through information sharing between the product developer and user. Figure 4.7 shows that the highest success factors for the Perodua MyVi are through its design and user friendly with 60.0 percent, followed by 40 percent for performance and 20 in percent for multi-function.

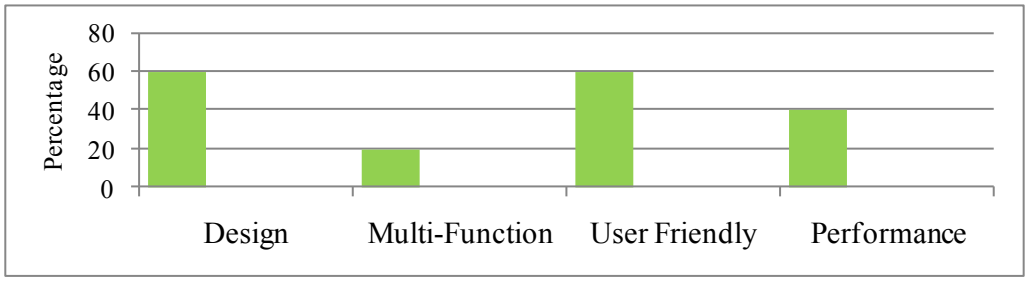

Figure 4.7: The success factors for Perodua MyVi

4.5 Conclusion

User involvement is highly required in the NPD process and can help the product designer to generate new product ideas, prevent creating irrelevant product, and produce the highest product quality. The involvement of the user is more appropriate in the product design and development stage where the specification of a new product is required to be identified. User involvement contributes significantly for product ideation

and product testing but is less required in the product design decision. The product designers indicated that users often provide new insights into a new product look based on their requirements and through their problems, which can contribute to the success of the product. The information is mostly obtained from product complaints, sales analysis and observation. A case study conducted on the Perodua MyVi shows that the involvement of the user in the early stage of product design and development contributed to the success of the product. The Perodua MyVi user acknowledged that the design characteristic of the Perodua MyVi is considered as the most important, followed by price and brand. These design characteristics are aesthetical design, simple and compact, user friendly and contemporary style. Several success factors were identified as contributing to the success of Perodua MyVi, which are design, user friendly, performance, brand and multi-function.

CHAPTER 5 IDENTIFYING THE SUCCESSFUL PRODUCT DESIGN

5.1 Introduction

This chapter presents and describes the data analysis and results gained from the end users and product management specialist survey in order to achieve objective 2 – *to identify the characteristics of a successful product and the requirements of product design*. The first investigation focused on 1) to determine user preference for three different product types, 2) to identify the characteristics of three different successful product types, and 3) to identify and differentiate user requirements for the three different product types. The second investigation involved product management specialists in an attempt 1) to categorize the product requirement into functional and aesthetical requirements, 2) to identify the source of product characteristics development in the design process, and 3) to find the contribution of the user for product characteristics development. The end-user survey was conducted using the questionnaire approach, while, structured interviews were employed on the product management specialists. The data were divided into three categories; namely, consumer product, furniture and automotive.

5.2 Data Analysis and Results of End-User Survey

5.2.1 Reliability of the Research Instrument

The end user-survey was divided into three categories, consumer product, furniture and automotive. A total of 33 items were used to survey the end users of each product category. Before the data were analyzed the reliability of the instrument needed to be tested by conducting a reliability analysis. Table 5.1 shows the reliability of the

research instrument for consumer product. The results indicate that the Cronbach's Alpha reliability is .86. A reliability of .86 indicates 86 percent consistency in the score produced by the instrument. Thus, the research instrument is satisfactory.

Table 5.1: Reliability of the research instrument statistic for consumer product

Cronbach's Alpha	N of Items
.86	33

Table 5.2 shows the reliability of the research instrument for furniture. The Cronbach's Alpha reliability is .86. A reliability of .86 indicates 86 percent consistency in the score produced by the instrument. Thus, the research instrument is satisfactory.

Table 5.2: Reliability of the research instrument statistic for furniture

Cronbach's Alpha	N of Items
.86	33

Table 5.3 shows the results of the research instrument tested for the end-user survey of the automotive category. The results indicate that the Cronbach's Alpha reliability is .86 indicating 86 percent consistency in the score produced by the instrument. Thus, the research instrument is satisfactory.

Table 5.3: Reliability of the research instrument statistic for automotive

Cronbach's Alpha	N of Items
.86	33

5.2.2 Results of End-User Survey

5.2.2.1 Characteristics of respondents

A total of three hundred and twenty (320) respondents classified as end users participated in this survey. The respondents' categories are consumer product user

(CPU) – 104, furniture user (FU) – 100 and automotive user (AU) – 116. Table 5.4 shows the gender of the respondents. The results indicate that the respondents for the consumer product category consisted of 55.8 percent males and 44.2 percent females; in the furniture category 44.0 percent males and 56.0 percent females, and in the automotive category there were 87.0 percent males and 25.0 percent females.

Table 5.4: Gender of the respondents

Gender	Frequency N			Percentage		
	CPU	FU	AU	CPU	FU	AU
Male	58	44	87	55.8%	44.0%	75.0%
Female	46	56	29	44.2%	56.0%	25.0%
Total	104	100	116	100.0%	100.0%	100.0%

Table 5.5 shows the age of the respondents. The table indicates that the respondents from the consumer product group are aged between 20 and 29 years old (48.1 percent), 30 and 39 years old (42.3 percent), 40 and 49 years old (6.7 percent), and more than 50 years old (2.9 percent). In the furniture group, the respondents are made up of 43.0 percent between 20 and 29 years old and 30 and 39 years old, followed by 40 and 49 years old (10.0 percent), and 4.0 percent more than 50 years old. In the automotive group the respondents are between 20 and 29 years old (43.1 percent), 30 and 39 years old (33.6 percent), 40 and 49 years old (10.3 percent), and more than 50 years old (12.9 percent).

Table 5.5: Age of the respondents

User Age	Frequency N			Percentage		
	CPU	FU	AU	CPU	FU	AU
20-29 years	50	43	50	48.1%	43.1%	43.1%
30-39 years	44	43	39	42.3%	43.0%	33.6%
40-49 years	7	10	12	6.7%	10.0%	10.3%
>50 years	3	4	15	2.9%	4.0%	12.9%
Total	104	100	116	100.0%	100.0%	100.0%

5.2.2.2 Brand, Design and Product Style

Users are a valuable reference in order to help the product designers to establish new product characteristics. They provide new ideas and opportunities through their experience and demands. Table 5.6 shows several mobile phone brands. The results indicate that the Nokia brand (44.2 percent) has become a trendy brand of mobile phone followed by Sony Ericsson (22.1 percent), Samsung (14.4 percent), BlackBerry (9.6 percent), Apple and HTC (3.8 percent), and LG (1.9 percent).

Table 5.6: Mobile phone brand

Mobile Phone Brand	Frequency N	Percentage
Nokia	46	44.2%
Sony Ericsson	23	22.1%
Samsung	15	14.4%
Blackberry	10	9.6%
Apple	4	3.8%
HTC	4	3.8%
LG	2	1.9%
Total	104	100.0%

Table 5.7 shows the mobile phone style. The results indicate that Hi-technology design (64.4 percent) is the most preferable product style followed by modern (21.2 percent), contemporary (9.6 percent) and classic (4.8 percent).

Table 5.7: The mobile phone style

Mobile Style	Frequency N	Percentage
Hi-technology	67	64.4%
Modern	22	21.2%
Contemporary	10	9.6%
Classic	5	4.8%
Total	104	100.0%

Users in furniture often choose a design rather than a product brand. Table 5.8 shows the design of a living room sofa design. The results indicate that users preferred 3+2+1 (40.0 percent) followed by L-Shape (32.0 percent), 3+2+1+1 (15.0 percent), and single (4.0 percent).

Table 5.8: Living room sofa design

Living room sofa	Frequency N	Percentage
3+2+1	40	40.0%
L-Shape	32	32.0%
3+2+1+1	15	15.0%
3+1+1	9	9.0%
Single	4	4.0%
Total	100	100.0%

Table 5.9 shows the user preference for the living room sofa style. The results indicate that users prefer the modern classic style (39.0 percent) followed by contemporary (34.0 percent), ultra-modern (23.0 percent), retro (2.0 percent), and antique and classic (1.0 percent).

Table 5.9: Living room sofa style

Furniture style	Frequency N	Percentage
Modern Classic	39	39.0%
Contemporary	34	34.0%
Ultra Modern	23	23.0%
Retro	2	2.0%
Antique	1	1.0%
Classic	1	1.0%
Total	100	100.0%

Table 5.10 shows the user preference for car manufacturer brands. The results indicate that Honda brand (19.9 percent) is the most favored brand followed by BMW (16.4

percent), Toyota (12.9 percent), Mercedes Benz and Audi (11.2 percent), Mitsubishi (7.8 percent), KIA (6.7 percent), Nissan (3.4 percent), Hyundai (2.6 percent), Proton (3.4 percent), Mazda and Volkswagen (1.7 percent), and Perodua (0.9 percent).

Table 5.10: The car manufacturer brand

Manufacturer Brand	Frequency N	Percentage
Honda	23	19.9%
BMW	19	16.4%
Toyota	15	12.9%
Mercedes Benz	13	11.2%
Audi	13	11.2%
Mitsubishi	9	7.8%
Kia	8	6.9%
Proton	4	3.4%
Nissan	4	3.4%
Hyundai	3	2.6%
Volkswagen	2	1.7%
Mazda	2	1.7%
Perodua	1	0.9%
Total	116	100.0%

Table 5.11: The car style

Car Style	Frequency N	Percentage
Large Family Car/MPV	30	25.9%
Sedan Car	26	22.4%
Sports Car	18	15.5%
SUV	17	14.7%
Compact MPV	16	13.8%
Compact Car	6	5.2%
4WD/Truck	2	1.7%
Wagon/Estate	1	0.9%
Total	116	100.0%

Table 5.11 shows the user preference for the car style. The results indicate that most users prefer the large family cars/MPVs (22.4 percent) followed by sedan cars (22.4

percent), sports cars (15.5 percent), SUVs (14.7 percent), compact MPVs (13.8 percent), compact cars (5.2 percent), 4WD/Trucks (1.7 percent), and wagon/estate (0.9 percent).

5.2.2.3 Success Factors of Product Design

User satisfaction is considered as a useful tool to evaluate and measure the level of product success. Building an understanding regarding product satisfaction can help to achieve higher performance of a new product.

Table 5.12: Success factors for consumer product

Success factors	N	Median	Mode	Min	Max	Sum
Design	104	4.00	4.00	1.00	5.00	417.00
Function	104	5.00	5.00	2.00	5.00	467.00
Technology	104	5.00	5.00	2.00	5.00	463.00
Brand	104	4.00	4.00	1.00	5.00	401.00
Price	104	4.00	5.00	2.00	5.00	437.00
Safety	104	4.00	5.00	1.00	5.00	400.00

Table 5.12 shows the success factors for consumer product. The results indicate that the users in consumer products mostly emphasize the function of a product as their main criteria for selection followed by technology, price, design, brand and safety.

Table 5.13: Success factors for furniture

Success factors	N	Median	Mode	Min	Max	Sum
Design	100	5.00	5.00	3.00	5.00	452.00
Function	100	4.00	4.00	2.00	5.00	392.00
Technology	100	3.00	3.00	2.00	5.00	353.00
Brand	100	3.00	3.00	1.00	5.00	316.00
Price	100	4.00	5.00	1.00	5.00	424.00
Safety	100	4.00	4.00	1.00	5.00	408.00

Table 5.13 shows the success factors for furniture. The results indicate that users of furniture products mostly prefer the design of a product as their main criteria followed

by price, safety, function, technology, and brand. Table 5.14 shows the user preference for automotive. The results indicate that the users of automotive product strongly prefer the safety of the product as their main criteria for selection followed by design, technology, price, function and brand.

Table 5.14: Success factors for automotive

Success factors	N	Median	Mode	Min	Max	Sum
Design	116	4.00	4.00	2.00	5.00	489.00
Function	116	4.00	4.00	2.00	5.00	461.00
Technology	116	4.00	4.00	1.00	5.00	479.00
Brand	116	4.00	4.00	1.00	5.00	444.00
Price	116	4.00	5.00	2.00	5.00	469.00
Safety	116	5.00	5.00	1.00	5.00	514.00

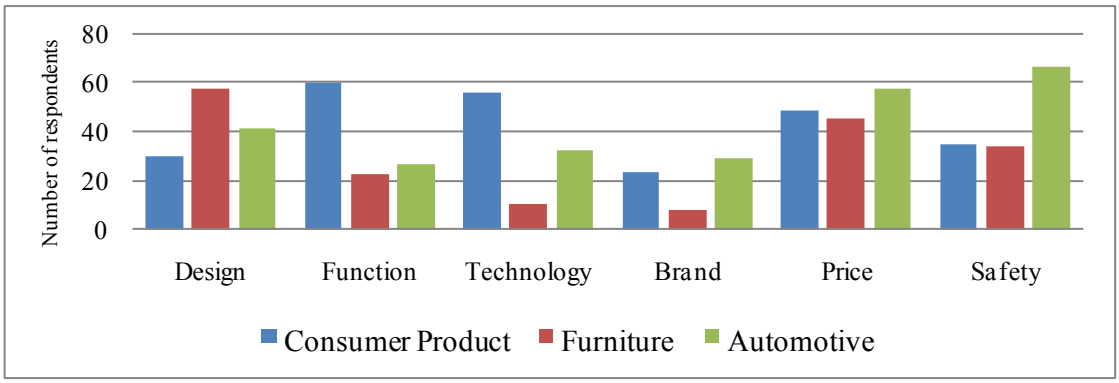

Figure 5.1: Success factors for the three product types

Figure 5.1 shows the success factors for the three product types based on the strongly important categorical scale. The results indicate that the users of consumer products prefer function (N=60) as the high priority for product selection decision followed by technology (N=56), price (N=49), safety (N=35), design (N=30), and brand (N=24). In furniture, the respondents prefer design (N=58) followed by price (N=46), safety (N=34), function (N=23), technology (N=11), and brand (N=8). The respondents in automotive selected safety (N=67) as the main criteria for product selection followed by price (N=58), design (N=42), technology (N=33), brand (N=29), and function (N=27).

5.2.2.4 Requirements of Product Design

The requirements for product design are a fundamental property of a product. Table 5.15 shows the requirements of product design for consumer products. The results indicate that technology is identified as the highest priority requirement for consumer product followed by quality, durability, maintenance, performance, usability, reliability, lifetime, size, ergonomics, effectiveness, safety, brand, form, appearance, shape, material, style, components, interface, image, color, texture and identity.

Table 5.15: Requirements of product design for consumer products

Product Requirements	N	Median	Mode	Min	Max	Sum
Technology	104	5.00	5.00	3.00	5.00	479.00
Quality	104	5.00	5.00	1.00	5.00	473.00
Durability	104	5.00	5.00	2.00	5.00	465.00
Maintenance	104	4.00	4.00	2.00	5.00	464.00
Performance	104	5.00	5.00	1.00	5.00	463.00
Usability	104	5.00	5.00	2.00	5.00	459.00
Reliability	104	5.00	5.00	2.00	5.00	456.00
Lifetime	104	4.00	5.00	1.00	5.00	442.00
Size	104	4.00	4.00	1.00	5.00	440.00
Ergonomic	104	4.00	4.00	1.00	5.00	439.00
Effectiveness	104	4.00	5.00	1.00	5.00	439.00
Safety	104	4.00	5.00	1.00	5.00	433.00
Brand	104	4.00	4.00	1.00	5.00	422.00
Form	104	4.00	4.00	1.00	5.00	408.00
Appearance	104	4.00	4.00	1.00	5.00	403.00
Shape	104	4.00	4.00	1.00	5.00	397.00
Material	104	4.00	4.00	1.00	5.00	397.00
Style	104	4.00	4.00	1.00	5.00	394.00
Components	104	4.00	4.00	1.00	5.00	393.00
Interface	104	4.00	4.00	1.00	5.00	387.00
Image	104	4.00	4.00	1.00	5.00	385.00
Color	104	4.00	4.00	1.00	5.00	383.00
Texture	104	4.00	4.00	1.00	5.00	369.00
Identity	104	4.00	4.00	1.00	5.00	367.00

Table 5.16 shows the requirements of product design for furniture. The results indicate that the respondents for furniture identified quality as the main priority criteria for furniture products followed by durability, form, ergonomic, lifetime, safety, color, appearance, shape, usability, material, effectiveness, reliability, size, maintenance, style, performance, technology, texture, components, image, brand, identity and interface.

Table 5.16: Requirements of product design for furniture

Product Requirements	N	Median	Mode	Min	Max	Sum
Quality	100	5.00	5.00	3.00	5.00	456.00
Durability	100	5.00	5.00	3.00	5.00	450.00
Form	100	5.00	5.00	2.00	5.00	444.00
Ergonomic	100	5.00	5.00	1.00	5.00	436.00
Lifetime	100	4.00	4.00	2.00	5.00	434.00
Safety	100	4.00	4.00	2.00	5.00	429.00
Color	100	4.00	5.00	2.00	5.00	428.00
Appearance	100	4.00	5.00	1.00	5.00	424.00
Shape	100	4.00	4.00	2.00	5.00	419.00
Usability	100	4.00	4.00	2.00	5.00	417.00
Material	100	4.00	4.00	3.00	5.00	415.00
Effectiveness	100	4.00	4.00	1.00	5.00	407.00
Reliability	100	4.00	4.00	2.00	5.00	405.00
Size	100	4.00	4.00	1.00	5.00	405.00
Maintenance	100	4.00	4.00	2.00	5.00	398.00
Style	100	4.00	4.00	1.00	5.00	388.00
Performance	100	4.00	4.00	2.00	5.00	384.00
Technology	100	4.00	4.00	2.00	5.00	375.00
Texture	100	4.00	4.00	2.00	5.00	371.00
Components	100	4.00	4.00	1.00	5.00	366.00
Image	100	4.00	4.00	1.00	5.00	359.00
Brand	100	3.00	3.00	1.00	5.00	336.00
Identity	100	3.00	3.00	1.00	5.00	328.00
Interface	100	3.00	4.00	1.00	5.00	327.00

Table 5.17 shows the requirements of product design for automotive. In automotive, the respondents selected quality as the main priority element followed by safety, performance, ergonomic, durability, form, maintenance, lifetime, technology, reliability, appearance, effectiveness, usability, shape, brand, size, style, components, material, image, identity, texture, color and interface.

Table 5.17: Requirements of product design for automotive

Product Requirements	N	Median	Mode	Min	Max	Sum
Quality	116	5.00	5.00	2.00	5.00	530.00
Safety	116	5.00	5.00	1.00	5.00	512.00
Performance	116	4.00	5.00	3.00	5.00	509.00
Ergonomic	116	4.00	5.00	1.00	5.00	503.00
Durability	116	4.00	5.00	2.00	5.00	500.00
Form	116	4.00	4.00	1.00	5.00	496.00
Maintenance	116	4.00	5.00	2.00	5.00	493.00
Lifetime	116	4.00	5.00	1.00	5.00	487.00
Technology	116	4.00	4.00	2.00	5.00	486.00
Reliability	116	4.00	4.00	2.00	5.00	482.00
Appearance	116	4.00	4.00	3.00	5.00	480.00
Effectiveness	116	4.00	4.00	1.00	5.00	481.00
Usability	116	4.00	4.00	2.00	5.00	474.00
Shape	116	4.00	4.00	1.00	5.00	463.00
Brand	116	4.00	4.00	1.00	5.00	459.00
Size	116	4.00	4.00	1.00	5.00	449.00
Style	116	4.00	4.00	1.00	5.00	444.00
Components	116	4.00	4.00	1.00	5.00	441.00
Material	116	4.00	4.00	1.00	5.00	439.00
Image	116	4.00	4.00	1.00	5.00	423.00
Identity	116	3.00	3.00	1.00	5.00	406.00
Texture	116	3.00	3.00	1.00	5.00	403.00
Color	116	3.00	3.00	1.00	5.00	400.00
Interface	116	3.00	3.00	1.00	5.00	386.00

Figure 5.2 shows the requirements of product design for the three product types based on strongly important categorical scale. The results indicate that respondents for

consumer products selected technology (N=69) as the main criteria for product design followed by quality (N=67), durability (N=61), performance (N=61), reliability (N=57), usability (N=57), lifetime (N=51), safety (N=46), effectiveness (N=45), maintenance (N=42), ergonomic (N=36), brand (N=31), size (N=49), form (N=28), style (N=27), appearance (N=26), material, shape and image (N=25), components (N=21), color (N=20), interface (N=18), identity (N=16), and texture (N=12). For furniture, the respondents preferred quality (N=59) as the priority of product requirements followed by ergonomic (N=54), form (N=53), durability (N=52), color (N=45), lifetime (N=44), appearance (N=43), safety (N=38), usability (N=37), reliability and shape (N=32), size and effectiveness (N=30), material (N=29), maintenance (N=28), style (N=26), image (N=23), performance (N=19), technology (N=17), texture (N=16), brand (N=13), interface (N=12), and components and identity (N=11). The respondents for automotive identified quality (N=76) as the most important requirement for product design followed by safety (N=64), performance (N=56), durability (N=55), ergonomic (N=53), lifetime (N=49), maintenance (N=48), form (N=46), effectiveness (N=44), reliability (N=39), technology (N=38), usability (N=37), appearance (N=36), brand (N=35), shape and material (N=32), size (N=27), style (N=26), identity (N=24), image (N=21), color (N=16), texture (N=15), and interface (N=10).

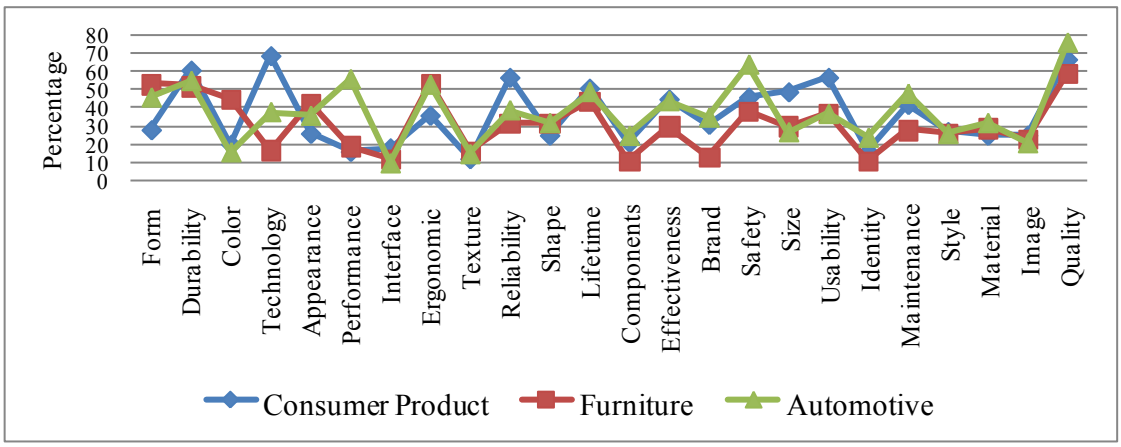

Figure 5.2: Requirements of product design for the three product types

5.3 Data Analysis and Results of Product Management Specialist Survey

5.3.1 Reliability of the Research Instrument

A total of 30 items were used in this survey. To validate the reliability of the instruments, all the questions were tested by using the reliability analysis. Table 5.18 shows the reliability of the research instrument statistics. It can be seen that all items in this research survey are satisfactory with α: .76. The reliability of .76 indicates 76 percent consistency in the score produced by the instrument. Hence, the research instrument is satisfactory.

Table 5.18: Reliability of the research instrument statistic for product management specialist survey

Cronbach's Alpha	N of Items
.76	30

5.3.2 Results of the Product Management Specialist Survey

5.3.2.1 Characteristics of Respondents

A total of 33 product management specialists were invited to participate in this survey. The respondents selected consisted of those designers who were project leaders in the selected companies. Table 5.19 shows the designation of the respondents. The results indicate that the respondents involved are categorized as senior designer with N=7 (21.2 percent), design manager with N=14 (42.4 percent), director with N=12 (36.4 percent).

Table 5.19: Designation of the respondents in product development

Designation	Frequency	Percent
Senior Designer	7	21.2
Design Manager	14	42.4
Director	12	36.4
Total	33	100.0

Table 5.20 shows the experience of the respondents in product development. The table shows that the respondents have a great deal of experience in product development where N=10 (30.3 percent) are those who have 10-15 years experience, N=15 (45.5 percent) are those respondents with 16-20 years experience, N=2 (9.1 percent) are those respondents who have 21-25 years experience and N=5 (15.2 percent) are those respondents who have more than 26 years experience.

Table 5.20: Experience of the respondents in product development

Respondent's Experience	Frequency N	Percentage
10-15 years	10	30.3%
16-20 years	15	45.5%
21-25 years	3	9.1%
More than26 years	5	15.2%
Total	33	100.0%

Table 5.21: Type of business of the respondents

Design Cluster	Frequency N	Percent
Consumer Product	11	33.3%
Furniture	13	39.4%
Automotive	9	27.3%
Total	33	100.0%

Table 5.21 above shows the type of business of the respondents. The table shows that the respondents consist of those from the consumer product with N=11 (33.3 percent), furniture with N=13 (39.4 percent) and automotive with N=9 (27.3 percent). Approximately 33.3 percent of the respondents work as consultants in design consultancy firms whilst 66.7 percent are attached to product design manufacturers.

5.3.2.2 Functional and Aesthetical Requirements of Product Design

Two requirements that the product designer should consider during the development of new product characteristics are the functional and aesthetical requirements. Figure 5.3 shows the functional requirements for product design. The results indicate safety (100 percent) as the main priority functional requirement of product design, followed by effectiveness and ergonomic (90.9 percent), usability (87.9 percent), technology (84.8), reliability and quality (81.8 percent), components and lifetime (75.8 percent), and size (60.6 percent).

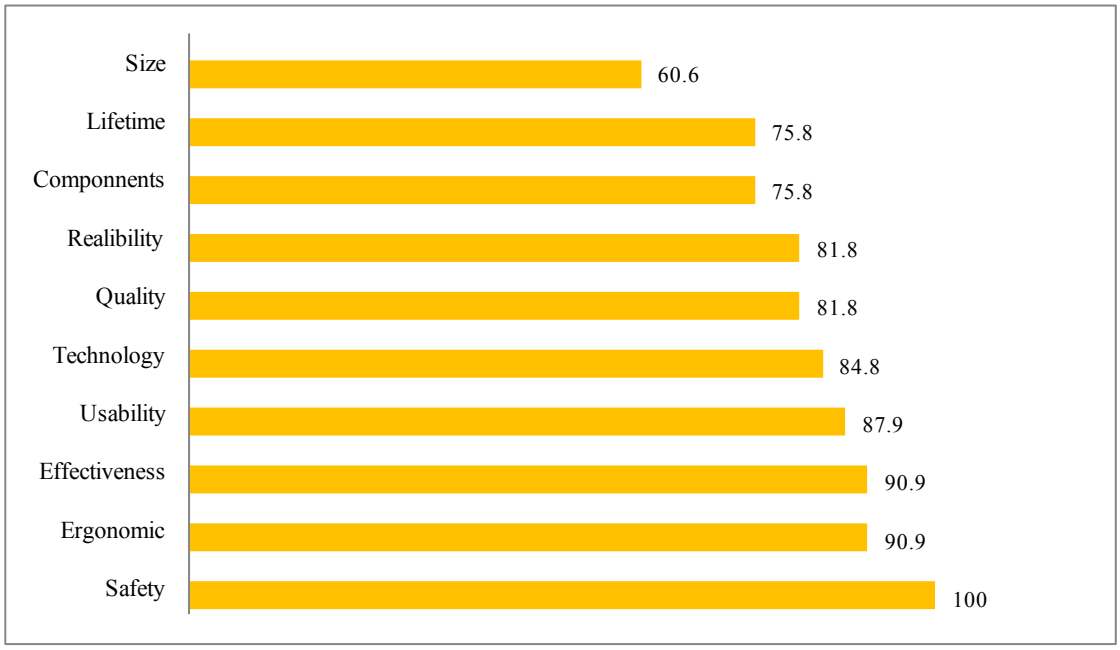

Figure 5.3: Functional requirement of product design

Figure 5.4 shows the aesthetical requirements of product design. The results indicate shape (100 percent) as the main priority aesthetical requirements of product design followed by other product requirements, such as form and color (97. percent), texture (90.9 percent), appearance (84.8 percent), emotion (81.0 percent), material (66.7 percent), interface (60.6 percent), semantic (57.6 percent) and semiotic (54.5 percent).

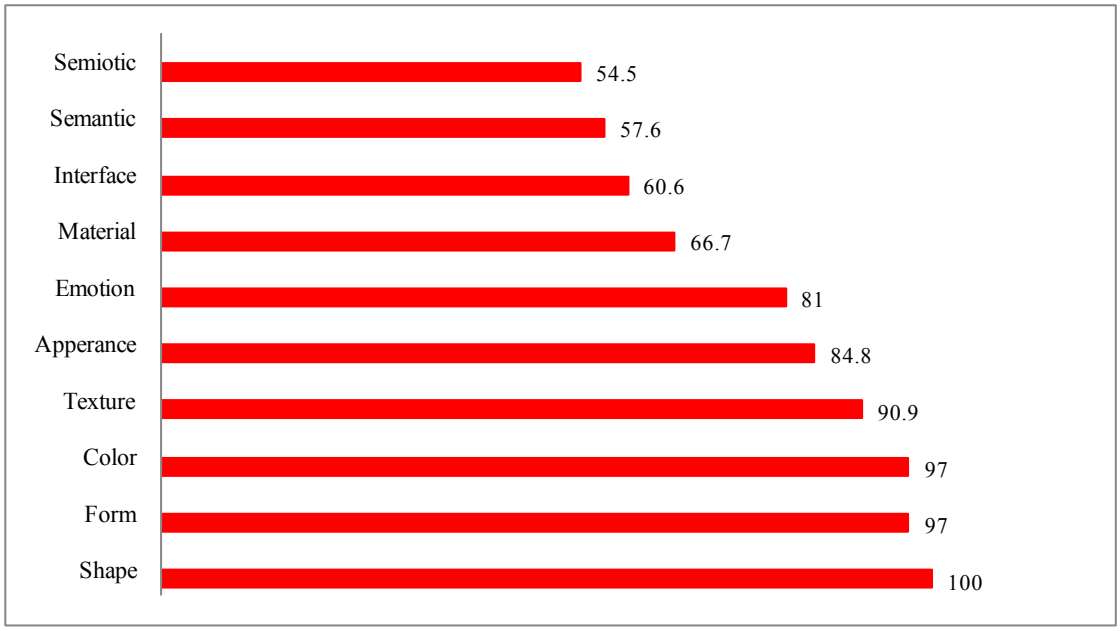

Figure 5.4: Aesthetical requirements of product design

Figure 5.5 shows the functional requirements for three product groups. For consumer products, all the respondents selected reliability, effectiveness, usability, ergonomic and safety as the most important functional requirements of product design. However, only ergonomic and safety were identified as the most important functional requirement for furniture, while, safety highlighted was the most important functional requirement for automotive design.

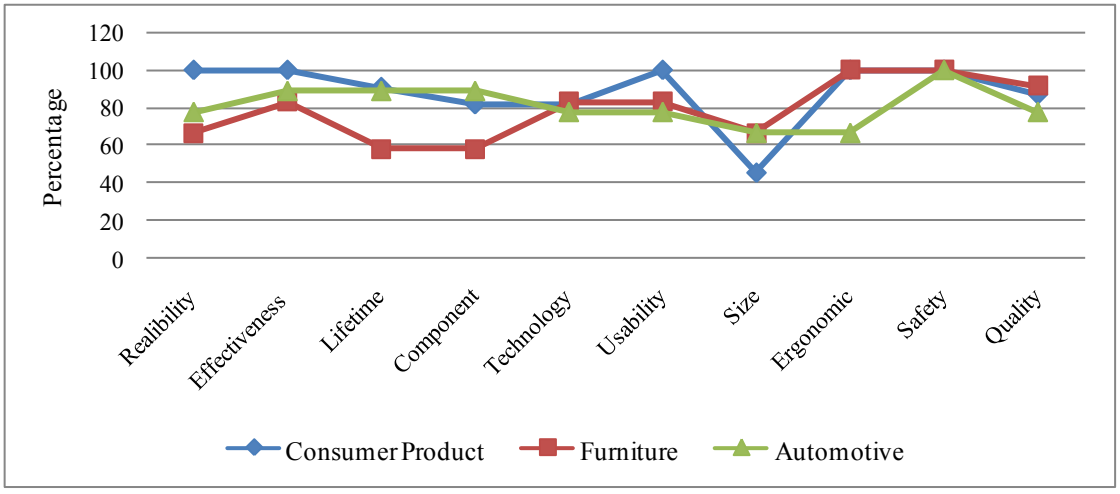

Figure 5.5: Functional requirements of product for the three product groups

Figure 5.6 shows the aesthetical requirements for the three product groups. The three product design groups identified shape and color as the most important aesthetical requirements of a product. Appearance was identified as the most important aesthetical requirements in consumer product, while form was identified as the most important in furniture design. The respondents in automotive design identified form, texture, material and emotion as the most important aesthetical requirements of a product.

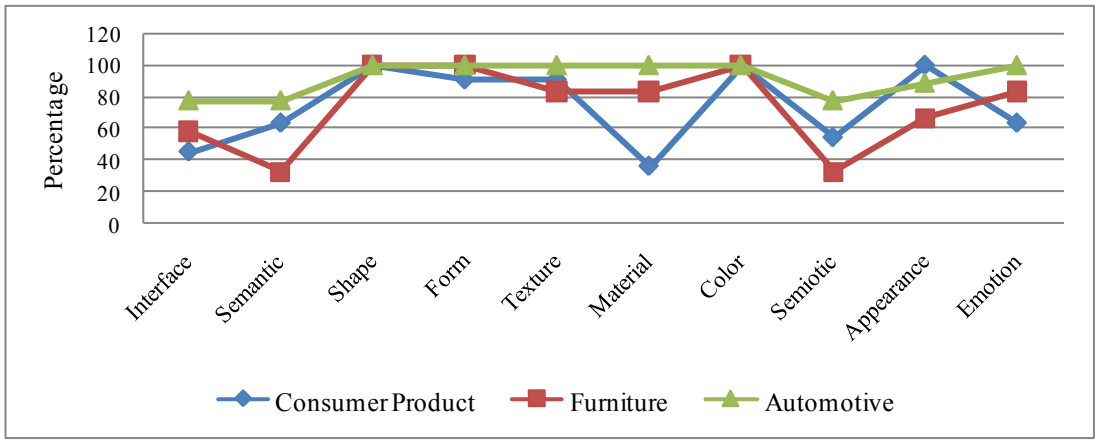

Figure 5.6: Aesthetical requirements of product for three product groups

5.3.2.3 Source of Information for Product Characteristics

Many available sources can be used in order to develop and establish the characteristics of a new product. The information is not only meant to provide shape the image of a new product but more as an opportunity that contributes to the product's success. Six aspects of design information were identified by product management specialists during the establishment of a new product characteristic contribution by user (90.9 percent) followed by market survey (87.9 percent), existing product (84.8 percent), observation (81.8 percent), online source (78.8 percent) and supplier (18.2 percent). Figure 5.7 shows the sources of information in product characteristics development from the three product groups. The results indicate that user and existing products were often referred to by respondents in consumer product followed by observation, market survey, online source, and supplier. In furniture, the respondents

referred to the user and market survey as the priority sources of information followed by existing product, observation, online source, and supplier. While, the respondents in automotive identified existing product and observation as the priority source of information for product characteristics followed by online source, user and market survey, and supplier.

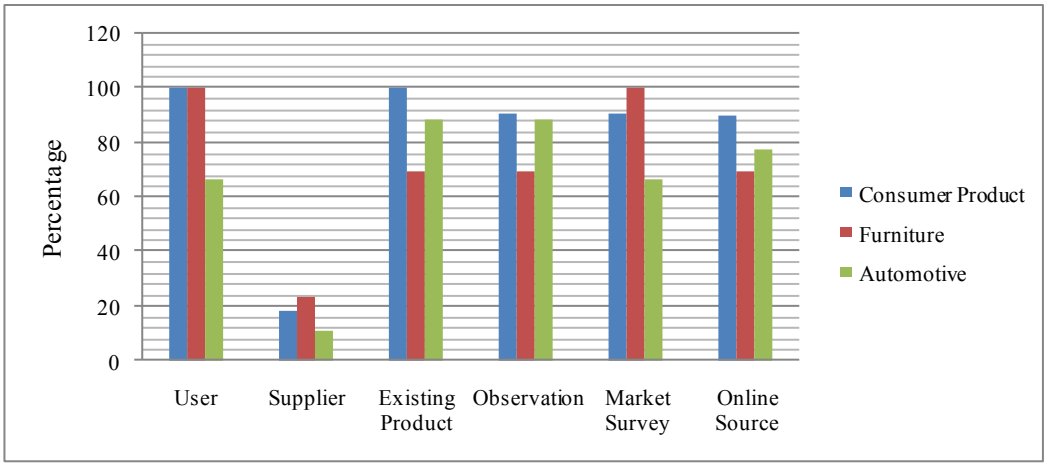

Figure 5.7: Source of information in the development of product characteristics

5.3.2.4 User Contribution in Product Characteristics Development

The key role of product development is to identify the needs and requirements for a specific target group. Product developers need to acquire related information in order to develop and establish its characteristics. It can be observed that the product developer often refers to user needs (100 percent) as the main criteria to develop a new product followed by user preference (81.5 percent), user problem (77.8 percent) and user experience (74.1 percent). Figure 5.8 shows the user contribution in product characteristics development from the three product groups. The results indicate that user problem studies are highly regarded by respondents in furniture with 88.9 percent compared to 77.8 percent in automotive and 66.7 percent in consumer product. The respondents for both furniture and consumer product, which shows 88.9 percent depend on the information regarding user preference compared to 66.7 percent in

automotive, which are more reliant on the design process. User experience is needed more in furniture with 88.9 percent compared to 77.8 percent in consumer product and 55.6 percent in automotive.

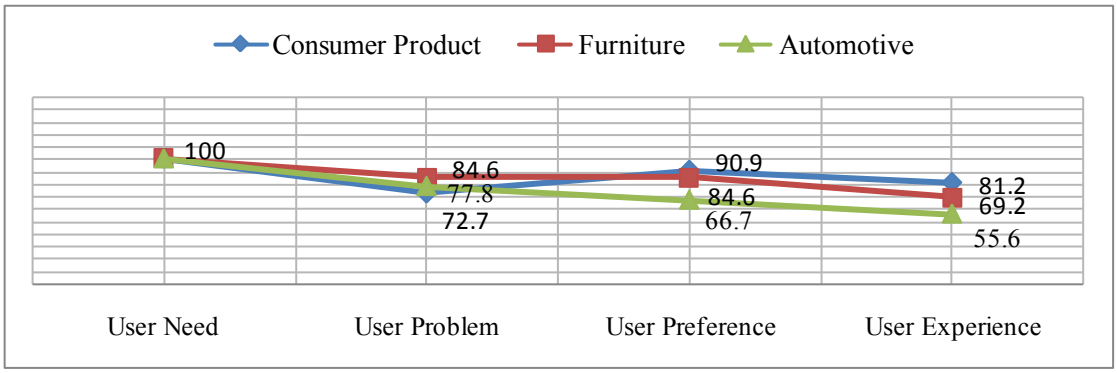

Figure 5.8: User contribution in product specification development for the three product groups

5.4 Conclusion

Building an understanding regarding user satisfaction can help to achieve the higher performance of a new product. The success of a product can be recognized through the user selection decision. Six product selection decisions are acknowledged design, function, technology, brand, price and safety. The priority of the selection decision by the user is different among the three product types, e.g. the user of consumer product strongly prefers the product function, while the furniture user prefers design and safety is chosen by the automotive user. In addition, several requirements were identified as part of the product design specifications that are significant for the establishment of new product characteristics. The requirements can be categorized into functional requirements and aesthetical requirements. The development of the product characteristics is mainly in the product definition stage of the design process, where both functional and aesthetical requirements are taken into consideration. The development of the product characteristics is often sourced from the user, existing product, observation, market survey, online source and supplier. However, the user is

most necessary for product information, which is based on their needs followed by problems, preferences and experiences.

CHAPTER 6 DEVELOPMENT OF THE PRODUCT DESIGN DEFINITION METHOD

6.1 Introduction

The focus of this chapter is on the development of a method to achieve research objective 3 – *to develop a design methodology that incorporates the requirements of the product designer and user with the successful characteristics of a product in the early stages of the design process*. It explains the process of combining the knowledge from both product designers (design requirements) and user requirements with the characteristics of past successful products as a strategy for improving the efficiency of generating a new product idea, increasing product quality and the likelihood of product success. Towards this end, this knowledge is incorporated into a new method called the Product Design Definition Method.

6.2 Developing Successful Product Design Characteristics Map

The empirical studies implied the outcome of coordinating product development activities and resources with users in the product definition stage of the design process. It is a valuable means of enhancing the development process and increasing the likelihood of product success. The collaboration of the product designer and user in the product definition stage in the design process is highly required to produce a new product with high value and originality. They become important as an effective strategy to identify a unique solution for the intended new product. Figure 6.1 shows the product design and development stage. The figure indicates that the characteristics of a new product can only be established in the product definition stage of the design process. The product definition is known as the early stage of the design process in which a new

product is born. This stage is important to identify and develop the specification of a new product. In addition, it covers the upfront product development activities that consider both the design and user requirements. The product definition stage focuses on the establishment of new product characteristics that map all the design specification and user requirements.

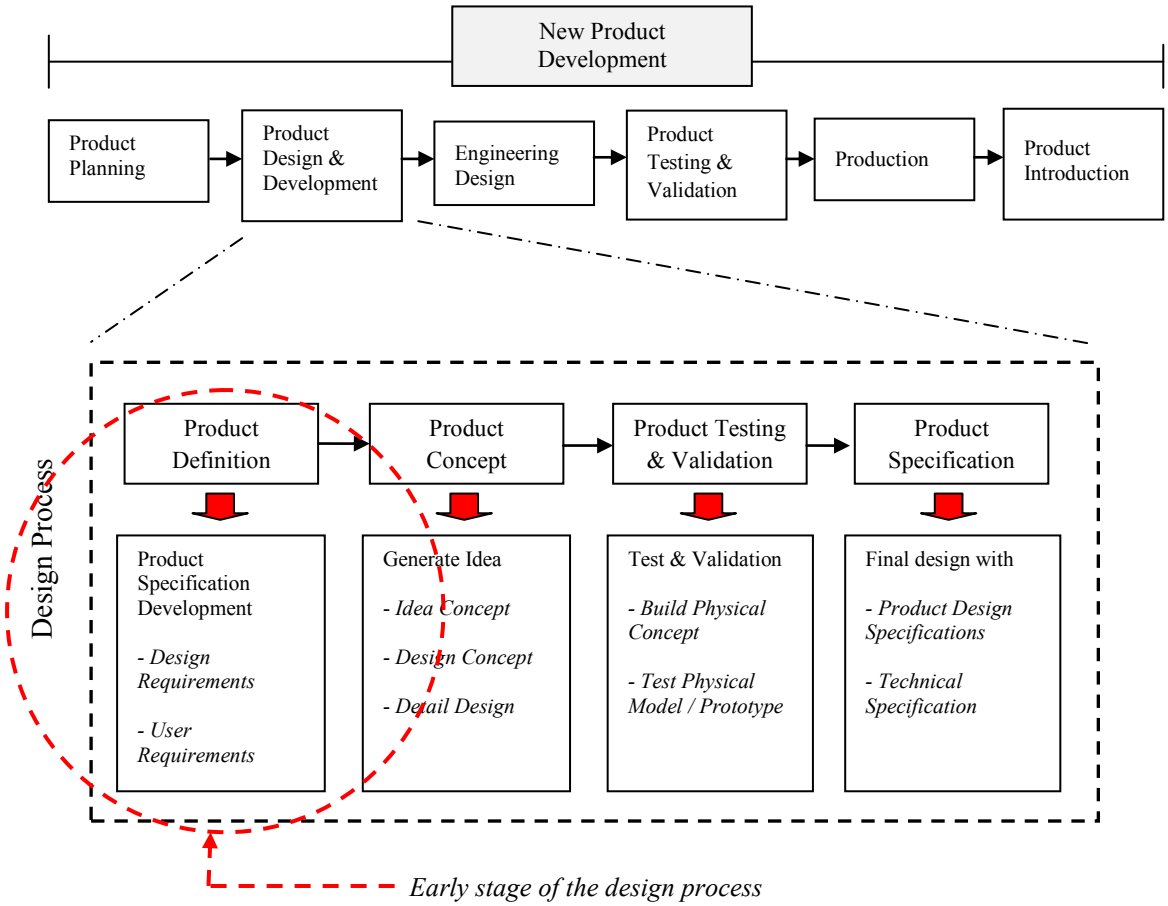

Figure 6.1: Product definition stage in the Product design and development

Therefore, in this stage, the new product idea must also be checked its fit to technology, the market strategies of the company, and requirements for resources. Each product is built from many variable facets, which, ultimately, give the product its personal and individual character. The characteristics of a product are constructed by a set of requirements that are also known as product design specifications. For a new product to achieve significant and rapid market penetration, it must map the requirements as new

features, and provide superior quality, a new look, be unique and have competitive pricing.

6.2.1 Mapping Successful Product Design Characteristics

Product innovation is often influenced by market performance and should be developed through proper planning and a systematic process, whereas the successful product characteristics and product design specification should be satisfied, and identified through the user needs.

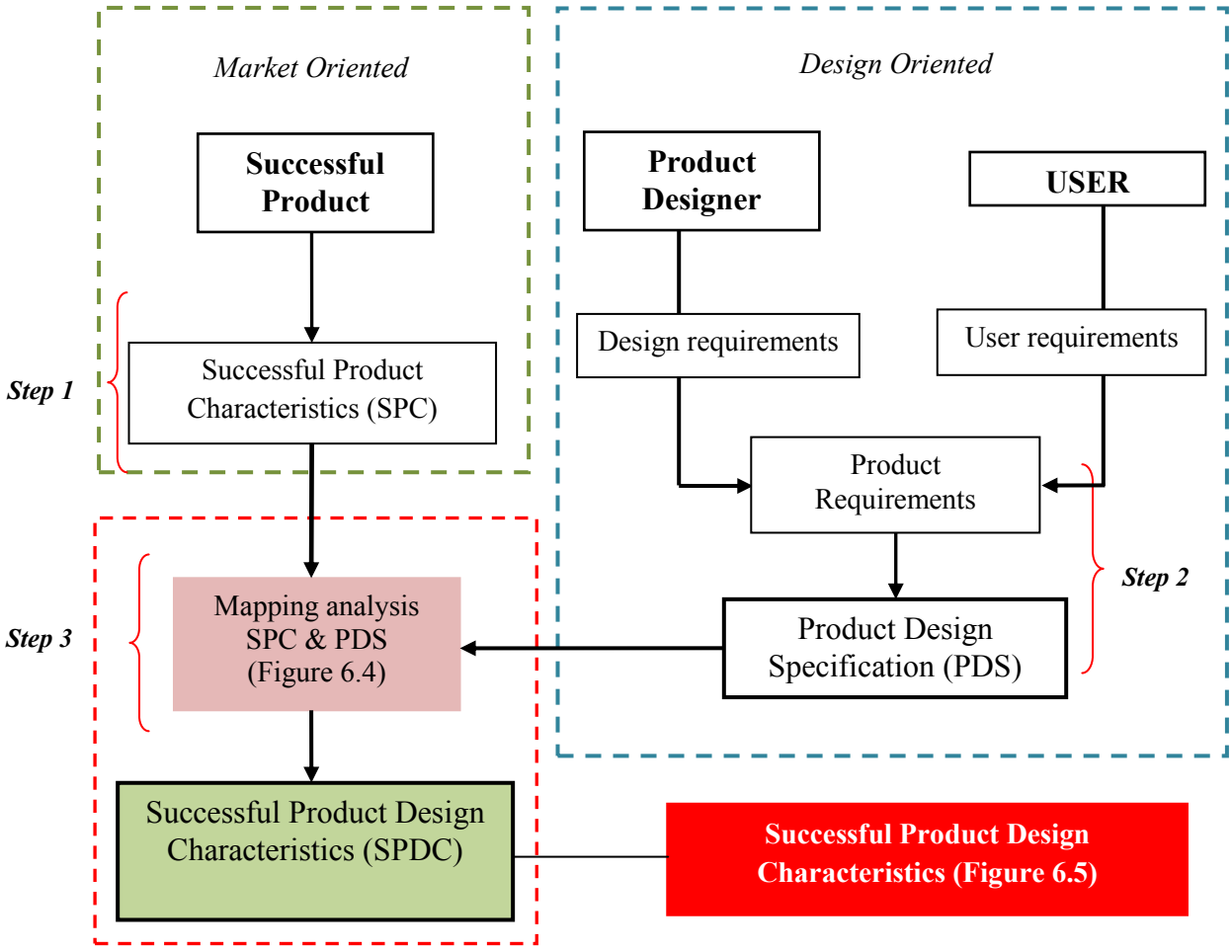

Figure 6.2: The process of developing SPDC Map

Figure 6.2 above shows the process of developing a successful product design characteristics (SPDC) Map. The process is important in order to establish the

successful product design characteristics (SPDC). In order to establish the successful product design characteristics (SPDC) Map, the structure and process is divided into three steps: Step 1: Identify successful product characteristics (SPC), Step 2: Identify product requirements from both product designer and user, which later will be labeled as product design specification (PDS), and Step 3: Map successful product characteristics (SPC) and product design specification (PDS) to become successful product design characteristics (SPDC) Map, which will be one of the tools in the new Product Design Definition Method (PDDM) proposed in this thesis.

6.2.1.1 Step 1: Identify Successful Product Characteristics

The successful product characteristics (SPC) were identified from past successful products. Table 6.1 explains the seven successful product characteristics.

Table 6.1: Successful product characteristics

Successful product characteristics (SPC)	Description
Multi-function	Incorporate the functionality of multiple, combination of some or all of the devices in one (Janlet & Stolterman, 1997; Jordan, 2002; Kotler & Keller, 2006 and Noble & Kumar, 2008)
Advanced Technology	Technology that is highly up-to-date to current time (Binnur, 2003; Carpinetti et al., 2003 and Senak et al., 2010)
Good Performance	Realized through the performance of its constituent components (Erns, 2003, Lettl, 2007 and Riedl et al., 2010)
Good Brand	Expectation about company product, exceed them and bring better product to the marketplace (Vihma, 1995 and Warell, 2001)
User Friendly	Ease of use, learn, operate and understand (Barcely, 2002 and Ljungberg & Edwards, 2003).
Good Design	Usefulness of product and satisfy certain criteria not only functional but also aesthetical and psychological (Glazer, 1991; Lundkvist & Yakhlet, 2004; Heiskanen & Repo, 2007 and Cooper & Kleinschmidt, 2011)
Environmentally Friendly	Any product that is not harmful to the atmosphere or surroundings when being made and in use (Carpinetti et al., 2003 and Senak, 2010)

These characteristics of being successful were established through literature studies and empirical investigation of past successful products, which are multi-function, advanced technology, good performance, good brand, user friendly, good design and environmentally friendly. These successful characteristics strongly contribute to the success of a product.

6.2.12 Step 2: Identify Product Design Specifications

The product design specifications were identified from the product designers (design requirements) and user requirements, while, the design requirements were generated from the product designers' input, and the user requirements were generated from the user input.

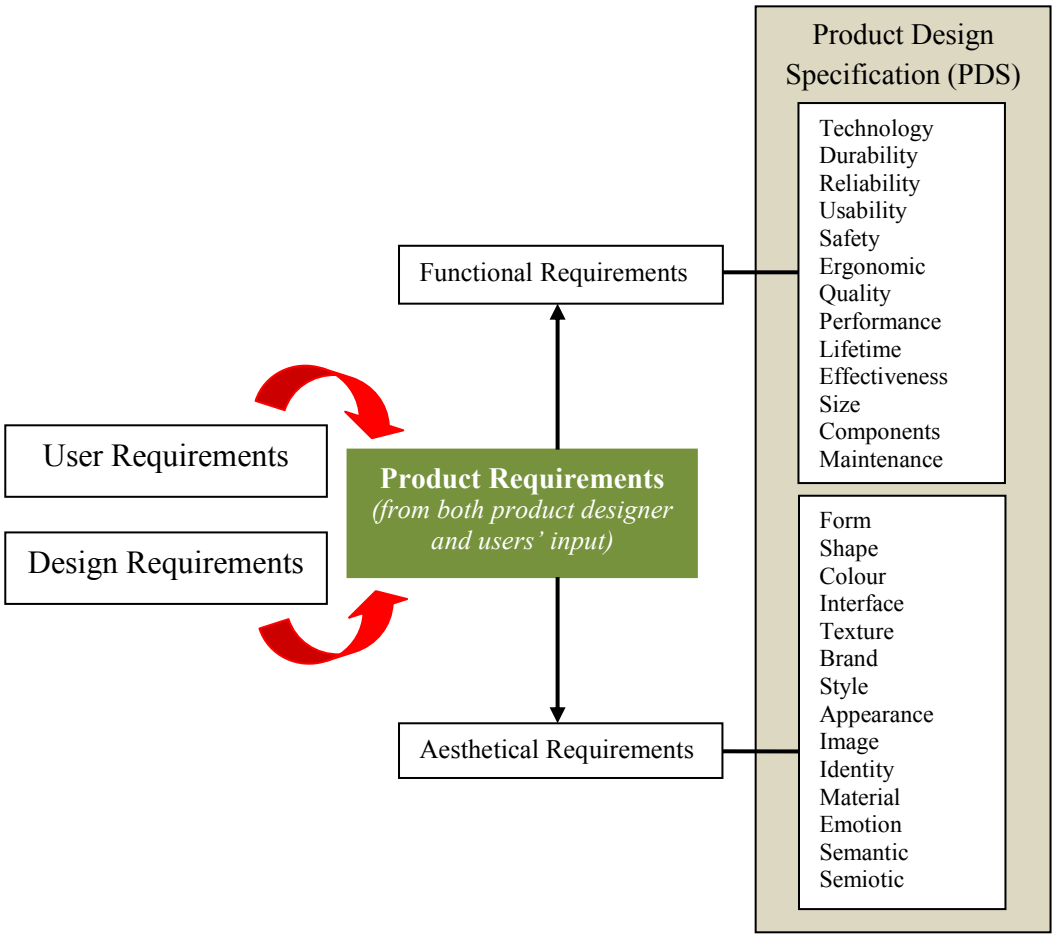

Figure 6.3: Product design specification process

Five specifications were considered as part of the product design specifications; namely, semantic, semiotic, durability, identity and brand. Both semantic and semiotic were strongly recommended by product designers as a part of the product design specification, while durability, identity and brand were suggested by users. Figure 6.3 above shows the product design specification process. The figure indicates that twenty-seven product design specifications were identified from both the product designer and user requirements, which is important in order to establish the successful product design characteristics (SPDC).

Table 6.2: The code for product design specifications

Product Design Specifications			
Functional requirements (Fr)	Code	Aesthetical requirements (Ar)	Code
Quality	Fr_{01}	Form	Ar_{01}
Safety	Fr_{02}	Appearance	Ar_{02}
Performance	Fr_{03}	Brand	Ar_{03}
Durability	Fr_{04}	Shape	Ar_{04}
Ergonomic	Fr_{05}	Style	Ar_{05}
Lifetime	Fr_{06}	Identity	Ar_{06}
Maintenance	Fr_{07}	Image	Ar_{07}
Effectiveness	Fr_{08}	Color	Ar_{08}
Technology	Fr_{09}	Texture	Ar_{09}
Reliability	Fr_{10}	Interface	Ar_{10}
Usability	Fr_{11}	Material	Ar_{11}
Size	Fr_{12}	Semantic	Ar_{12}
Components	Fr_{13}	Semiotic	Ar_{13}
		Emotion	Ar_{14}

In order to easily identify the twenty-seven product design specifications, all the specifications were coded. Table 6.2 above shows the code for the product design specifications. These specifications have been divided into two categories functional requirements and aesthetical requirements. The functional requirements refer to several functional requirements (Fr) and aesthetical requirements, which refer to a list of

aesthetical requirements (Ar). The functional requirements (Fr) have been coded from one (01) to thirteen (13), while the aesthetical requirements (Ae) have been coded from one (01) to fourteen (14). Table 6.3 below explains the twenty-seven product design specifications.

Table 6.3: Twenty-seven product design specifications

Product design specifications	Description
Technology	Specific technology is used and refers to a particular configuration that provides a technical platform in order to support product function (Krishnan & Ulrich, 2001; Binnur, 2003 and Carpinetti et al., 2003).
Durability	Durability to provide reliable service of intended function over a long service life under reasonable conditions of use (Garvin, 1988; Warell, 2001; Kujala, 2003 and Kuan & Jiang, 2008).
Reliability	Probability it will perform its intended function for a specified time period (garvin, 1988; Suh, 1990; Warell, 2001 and Kuang & Jiang, 2008)
Usability	Used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction (Bonapace, 2002 and Kujala, 2003).
Safety	Ability to be safe for intended user, and shall provide standard requirements (Suh, 1990 and Kujala, 2003).
Ergonomic	Safe and comfortable to maximize efficiency (Chapanis, 1995; Jordan, 1998 and Stanton & Yong, 1998).
Quality	Work reliably and perform all of it functions and fulfill the user expectations (Boutilier & McNaughton, 2006 and Bruch, 2007).
Performance	Response to external action in it working environment and realized through the performance of its constituent components (Erns, 2002; Bonner et al., 2005; Lettl, 2007 and Riedl et al., 2010).
Lifetime	Operated or used economically before the period of time is over (van Nes, 2003).
Effectiveness	Capability of a product to meet the user requirement and preference (Grunner & Homburg, 2000; McGregor, 2003; Jeppesen & Molin, 2003 and Kujala, 2003).
Size	Specified quantity of product (Nijssen & Frambach, 2000 and Ottoson, 2006).
Components	The relationship between the components of the product and quality for user emotion and satisfaction (Hubka & Eder, 1988).
Maintenance	Prior to the expiration date to ensure that it continues to have access to product updates (Thompson, 1999).
Form	The organization of the relationship among the material, expression, appearance and function that must be present in order for the product to appear (Jordan, 2003 and Ljungberq & Edwards, 2003).
Shape	Quality of a distinct product in having an external surface or outline of specific form (Jordan, 2003 and Dieter & Schmidt, 2009).

Color	Visual perceptual property of product (Jordan, 2003 and Dieter & Schmidlt, 2009).
Interface	A common language of product information in better definition between subsystem and component (Kujala, 2003 & Warell, 2001).
Texture	Variation of the intensity of a surface (Dieter & Schmidt, 2009).
Brand	Expectation about company product (idea or image of product), exceed them and bringing better product to the marketplace (Vihma, 1995 and Warell, 2001).
Style	A form of appearance, which is something expressed or performed and considered as part of its intrinsic content, meaning and characteristics (Hofstede, 2001; Carpinetti et al., 2003 and Senk et al., 2010).
Appearance	Physical composition of the product and describes how the product looks and feels to the user (Garvin, 1988 and Hertenstein et al., 2005).
Image	Serves to provide discrimination between products or to differentiate from others (Bamossy et al., 1983; Garvini, 1988; Berclay, 2002 and Cooper & Kleinschmidt, 2011.
Identity	Represents a corporate image to user diversified tests and wants (Bamossy et al., 1983 and Warell, 2001).
Material	Concerned with physical product property in order to show the product character (Ljungberg & Edwards, 2003).
Emotion	Implies and involves a relation between the person experiencing them and a particular object (Bamossy et al., 1983 and Noble & Kumar, 2008).
Semantic	The possibility to communicate a clear message and interpret the meaning of a product (Krippendorff, 2005 and Karjalainen, 2007).
Semiotic	The use of signs in the design of a physical product (Silverman, 1983)

6.2.1.3 Step 3: Mapping SPC and PDS

Understanding and recognizing that successful product characteristics (SPC) and product design specifications (PDS) are important for a product designer to produce a product that meets its specification. The product designer uses SPC as a preliminary knowledge for the intended product, while the PDS becomes the main template for the technical specifications of the product. Figure 6.4 below shows the successful product design characteristics (SPDC) Map. The SPDC Map incorporates both the successful product characteristics (SPC) and product design specification (PDS).

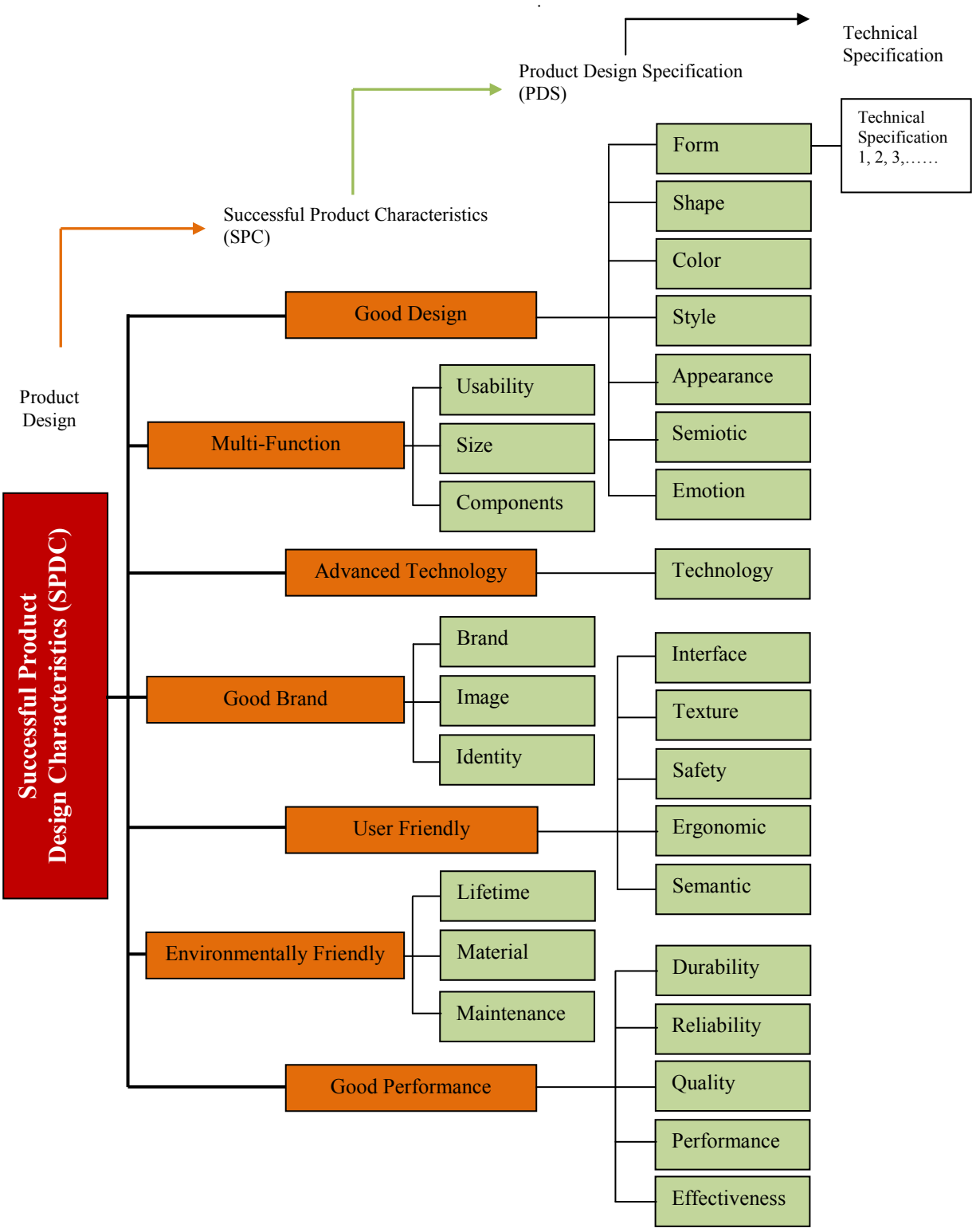

Figure 6.4: Successful product design characteristics (SPDC) Map

The map indicates seven successful product characteristics (SPC) that have been generated from past successful products and twenty-seven product design specifications (PDS), which were earlier captured from the product designers and users. This

knowledge is important to establish the successful product design characteristics (SPDC), as defined by this formula 6.1 below.

$$SPDC = [SPC] + [PDS] \quad (6.1)$$

Successful Product Design Characteristics =
Successful Product Characteristics + Product Design Specifications

6.3 Product Design Definition Method

As mentioned in chapter, the development of a new design methodology is important to support the early design activities in the early stage of the design process. The purpose of the new design methodology is to incorporate the product designer (design requirements) and user requirements with the characteristics of a successful product in the early stage of product development. Many existing methods have a similar purpose, but, unfortunately, these methods do not take into consideration the characteristics of a successful product in product design. Hence, a new design methodology is developed to incorporate these three characteristics; product designers (design requirements), user requirements and successful product, which attempt to establish the successful product design characteristics and increase the probability of product success.

6.3.1 Application of the Method

The Product Design Definition Method (PDDM) is now proposed attempt to meet the user expectations and determine the success of a new product, as shown in Figure 6.5 below. The PDDM was intentionally developed as a process to identify and establish the successful product design characteristics (SPDC) in the product definition stage of the design process. There are four steps that the product designer should follow to use the proposed PDDM framework in order to establish the successful product

design characteristics (SPDC). The application of the method commences with: 1) getting the user input according to successful product design characteristics (SPDC) Map, 2) prioritizing successful product characteristics (SPC), 3) verifying product design specification (PDS), and 4) building SPDC into the XS-Detailed Description.

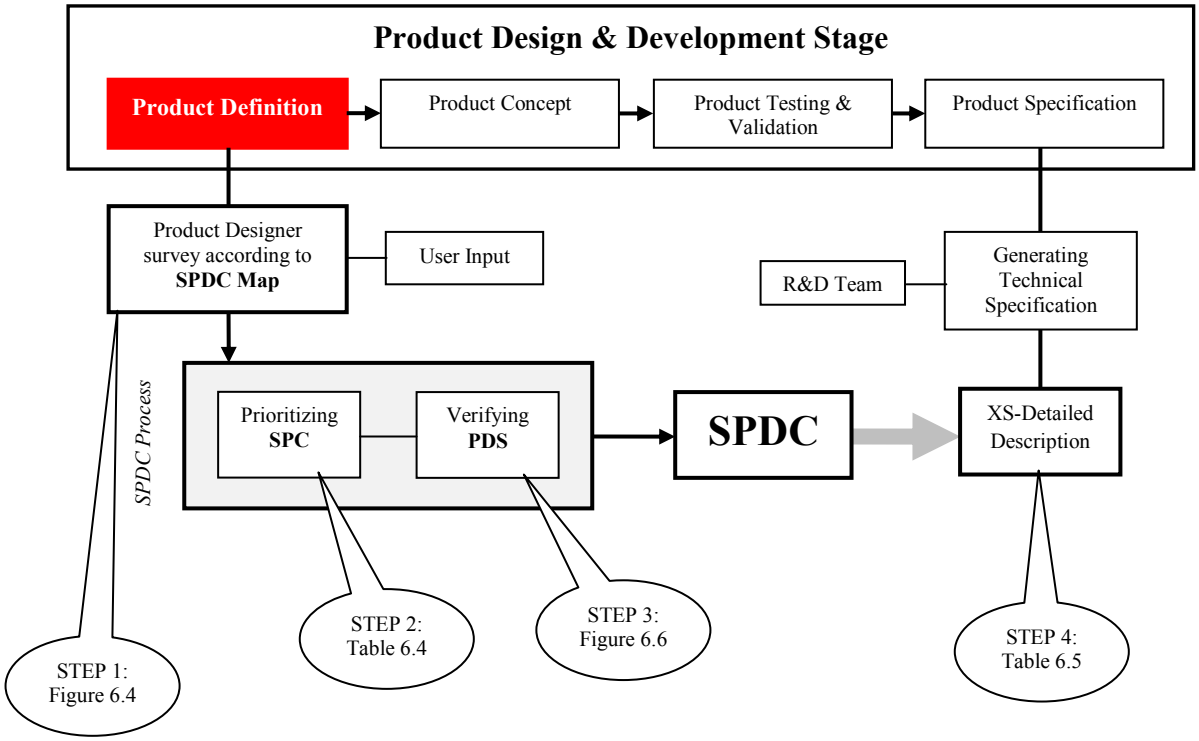

Figure 6.5: Product Design Definition Method

6.3.1.1 User Input According to SPDC Map

In the first step, user input is required, in which the product designer team should capture the information needed according to the SPDC map (details in Figure 6.4 in Chapter 6). This process involves a number of product users in order to grade the significance of the seven successful product characteristics (PDC) and twenty-seven item product design specification (PDS). This process attempts to rank the most important of both the PDC and PDS for the intended new product. The user input can be gained through a survey using several methods or tools, such as interview,

questionnaire, focus group, group discussion or observation. Whichever data collection method is used, the product designer must capture the data for both SPC and PDS.

6.3.1.2 Prioritizing Successful Product Characteristics

Successful product characteristics (SPC) can be viewed as an expression and recognized as the fundamental opinion of users. They also express the essential properties of what the product must have, and the desired properties of what the users like to have.

Table 6.4: Successful product characteristics matrix

Successful product characteristics (SPC)	Prioritizing successful product characteristics	Percentage
Multi-function Advanced Technology Good Performance Good Brand User Friendly Good Design Environmentally Friendly	Priority 1 - Very strong	90-100
	Priority 2 - Strong	70-89
	Priority 3 - Average / Medium	60-79
	Priority 4 - Weak	50-59
	Priority 5 - Very Weak	0-49

In this stage, these seven successful product design characteristics need to be prioritized using values from one to five, in which one (1) is indicated as being very strong successful product characteristics to the lowest, which is five (5), as shown in Table 6.4. The table indicates that seven successful product characteristics were leveled and rated as: 1) Priority 1 – very strong (90-100 percent), Priority 2 – strong (70-89 percent), Priority 3 – average / medium (60-79 percent), Priority 4 – weak (50-59 percent) and Priority 5 – very weak (0-49 percent).

6.3.1.3 Verifying Product Design Specifications

In order to establish the product design specifications (PDS), the requirements that were identified based on the SPDC Map (Section 6.2.1.3 in Chapter 6) must be clustered into four categories of the PDS Matrix: 1) Must Have (MH) – where the product design specifications are essential for the success of a product, 2) Should Have (SH) – the product design specifications that can increase the likeliness of product success, 3) Not Necessary to Have (NNH) – the product design specifications that do not have a major impact on product success, and 4) Must Not Have (MNH) – the product design specifications that have a harmful impact on product success.

Only the matrix Must Have (MH) and Should Have (SH) would be given priority as product design specifications and would be incorporated as important product design specifications for the intended new product. However, the product designer can also employ the specifications of Not Necessary to Have (NNH) categories as part of the product characteristics. The selection of NNH as product design specifications will result, in an 1) increase in the product process and cost, and 2) differentiate it from other products. Therefore, the product designers should not employ what is listed as specifications in MNH as a product design specification because it has a harmful impact on product success. Figure 6.6 shows the clustering process for developing the product design specification. The figure illustrates the PDS Matrix model of the clustering process in order to verify and prioritize the product design specification value based on its significance to the intended new product in order for the product to not only satisfy the user needs but also increase its likelihood of success. The list of significant requirements that were collected from the user survey should be converted into a percentage and clustered to arrange entire all the PDS Matrix levels from 1-4 based on the scoring percentage. The score Level 1 is between 80 and 100

percent, Level 2 is between 60 and 79 percent, Level 3 is between 40 and 59 percent, and level 4 is between 0 and 39 percent.

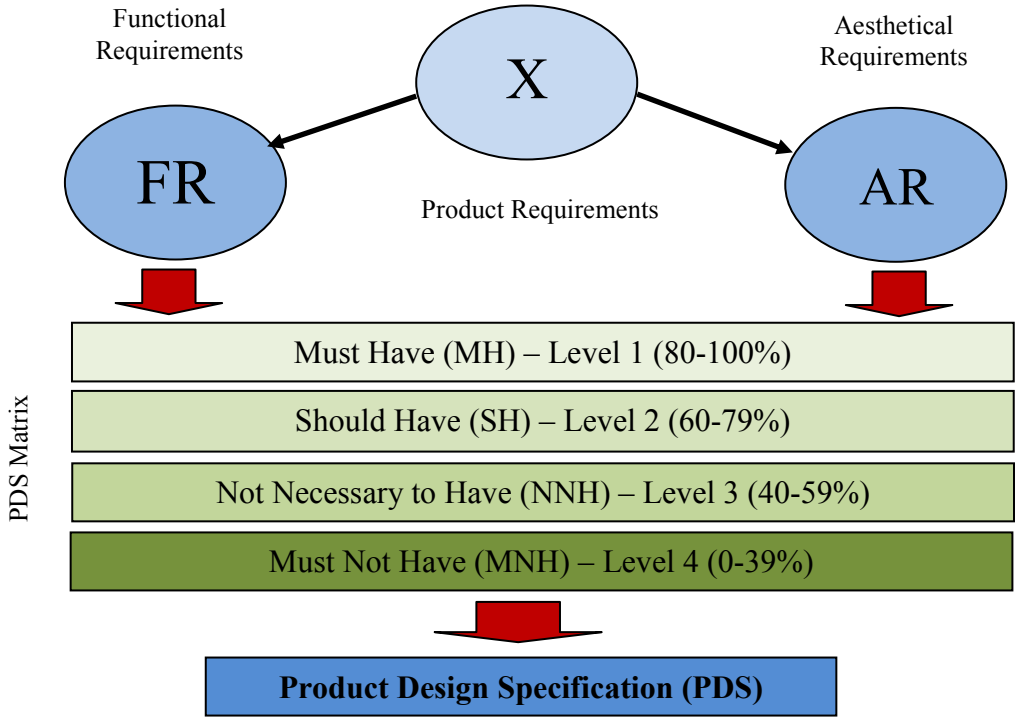

Figure 6.6: Clustering process for product design specifications

Finally, to the end of the clustering process, the product designers obtain product design specifications out of twenty-seven product design specifications. The decision-making model for the product design specification is defined by formula 6.2 below.

$$\text{PDS: [FR] + [AR]} \tag{6.2}$$

$$\text{FR-}W_1\,\Sigma\text{: } (Fr_{01} + Fr_{05} + Fr_{11}) + \text{AR-}W_2\,\Sigma\text{: } (Ar_3 + Ar_{07} + Ar_{13})$$

Product Design Specifications =

Functional Requirements (Quality + Ergonomic + Usability) +
Aesthetical Requirements (Brand + Image + Semiotic)

6.3.1.4 Building SPDC into the XS-Detailed Description

The success factors (XS) Detailed Description is a worksheet, which was designed to document the complete product characteristics and detail to be considered during the product definition stage of the design process, as this information is useful to determine the product success. The XS-Detailed Description is important in order to facilitate the product designer to conclude their new product decision of a product. In addition, this worksheet is also important to be used in order to identify the technical specification of each product design characteristic.

Table 6.5: The XS-Detailed Description *(example product: Perodua MyVi)*

Successful Product Characteristics (SPC)	**Product Design Specification (PDS)**	**Technical Specifications (TS)**
Good Design	*Must Have*	
	Form	*Slightly shorter and curvier, Five-door hatchback*
	Color	*Lime green (metallic), Dazzling red (metallic) and Ivory white (metallic)*
	Should Have	
	Shape	*Full body kit from front bumper, rear bumper and new interior design which features carbon fiber surface*
	Not Necessary to Have	
	Style	*Multi-purpose compact car*
User Friendly	*Must Have*	
	Safety	*Dual SRS airbags, ABS with EBD &BA, Anti-theft device, Rear seat belts, ISOFIX child restraint system*
	Ergonomic	*Seat height adjuster, power steering, power window, Adjustable seat belt anchors*
	Should Have	
	Interface	*Multi-info display, Shift position indicator, Meter illumination control*

Table 6.5 shows an example of the XS-Detailed Description. The table also shows the specific design features for the successful product design characteristics for the Perodua MyVi. The XS-Detailed Description is divided into three columns: 1) successful product characteristics (SPC) – seven success factors were placed according to the significance to the product success from one (1) to five (5), 2) product design

specification (PDS) – verification of product specifications, and 3) technical specification – detailed requirements for each specification that can ensure the product work and performance (determined by R&D team). After the successful product design characteristics (SPDC) were identified in the product definition stage of the design process, the next process can be carried out, such as developing the product concept. In addition, technical specifications can concurrently be identified through involving research and development (R&D) team members, such as engineers, marketers, managers and production engineers.

6.4 Conclusion

This chapter introduced a new design methodology known as the Product Design Definition method (PDDM). The PDDM was developed for product designers in order to identify and verify user requirements and preferences for a new product, and contribute to the likelihood of the success of the product. The PDDM process incorporates the three characteristics from the product designer (design requirements) and user requirements with the past successful products. All three characteristics are important during the early stage of product development process in order to establish the successful product design characteristics (SPDC). The PDDM process took place according to specified steps, as summarized by the PDDM in Table 3.6 below.

Table 3.6: Product Design Definition Method in Practice

STEP	Description	Tools
STEP 1	User input is required, which product designers' team should capture information needed according to SPDC Map.	SPC Map (refer to Figure 6.4)
STEP 2	Prioritizing successful product design (PDS).	SPC Matrix (refer to Table 6.4)
STEP 3	Verifying product design specification (PDS) through clustering process.	PDS Matrix (refer to Figure 6.6)
STEP 4	Building successful product design characteristics (SPDC) into the success factor (XS) Detailed Description worksheet.	XS-Detailed Description (refer to Table 6.5)

CHAPTER 7 VALIDATING THE PRODUCT DESIGN DEFINITION METHOD

7.1 Introduction

This chapter evaluates the proposed Product Design Definition Method (PDDM). The validation for product success through the new design methodology proposed involved the professional end-user survey and technical specification analysis. Then, a correlation test was conducted with product sales performance in order to validate the significance of the variable and the strengths of the correlation that contributed to the success of a new product.

7.2 Verification of Method

The success of a new product design is sufficient profit if the product developer can fulfill the user requirements and preferences. In order to increase the success of a new product, the product developers must integrate the successful product characteristics (SPC) and product design specification (PDS) into the intended new product, and then identify the technical specification (TS) of how the product can perform and work accordingly. The successful product design can be identified through the following formula:

$$\mathbf{XS = SPDC\ [SPC + PDS] + TS} \qquad (7.1)$$

Success Factors (XS) =
Successful Product Design Characteristics (Successful Product Characteristics + Product Design Specification) + Technical Specifications

Many factors influence the success of a new product. However, in the context of product purpose, does it meet the user needs? And, how do the user requirements and preferences contribute to the success of a new product? In this study, the success of a new product can be defined as XS = SPDC (SPC + PDS) + TS (details of formula 7.1 in Chapter 7). The formula shows that the success of a new product is not only depending on the successful product design characteristics (SPDC) that incorporated successful product chacteristics (SPC) and product design specification (PDS) but it must associates with the detail of the technical specification (TS). Before the product designers establish the successful product design characteristics, they must identify the success factors for product design and verify the specification of a new product. The successful product design characteristics map (details in Figure 6.4 in Chapter 6) is used to define the product success. This can be done through a survey involving the end user by using several methods, such as observation, questionnaire, sales performance and interviews. To be able to clarify the factors that influence product success, the investigation conducted a survey involving three mobile smart phone products; namely, Samsung Galaxy Tab 7.0 plus, BlackBerry Bold and Apple iPhone4. The survey conducted involved professional end user and technical specifications of the product. The successful product characteristics (SPC) were used as a product indicator and correlated to the product design specifications (PDS). To provide a better understanding of the success of a new product, it can be defined as SPDC = [SPC] + [PDS] (details of formula 6.1 in Chapter 6). To illustrate the detailed procedure and to prove the practicability of the proposed new design methodology, validation of the product success through a professional end-user survey and technical specifications analysis was conducted in section 7.3 below.

7.3 Data Analysis and the Results of the Professional End-User Survey

7.3.1 Reliability of the Research Instrument

A total of 32 items were used in this survey. To validate the reliability of the instruments, all the questions were tested by using a reliability analysis. Table 7.1 shows the reliability of the research instrument in which the Cronbach's Alpha, .88, shows that all 32 items in this research survey are satisfactory. The reliability of .88 indicates 88 percent consistency in the score produced by the instrument. Hence, the research instrument is satisfactory.

Table 7.1: Reliability of the research instrument statistic for professional end-user survey

Cronbach's Alpha	N of Items
.88	32

7.3.2 Results of Professional End-User

7.3.2.1 Characteristics of Respondents

A total of 98 product users took part in this survey. Only the respondents with more than three months experience of mobile application use were invited to participate in this survey. The respondents were divided into three user groups; BlackBerry Bold user, Apple iPhone4 user and Samsung Galaxy Tab 7.0 Plus user. SPSS was used to analyze and calculate the frequencies of the respondents.

Table 7.2: Gender for the three smartphones

Product/Gender	Male		Female	
	N	Percentage	N	Percentage
Apple iPhone4	18	56.0%	14	43.8%
Blackberry Bold	15	48.4%	16	51.6%
Samsung Galaxy Tab 7.0 Plus	17	48.6%	18	51.4%

Table 7.2 shows the gender of the respondents for the three smartphones. The results indicate that 51.0 percent of respondents involved in this survey were male and 49.0 percent female. Table 7.3 shows user experience for the three smartphones. The results specify that 71.9 percent of the respondents for the Apple iPhone4 mobile had experience of mobile application use of between 3 and 6 months, followed by 18.8 percent between 7 and 12 months, and 9.4 percent more than 12 months. For the BlackBerry Bold, 61.3 percent of the respondents had experience of mobile application use of between 3 and 6 months, followed by 32.3 percent between 7 and 12 months and 6.5 percent more than 12 months. While, 48.6 percent of the respondents had experience of mobile application use of between 3 and 6 months, followed by 37.1 percent between 7 and 12 months and 14.3 percent more than 12 months for Samsung Galaxy Tab 7.0 Plus users.

Table 7.3: User experience for the three smartphones

Experience of mobile use	Apple iPhone4	Blackberry Bold	Samsung Galaxy Tab 7.0 Plus
3-6 months	71.9%	61.3%	48.6%
7-12 months	18.8%	32.3%	37.1%
>12 months	9.4%	6.5%	14.3%

7.3.2.2 Results from the User Based on the SPC Map

a) Prioritizing SPC of Smartphones

The successful product characteristics of three smartphones can be identified through the SPC Matrix (details in Table 6.4 in Chapter 6). The results indicate that the users have their own criteria for the selection of successful product characteristics for the three smartphones, as shown in Table 7.4 below. It shows that the users of Apple iPhone4 select the successful product characteristics are follow: first priority - multi-function, advanced technology, good brand, good performance and user friendly, followed by second priority - good design, and third priority – environmentally friendly.

The Blackberry Bold users select the following successful product characteristics: first priority - multi-function, advanced technology, good brand and good performance, followed by second priority - good design and user friendly, and fourth priority - environmentally friendly. While, the users of the Samsung Galaxy Tab 7.0 Plus select the following successful product characteristics: first priority - multi-function, advanced technology and good performance, followed by second priority - good design, third priority – good brand and user friendly, and fourth priority - environmentally friendly.

Table 7.4: Successful product characteristics for the three smartphones

Apple iPhone4	**BlackBerry Bold**	**Samsung Galaxy Tab 7.0 Plus**
Multi-Function (100%)	Multi-Function (96.7%)	Multi-Function (97.1%)
Advanced Technology (96.9%)	Advanced Technology (96.7%)	Advanced Technology (91.7%)
Good Performance (96.9%)	Good Brand (90.4%)	Good Performance (91.7%)
Good Brand (96.9%)	Good Performance (90.3%)	Good Design (82.0%)
User Friendly (90.7%)	Good Design (83.9%)	Good Brand (74.2%)
Good Design (84.4%)	User Friendly (74.2%)	User Friendly (71.4%)
Environmentally Friendly (65.6%)	Environmentally Friendly (51.6%)	Environmentally Friendly (37.1%)

b) Verifying PDS of Smartphones

The product design specifications for the three smartphones can be identified through formula PDS: [FR] + [AR] (details formula 6.2 in Chapter 6). The verifying of the product design specifications were divided into four categories Must Have, Should Have, Not Necessary Have and Must Not Have (details in Figure 6.6). Table 7.5 shows the product design specification for the three smartphones. The table indicates ten functional requirements and eleven aesthetical requirements are classified as Must Have specifications for the Apple iPhone, followed by three functional requirements and three aesthetical requirements as Should Have specifications. The BlackBerry Bold identified

nine functional requirements and five aesthetical requirements as classified Must Have specifications followed by four functional requirements and nine aesthetical requirements as Should Have specifications. While, seven functional requirements and five aesthetical requirements were identified as Must Have specifications for Samsung Galaxy Tab 7.0 Plus followed by four functional requirements and eight aesthetical requirements as Should Have. In addition, two functional requirements and one aesthetical requirement are classified as Not Necessary to Have specifications in this mobile.

Table 7.5: Product Design Specifications for the three smartphones

Smartphone	Product design specifications
Apple iPhone4	MUST HAVE **FR-$W_1\Sigma$:** (Technology + Quality + Performance + Usability + Ergonomic + Safety + Durability + Reliability + Effectiveness + Size) + **AR-$W_2\Sigma$:** (Appearance + Style + Brand + Interface + Image + Material + Identity + Shape + Form + Color + Emotion)
	SHOULD HAVE **FR-$W_1\Sigma$:** (Lifetime + Component + Maintenance) + **AR-$W_2\Sigma$:** (Semiotic + Texture + Semantic)
BlackBerry Bold	MUST HAVE **FR-$W_1\Sigma$:** (Technology + Quality + Performance + Usability + Reliability + Effectiveness + Durability + Safety + Ergonomic) + **AR-$W_2\Sigma$:** (Identity + Style + Appearance + Image + Brand)
	SHOULD HAVE **FR-$W_1\Sigma$**: (Lifetime + Size + Component + Maintenance) + **AR-$W_2\Sigma$:** (Color + Shape + Form + Interface + Emotion + Semiotic + Semantic + Texture + Material)
Samsung Galaxy Tab 7.0 Plus	MUST HAVE **FR-$W_1\Sigma$:** (Technology + Quality + Performance + Usability + Durability + Effectiveness + Reliability) + **AR-$W_2\Sigma$:** (Appearance + Interface + Form + Emotion + Semantic)
	SHOULD HAVE **FR-$W_1\Sigma$:** (Ergonomic + Safety + Size + Component) + **AR-$W_2\Sigma$:** (Identity + Brand + Shape + Style + Color + Semiotic + Material + Image)
	NOT NECESSARY to HAVE **FR-$W_1\Sigma$:** (Lifetime + Maintenance) + **AR-$W_2\Sigma$:** (Texture)

c) SPDC of Smartphones

Successful product design characteristics for the three smartphones success can be identified through the formula SPDC: [SPC] + [PDS], (details of formula 6.1 in Chapter 6).

Table 7.6: Successful product characteristics for the three smartphones

Smartphones	Priority	PDC + PDS
Apple iPhone4	1st	Multi-Function (MH: Fr_{11} + Fr_{12}) + (SH: Fr_{13})
		Advanced Technology (MH: Fr_{09})
		Good Brand (MH: Ar_{03} + Ar_{07} + Ar_{06})
		Good Performance (MH: Fr_{01} + Fr_{03} + Fr_{04} + Fr_{10} + Fr_{08})
		User Friendly (MH: Fr_{05} + Fr_{02} + Ar_{10}) + (SH: Ar_{09} + Ar_{12})
	2nd	Good Design (MH: Ar_{02} + Ar_{05} + Ar_{04} + Ar_{01} + Ar_{08} + Ar_{14}) + (SH: Ar_{13})
	3rd	Environmentally Friendly (MH: Ar_{11}) + (SH: Fr_{06} + Fr_{07})
BlackBerry Bold	1st	Multi-Function (MH: Fr_{11}) + (SH: Fr_{12} + Fr_{13})
		Advanced Technology (MH: Fr_{09})
		Good Brand (MH: Ar_{06} + Ar_{07} + Ar_{03})
		Good Performance (MH: Fr_{01} + Fr_{03} + Fr_{10} + Fr_{08} + Fr_{04})
	2nd	Good Design (MH: Ar_{05} + Ar_{02}) + (SH: Ar_{08} + Ar_{04} + Ar_{01} + Ar_{14} + Ar_{13})
		User Friendly (MH: Fr_{02} + Fr_{08}) + (SH: Fr_{07} + Ar_{12} + Ar_{10} + Ar_{09})
	4th	Environmentally Friendly (SH: Fr_{06} + Ar_{11})
Samsung Galaxy Tab 7.0 Plus	1st	Multi-Function (MH: Fr_{11})
		Advanced Technology (MH: Fr_{09})
		Good Performance (MH: Fr_{01} + Fr_{03} + Fr_{04} + Fr_{08} + Fr_{10})
	2nd	Good Design (MH: Ar_{02} + Ar_{01} + Ar_{14}) + (SH: Ar_{04} + Ar_{05} + Ar_{08} + Ar_{13})
	4th	Good Brand (SH: Ar_{06} + Ar_{03} + Ar_{07})
		User Friendly (SH: Ar_{10} + Ar_{12}) + (SH: Fr_{02} + Fr_{05}) + (NNH: Ar_{09})
	5th	Environmentally Friendly (SH: Ar_{11}) + (NNH: Fr_{06} + Fr_{07})

Table 7.6 shows the successful product design characteristics for the three smartphones: Apple iPhone4, BlackBerry Bold and Samsung Galaxy Tab 7.0 Plus. The table indicates the priority of successful product design for the three smartphones. The priority of successful product design characteristics were found to be similar among the three

smartphones, where the three SPCs identified as highest priority are multi-function, advanced technology and good performance. Only for the Apple iPhone4 and BlackBerry was good brand included as part of the first priority requirements. Therefore, four product design specifications were found from the three smartphones that contributed to product success; namely, usability (Fr_{11}), technology (Fr_{09}), quality (Fr_{01}) and performance (Fr_{03}). Most smartphones place good design as second priority of SPC. In addition, form (Ar_{01}) and appearance (Ar_{02}) were identified as strong specifications for good design that contributed to product success. The BlackBerry Bold was placed user friendly as second SPC requirements, while the fourth placed for Samsung Galaxy Tab 7.0 Plus. In addition, the environmentally friendly requirements placed at the last of the three smartphones.

7.3.3 Technical Specifications for Smartphones Success

After the successful product design characteristics (SPDC) were identified, further investigation was conducted to identify the technical specification (TS) for each product design specification through the success factors (XS) Detailed Description. The XS-Detailed Description is important in order to identify the technical specifications that can ensure the product works according to its purpose. It is also considered as detailed product requirements and that mainly contributed to the product success. The results indicated several technical specifications of product that contributed to product success based on the three most important successful product characteristics, which are multi-function, advanced technology and good performance (details in Table 7.4 in Chapter 7). The detailed technical specifications of the product are presented in Appendix C-1 (Table 7.7).

Table 7.7: The XS-Detailed Description for the three smartphones.

7.3.4 Sales Performance Analysis of Apple iPhone

Product success is actually derived from product innovation and product introduction, whereby, innovation is initiated during the design process. The product requirements often refer to the specification of the product that is always required by the user. Therefore, it is a major concern in product design development whereby product function refers to the technology application and performance satisfaction. Nowadays, most of the mobile companies have introduced smartphones that offer advanced and multiple functions. In mobile phone development, innovative features and applications are continuously being added in order to make them perform with more new functions. The success of a new product can be identified through its sales performance. In this section a case study is conducted to identify and prove the success factors of the Apple iPhone through sales performance. The Apple iPhone was selected from among the other mobiles because of user satisfaction. According to a customer satisfaction research conducted by Change Wave Research (2012), there is 75 percent customer satisfaction for the iPhone product, followed by Samsung and HTC (47 percent), Motorola (45 percent), LG (31 percent), Nokia (23 percent), and Blackberry (22 percent). The results show that the development of the Apple iPhone focused more on meeting user needs through innovative features with new functions and applications. Figure 7.1 shows the Apple iPhone worldwide sales from 2007-2012. Five Apple iPhones have been introduced since 2007. However, there are only three Apple iPhones on the market iPhone3GS, iPhone4 and iPhone4S. A total of 244,334,000 million Apple iPhone mobiles were sold based on the five models since 2007 until 2012. The iPhone4 has proved to be a successful model that has contributed to the incensing sales volume compared to the previous model. Then, the sales of Apple iPhone continuously increased through the new iPhone4S.

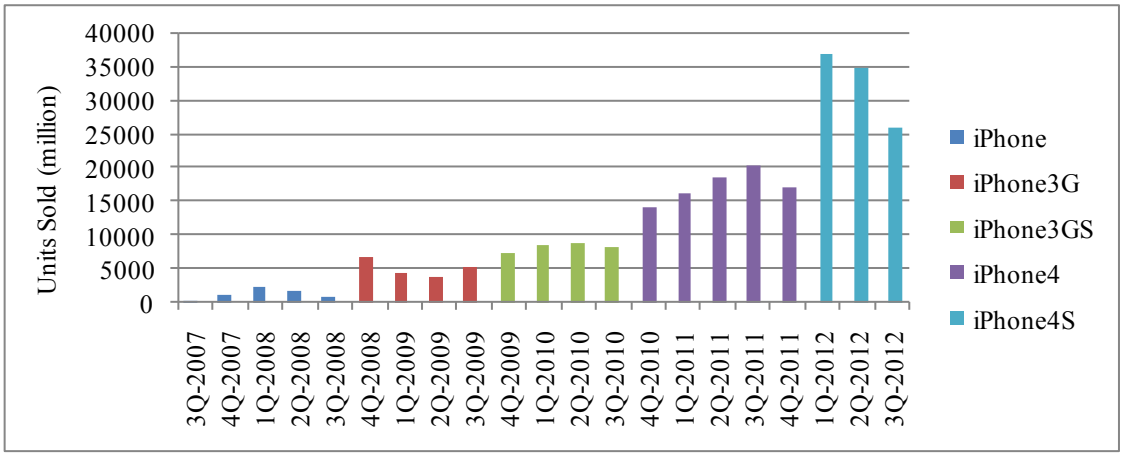

Figure 7.1: Apple iPhone worldwide sales from 2007-2012

Table 7.8 illustrates the successful product characteristics of the Apple iPhone. The results from the product user survey indicate that multi-function contributes very strongly to the success of the iPhone4 followed by advanced technology, good performance, good brand and user friendly. Therefore, the table also reports that two strong characteristics also contributed to the success of the iPhone4, which are good design and environmentally friendly.

Table 7.8: Successful product characteristics of Apple iPhone mobile

Successful product characteristics (SPC)	**Prioritizing successful product characteristics**	**Percentage**
Multi-function Advanced Technology Good Performance Good Brand User Friendly	Priority 1 - Very strong	90-100
Good Design	Priority 2 – Strong	70-89
Environmentally Friendly	Priority 3 - Average / Medium	60-69
	Priority 4 – Weak	50-59
	Priority 5 - Very Weak	0-49

7.3.4.1 Technical Specification Analysis of the Apple iPhone

Five characteristics strongly contributed to the success of the iPhone4 (details in Table 7.8 in Chapter 7): multi-function, advanced technology, good performance,

good brand and user friendly. Only three were selected based on the highest priority of Apple iPhone success. Therefore, five Apple iPhone models were selected in order to validate the success factors and product design specification with sales performance. Table 7.9 shows the success factors for the Apple iPhone with the technical specifications. The table shows four factors that influenced the increment in product sales and illustrates the evolution of the Apple iPhone through the various models iPhone, iPhone3, iPhone3GS, iPhone4 and iPhone4S. Four successful product characteristics and product design specifications were evaluated: 1) multi-function – usability (FR_{11}), 2) advanced technology – technology (FR_{09}), 3) good performance – performance (Fr_{03}), and 4) user friendly – interface (Ar_{10}). For instance, the results indicated that multi-function characteristics through usability have been increasing the number of product features from previous iPhone models to the new iPhone4S model which influenced of product success.

Table 7.9: The XS-Detailed Description for Apple iPhone

Successful Product Characteristics	Product Design Specification	iPhone	iPhone3G	iPhone3GS	iPhone4	iPhone4S
Multi-Function	Usability (Features)	USB 2.0 / dock connector	*In addition to previous:* assisted GPS, includes earphone with mic	*In addition to previous:* Voice control, digital compass (magnetometer), Nike + camera tap to focus (iOS 4.0 + include earphones with remote and microphone	*In addition to previous:* 3-axis gyroscope, Dual-microphone noise suppression, microSIM, rear camera LED flash	*In addition to previous:* Siri (beta) Voice assistant and GLONAS5 support
Advanced Technology	Technology (Camera)	2.0 megapixel, f/2.8 still image only		3.0 megapixel, f/2.8 VGA video at 30 frame/s	*Front:* 3.0 megapixel (VGA) 480p VGA video at 30 frame/s *Rear:* 5.0 megapixel, f/2.0 720p HD video at 30 frame/s	*Rear:* 8.0 megapixel, f/2.4 1080p full HD video at 30 frame/s
	Technology (Cellular Connecting)	Quad band GSM/GPRS/EDGE (850, 900, 1,800, 1,900 MHz)	*In addition to previous:* Tri-band 3.6 Mbit/s UMTS/HSDPA (850, 1,900, 2,100 MHz)	*In addition to previous:* 7.2 Mbit/s – HSDPA	*In addition to previous:* GSM model 5.76 Mbit/s HSUPA, UMTS/HSDPA at 800 and 900 MHZ CDMA model Dual-band CDMA/EV-DO Rev. A(800, 1,900 MHz)	*In addition to previous:* 14.4 Mbit/s HSDPA, Redesigned dynamically switching dual antenna, combined GSM/CDMA capability
	Technology (Display)	89mm (3.5 in) glass LCD, 3:2 aspect ratio				
		480 x 320 px (HVGA) at 163 ppi			960 x 640 px at 326 ppi	

Good Performance	Performance (Power)	Built-in, non-removable, rechargeable lithium-ion polymer battery				
	Performance (CPU Core)	62 MHz / ARM 1176JZ(F)-S		833 MHz / ARM Cortex-A8	1GHz / Apple A4	1GHz / Dual – Core Apple A5
	Performance (Graphics)	Power VR MBX Lite 3D GPU		Power VR SGX535 GPU		Power VR SGX543MP2 GPU
		103 MHz		150 MHz	200 MHz	
	Performance (Memory)	128 MB DRAM		256 MB DRAM	512 MB DRAM	
User Friendly	Interface (Application communication)	SMS / e-mail / Google maps	In addition to previous: MMs	In addition to previous: Bluetooth 2.1 + EDR wireless technology / GPS / Digital compass / language support / dictionary support	In addition to previous: iMessage / push email / image editor	

Note: *The successful product characteristics of Apple iPhone are 1) multi-function, 2) advanced technology and 3) good performance, 4) good brand and 5) user friendly. Other characteristics are good design and environmentally friendly.*

7.3.4.2 Sales Performance through Regression Analysis

In order to identify its contribution to sales increments, the sales factor analysis was conducted through the correlation and regression method using the SPSS software. The sales factor analysis attempted to identify variables that contributed to the success of the Apple iPhone. The significant variable can be found if the $p<.05$. Then, regression analysis was identified through the formula; $Y = a + bX$ (detail formula in 3.1) and $Y = a + b_1X_1 + b_2X_2 + \ldots\ldots B_kX_k$ (details formula in 3.2 in Chapter 3). The results justified the significant correlation of product variables, which contributed to the success of the product.

7.3.4.2.1 Correlation Test for Multi-Function Characteristics

The features variable has highly contributed to the success of the iPhone. Table 7.10 shows the correlation between the sales and features variable of the iPhone. The results show that there is a significant and very strong correlation between the sales and features variable ($r = 0.98$; $p<.05$). The results also indicate that value $R^2=0.95$ showing 95 percent the features variable strongly influenced the increment in sales.

Table 7.10: Correlation sales and features variable

		Sales	Features
Sales	Pearson Correlation	1	.976*
	Sig. (2-tailed)		.004
	N	5	5
Features	Pearson Correlation	.976*	1
	Sig. (2-tailed)	.004	
	N	5	5

*. Correlation is significant at the 0.05 level (2-tailed).

The results also show that if more features variables were added to the product it would increase the sales volume. The increment of sales has been proven by using the formula

(detail formula in 3.1 in Chapter 3). The correlation is found as follows (details in Appendix C-2):

$$Y = -14003.05 + 7856.23X \quad (7.2)$$

7.3.4.2.2 Correlation Test for Advanced Technology Characteristics

There are two variables from the advanced technology characteristics X1 (camera) and variable X2 (display) that are also shown to contribute to the sales of the iPhone.

Table 7.11: Correlation sales and technology variables

		Y	X1 (camera)	X2 (display)
Pearson Correlation	Y	1.000	.940*	.967*
	X1 (camera)	.940	1.000	.895*
	X2 (display)	.967	.895	1.000
Sig. (1-tailed)	Y	.	.009	.004
	X1 (camera)	.009	.	.020
	X2 (display)	.004	.020	.
N	Y	5	5	5
	X1 (camera)	5	5	5
	X2 (display)	5	5	5

* Correlation is significant at the 0.05 level (1-tailed)
Note: Y= sales, X1=camera (megapixel), X2=Display (ppi)

Table 7.11 shows the correlation between sales and two technology variables. The results indicate that there is a significant and very strong correlation between the sales and variable X1 (camera) ($r = 0.94$; $p<.05$). Variable X2 (display) shows that there is a significant and very strong correlation ($r = 0.97$; $p<.05$). Therefore, variable X1 and variable X2 also show that there is a significant and strong correlation ($r = 0.90$; $p<.05$). The results also indicate that value $R^2=0.96$ showing 96 percent both technology variables are strongly influenced in increment of sales. In addition, if more X variables are added to the product it will increase the sales volume. The increment of sales has

proven been using the formula (details of formula in 3.2 in Chapter 3). The correlation result is shown as follows (detail in Appendix C-3):

$$Y = -3343.18 + 11945.71X_{1+} 19.31X_2 \quad (7.3)$$

7.3.4.2.3 Correlation Test for Good Performance Characteristics

The performance of the product shows that the contribution to the increment of the iPhone sales was through three variables: variable X1 (CPU), variable X2 (graphics) and variable X3 (memory). The three variables show a consistent influence in the increment of iPhone sales.

Table 7.12: Correlation of sales and performance variable

		Y	X1 (CPU)	X2 (graphics)	X3 (memory)
Pearson Correlation	Y	1.000	.868*	.967*	.985*
	X1 (CPU)	.868	1.000	.957*	.910*
	X2 (graphics)	.967	.957	1.000	.991*
	X3 (memory)	.985	.910	.991	1.000
Sig. (1-tailed)	Y	.	.028	.004	.001
	X1(CPU)	.028	.	.005	.016
	X2 (graphics)	.004	.005	.	.001
	X3 (memory)	.001	.016	.001	.
N	Y	5	5	5	5
	X1 (CPU)	5	5	5	5
	X2 (graphics)	5	5	5	5
	X3 (memory)	5	5	5	5

* Correlation is significant at the 0.05 level (1-tailed)
Note: Y=sales, X1=CPU core (MHz), X2=Graphics (MHz), X3=memory (DRAM)

Table 7.12 shows the correlation between the sales and three performance variables. The results show that there is a significant and strong correlation between sales and X1 (CPU) ($r = 0.87$; $p<.05$). Variable X2 (graphics) is strongly significant and has a very strong correlation ($r = 0.97$; $p<.05$). Variable X3 (memory) has a significant and very strong correlation ($r = 0.99$; $p<.05$). Therefore, variables X1 and X2 show a significant

and strong correlation (r = 0.96; p<.05). Variables X1 and X3 show a significant and strong correlation (r = 0.91; p<.05). Then, variables X2 and X3 also show a significant and strong correlation (r = 0.99; p<.05). The results also indicate that value R^2=0.98 showing 98 percent good performance variables is strongly influence on the increment in sales. In addition, if more performance variables are added to the product, it will increase the sales volume. The increment of sales has been proven using the formula (details of formula in 3.2 in Chapter 3). The resulting correlation is indicated as follows (details in Appendix C-4):

$$Y = 6943.67 + 54.82X_1 + 122.42X_2 - 29.39X_3 \quad (7.4)$$

7.3.4.2.4 Correlation Test for User Friendly Characteristics

The interface variable from user friendly characteristics shows that they contribute to the increment in iPhone sales.

Table 7.13: Correlation of sales and interface variable

		Sales	Interface
Sales	Pearson Correlation	1	.923*
	Sig. (2-tailed)		.025
	N	5	5
Interface	Pearson Correlation	.923*	1
	Sig. (2-tailed)	.025	
	N	5	5

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7.11 presents the correlation between the sales and interface variables. The results indicate that there is a significant and very strong correlation between the sales and interface variables (r = 0.92; p<.05). The results also indicate that value R^2=0.85 showing 85 percent the interface variable is strongly influenced the increment in sales. In addition, if more interface variables are added to the product, it will increase the sales

volume. The increment in sales has been proven using the formula (details of formula 3.1 in Chapter 3). The correlation results are indicated as follows (details in Appendix C-5):

$$Y = -18637.51 + 7847.01X \quad (7.5)$$

7.4 Conclusion

The success of a new product is acknowledged to depend on the product satisfying the user requirements and preferences. The user requirements influence the development of a new product by providing the product direction, while preferences determine the product success. The product designers can satisfy through considering the successful product characteristics (SPC) and product design specification (PDS). Both of them are significant elements to help product designers to establish the successful product design characteristics (SPDC) and increase the likelihood of product success. The Product Design Definition Method (PDDM) is developed to facilitate the product designer to establish the successful product design characteristics. It presents a complete process to involve users in the product definition stage of the design process. The validation of the new method was conducted through using one example of a very successful product as a case study. The case study used for product success was the Apple iPhone4, where, in this validation exercise, it showed that the mobile phone success was influenced by the seven characteristics of a successful product and supported by several product design specifications. In addition, the in-depth study of sales analysis involving the Apple iPhone4 shows that products with more technical functions and higher specification tends to be successful, and, thus, have higher sales.

CHAPTER 8 CONCLUSION

8.1 Introduction

This chapter draws the conclusions from the research results. This is followed by an explanation of the research contribution and novelty. Finally, the research limitations and recommendations for future research are discussed.

8.2 Conclusion

The first objective was to investigate the extent of user involvement and their contribution to product development that has resulted in the success of a new product. User involvement and their contribution in the early stages of the design process, known as the product definition stage, positively improves the product quality as well as increases the company profits. This was proven through a case study of a successful product, the Perodua MyVi. The user was seen to be a valuable source for most new products by providing a greater variety of ideas; thus, creating higher product value and quality, and reducing market uncertainties. The user was also perceived as important in assisting the product designer to establish the characteristics of a new product; specifically, from problem identification and requirements. Two of the most important sources of information come from product complaints and observation, while interviews and questionnaires are increasingly being used to provide information. It was also found that the success of a product was not only due to its design but also from several other characteristics, such as performance, user friendly, multi-function and brand.

The second objective was to identify the characteristics of a successful product and the requirements of product design. A survey was conducted on three different types of product; namely, consumer product, furniture and automotive. As a result five

successful product characteristics were established, which were good design, good performance, good brand, user friendly and multi-function. Two other characteristics were identified from the literature; namely, advanced technology and environmentally friendly, which were found to not only increase the company sales but also differentiate them from other competitors. However, the different products were ranked differently for the seven characteristics of a successful product, e.g. new technology was ranked highly for consumer product but less for furniture. In addition, twenty-seven requirements for product design were established from the product designer (design requirements) and user requirements. These requirements were acknowledged to be product design specifications, which were categorized into functional requirements and aesthetical requirements. The product design specifications were acknowledged to be an important element in the establishment of the successful product design characteristics and would definitely help to increase the success of a new product.

The third objective was to develop a design methodology that incorporates the requirements by the product designer and user with the successful characteristics of a product in the early stages of the design process. Four tools were developed to establish the successful product design characteristics (SPDC) through the Product Design Definition Method (PDDM): SPDC Map, SPC Matrix, PDS Matrix and the XS-Detailed Description. The applications of the method with all the supporting tools were validated with the case study of a mobile phone. Two SPC of the mobiles phones, which strongly influence sales, are multi-function and advanced technology. An in-depth the case study of the Apple iPhone found that the highest sales were attained by having the characteristics that were identified using the proposed method; namely, Product Design Definition Method (PDDM).

8.3 Research Contributions to Knowledge

This investigation concerning the topic contributes to knowledge in four ways.

Firstly, this research contributes to the development of a new approach for identifying the product characteristics that satisfy the user requirements and preferences, and the characteristics of a successful product. The PDDM is designed in order to facilitate the product designer to establish the successful product design characteristics which incorporate the characteristics from the product designer (design requirements) and user requirements with the characteristics of a successful product in the early stage of the design process.

Secondly, the research provides theoretical and empirical evidence of user involvement and contribution in product development that result in the success of a new product and the characteristics of a successful product. The user value of a new product is dynamic, which is useful in the product definition stage of the design process in order to identify their needs, wants and wishes, and translate them as product design specifications. This study gives an insight into the importance of both product designers and users working together in order to determine the success or failure of a new product, generate innovative product ideas and enhance product quality.

Thirdly, the research can help to increase the effectiveness of involving the user in product development and incorporating the characteristics of a successful product. This study places interest in the importance of user requirements and past successful characteristics in product development as a central source of product information during the development and establishment of the characteristics of a new product. The knowledge of both the product designer and user are essential not only to identify the specification of a new product but also to establish the successful product characteristics. A good understanding of both will bring more opportunities to the success of a new product on the market.

Fourthly, the research can also help the product developers to minimize the possibility of creating an irrelevant design concept, reduce the operating cost and shorten the time frame for the product to enter the market. From the point of view of productivity, the product developers believe that user input for a new product is significant for achieving highest product quality and value, excellent performance and good appearance. It also becomes a reference for product developers to sustain their product in the dynamic market environment. Finally, it can produce a new product that fulfills user expectations and bring the product to the market-place faster.

8.3.1 Novelty of Research

The novelty of this research is the idea that the whole concept of the Product Design Definition Method (PDDM) was built. The PDDM was designed by introducing an adequate framework to establish the successful product design characteristics (SPDC) in the product definition stage of the design process to increase the probability of product success, which incorporated the three characteristics from the product designer (design requirements), user requirements and successful product characteristics. This method also becomes a decision-making tool in which the product designers can determine a new product that meets the user needs and determine the likelihood of product success, as was proved through the validation study, which was discussed in Chapter 7. Four steps are involved in the Product Design Definition Method (PDDM) process in an attempt to establish the successful product design characteristics (SPDC): 1) getting the user input according to SPDC Map, 2) prioritizing SPC, 3) verifying PDS, and 4) building SPDC into the XS-Detailed Description. Figure 8.1 shows the Product Design Definition Method and process.

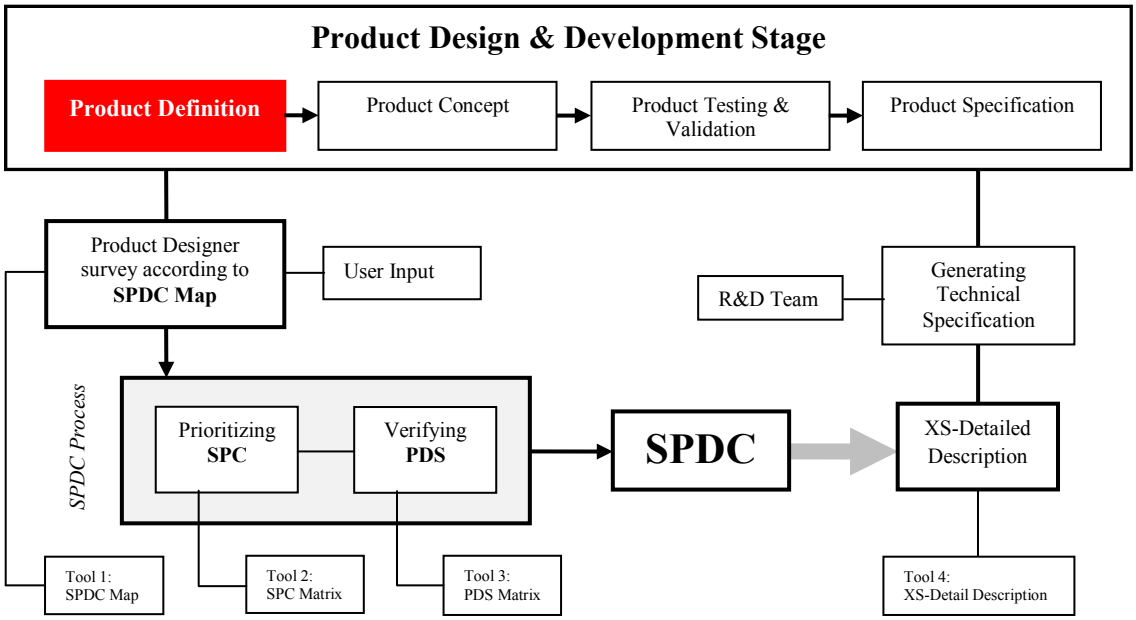

Figure 8.1: Product Design Definition Method

8.4 Limitations of this Research

Three limitations were experience in conducting this research, which are identified and described as follows. Firstly, there is a lack of knowledge of user perception concerning product design requirements, in that most of the users do not know specifically the specification of the product. The users are only familiar with three characteristics; namely, design, function and price. During conducting the end-user survey, most time was spent in explaining further all about the product requirements. Secondly, a large sample size in this survey was difficult to reach because the population size could not be determined, especially involving the end-user product. However, the sample obtained for the quantitative study was adequate to enable generalization of the finding from this research. Thirdly, time limitations and financial problems were among the issues faced by the author during conducting this study, especially it involved a large number of survey respondents. The author spent much time and money conducting surveys as the data collection involved multiple sources

product designers, product management specialist, end users and Perodua MyVi end users.

8.5 Recommendations for Future Research

The knowledge generated through this research is useful for developing a new design methodology in order to establish the successful product design characteristics in the early stage of the design process, which incorporated three characteristics from product designers, users and successful product. Further research should be conducted to introduce this method in a mathematical model that attempts to ensure the tool can be uses easily and that it is user friendly. The results could be more informative through collaborative teamwork, which would enable the product designer to access the design knowledge and support the design ideas in the early stage of the design process by allowing the product designer to communicate at multiple levels of the organization.

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APPENDICES

APPENDIX A: Questionnaire Survey

APPENDIX B: Structured Interview Survey

APPENDIX C: Regression Analysis Result

Dear Respondent

This survey is a part of my PhD study at the Faculty of Engineering, University of Malaya. The objective of the survey is "to investigate the extent of user involvement and contribution in product development that has resulted in the success of a new product". I would really appreciate if you could complete this survey. Any information obtained in connection with this study that can be identified with you will remain confidential. In any written reports or publication, nobody will be identified and only group data will be presented.

Thank you

Section A: Respondent's Background (Please tick where is appropriate) | For office use only

A1 Gender

☐ Male / *Lelaki* ☐ Female / *Perempuan* | A1 ☐

A2 Age

☐ <29 years ☐ 30-40 years ☐ 41-50 years ☐ >51 years | A2 ☐

A3 Highest Qualification

☐ Diploma ☐ Degree ☐ Master ☐ PhD | A3 ☐

A4 Years of Experience

☐ <2 years ☐ 3-5 years ☐ 6-10 years ☐ >11 years | A4 ☐

A5 Designation

☐ Designer ☐ Senior Designer | A5 ☐
☐ Manager ☐ Director
☐ Other _____

A6 Company Business Type

☐ Consumer Product Design ☐ Furniture Design | A6 ☐
☐ Automotive Design ☐ Other
_____

A7 Business Activity

☐ Design Consultant ☐ Manufacturer | A7 ☐
☐ Sales & Marketing ☐ Other
_____

Section B: Designer Knowledge

For office use only

The Categorical Scale

1=Not Important **2**=Less Important **3**=Neutral **4**=Important **5**=Strongly Important

Please indicate the extent of your agreement by ticking the appropriate response scale

No	Question	Not Important	Less Important	Neutral	Important	Strongly Important	
B1	Is user involvement important in new product development?	1	2	3	4	5	B1
B2	Is user involvement and preference important in determining the success of a new product?	1	2	3	4	5	B2
B3	During product development, at what stages is user involvement important in new product development?						
	a) Product Planning *(e.g. project brief, schedule, etc)*	1	2	3	4	5	B3a
	b) Product Concept *(e.g. product definition, conceptual, etc)*	1	2	3	4	5	B3b
	c) Product Engineering *(e.g. detail function, mechanism, etc)*	1	2	3	4	5	B3c
	d) Product Testing & Validation	1	2	3	4	5	B3d
	e) Production *(e.g. machine selection*	1	2	3	4	5	B3e
	f) Product Introduction *(e.g. sale & marketing)*	1	2	3	4	5	B3f
B4	Is the following information required from the user important in the early stage of product development?						
	a) Problem identification	1	2	3	4	5	A4a
	b) Requirement & Preference	1	2	3	4	5	A4b
	c) Market Need & Demand	1	2	3	4	5	A4c
	d) Lifestyle & Culture	1	2	3	4	5	A4d

e) Technology & Function	1	2	3	4	5	A4e
f) Environment & Lifecycle	1	2	3	4	5	A4f

B5 How do you obtain user knowledge in order to establish the characteristics of a product?

a) Interview	1	2	3	4	5	A5a
b) Questionnaire	1	2	3	4	5	A5b
c) Observation	1	2	3	4	5	A5c
d) Sales Analysis Data	1	2	3	4	5	A5d
e) Product Complaint Report	1	2	3	4	5	A5e

B6 Which is the most important role for user involvement in product development?

a) As Resources – *Ideation*	1	2	3	4	5	A7a
b) As Creator – *Design & Development*	1	2	3	4	5	A7b
c) As User – *Testing & Support*	1	2	3	4	5	A7c
d) As part of Decision Maker	1	2	3	4	5	A7d

End of the questions

Thank you, I appreciate your kindness in sparing your times to completing this questionnaires.

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Appendix A-2: Perodua MyVi End User of Survey

Dear Respondent

This survey is a part of my PhD study at the Faculty of Engineering, University of Malaya. The objective of the survey is "to identify the elements of product design contributed by the user which are significant to the success of a product". I would really appreciate it if you could complete this survey. Any information obtained in connection with this study that can be identified with you will remain confidential. In any written reports or publication, nobody will be identified and only group data will be presented.

Thank you

Section A: Respondent's Background (Please tick where appropriate)
Latarbelakang Pemberi maklumat (Sila tanda di mana yang berkaitan)

For office use only

A1 Gender / *Jentina*

☐ Male / *Lelaki* ☐ Female / *Perempuan* | **A1** ☐

A2 Age / *Umur*

☐ <29 years ☐ 30-39 years
☐ 40-49 years ☐ >50 years | **A2** ☐

A3 Highest Qualification / *Pendidikan Tertinggi*

☐ SPM/Certificate ☐ Diploma ☐ Degree
☐ Master ☐ PhD | **A3** ☐

A4 Designation / *Jawatan*

☐ Supporting Staff / *Staf sokongan* ☐ Officer / *Pegawai*
☐ Manager / *Pengurus* ☐ Director / *Pengarah*
☐ CEO / *Ketua Pegawai Eksekutif* ☐ Others / *Lain-lain* | **A4** ☐

A5 Years of Experience / *Tempoh perkhidmatan*

☐ < 5 years ☐ 6-10 years ☐ 11-20 years
☐ 21-30 years ☐ 31-40 years ☐ > 41 years | **A5** ☐

A6 Monthly Gross Income / *Pendapatan bulanan*

☐ <RM 1900 ☐ RM 4000-5900 ☐ RM8000-9900
☐ RM 2000-3900 ☐ RM 6000-7900 ☐ >RM10000 | **A6** ☐

A7 Company Business Type / *Jenis Perniagaan Syarikat*

☐ Government /*Kerajaan* ☐ Private / *Swasta* ☐ Self-Employee / *Bekerja sendiri* | **A7** ☐

Section B: User Satisfaction Survey

No	Question	For office use only

B1 Is Perodua MyVi your first car?
Adakah Perodua MyVi merupakan kereta pertama anda?

☐ Yes / *Ya* ☐ No / *Tidak* B1 ☐

B2 Is Perodua MyVi your first choice?
Adakah Perodua MyVi merupakan pilihan utama anda?

☐ Yes / *Ya* ☐ No / *Tidak* B2 ☐

If NOT, what is your first choice? *Jika Tidak, apakah pilihan utama anda?*

Brand: ☐ Model : ☐

B3 Why do you like Perodua MyVi? *(please answer one only)*
Kenapa anda menyukai Perodua MyVi? (sila jawab satu sahaja)

☐ Price / *Harga* ☐ Design / *Reka Bentuk* ☐ Brand / *Jenama* B3 ☐

The Categorical Scale

1=Not Important	**2**=Less Important	**3**=Neutral	**4**=Important	**5**=Strongly Important

Please rate in response scale by placing number either (1,2,3,4 or 5) in the answer box
Sila kategorikan aras jawapan dengan meletakkan nombor samada (1,2,3,4 atau 5) dalam kotak jawapan

B4 What are the important factors that influenced your buying decision? *(please rate in response scale)*
Apakah faktor penting yang telah mempengaruhi dalam keputusan pembelian anda? (sila kategorikan dalam aras jawapan)

☐	Contemporary Style / *Gaya Terkini*	☐	Safety / *Keselamatan*
☐	Own identity / *Identiti Tersendiri*	☐	User Friendly / *Mesra pengguna*
☐	Image / *Imej*	☐	Technology / *Teknologi*
☐	Aesthetical Design / *Estetik reka bentuk*	☐	Driving performance / *Prestasi pemanduan*

B4 ☐

☐	Simple & compact / *Ringkas & padat*	☐	Driving in comfort / *Pemanduan selesa*
☐	Easy to operate / *Senang dikendalikan*	☐	Environmentally friendly / *Mesra alam*
☐	Other: *Lain-lain:* _____		

B5 In your opinion, what are the important factors that contributed to the success of Perodua MyVi on the market? *(please rate in response scale)*
Pada pandangan anda, apakah faktor penting yang menyumbang kepada kejayaan Perodua MyVi di pasaran? (sila kategorikan dalam aras jawapan)

☐	Form / *Bentuk*	☐	Durability / *Ketahanan*
☐	Color / *Warna*	☐	Technology / *Teknologi*
☐	Appearance / *Rupa paras*	☐	Performance / *Prestasi*
☐	Interface / *Paparan grafik*	☐	Ergonomic / *Keselesaan*
☐	Texture / *Texture*	☐	Quality / *Kualiti*
☐	Shape / *Rupa*	☐	Lifetime / *Jangka hayat*
☐	Component s / *Komponan*	☐	Material / *Bahan*
☐	Brand / *Jenama*	☐	Safety / *Keselamatan*
☐	Size / *Saiz*	☐	Usability / *Keboleh gunaan*
☐	Identity / *Identiti*	☐	Maintenance/ *penyelenggaraan*
☐	Style / *Gaya*	☐	Effectiveness / *Keberkesanan*
☐	Image / *Imej*	☐	Reliability / *Keboleh gunaan*
☐	Other/ *lain-lain*: _____		

B5 ☐

End of the question

Thank you, I appreciate your kindness in sparing your times in completing this questionnaires.

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Appendix A-3-1: End User (consumer Product) Survey

Dear Respondent

This survey is a part of my PhD study at the Faculty of Engineering, University of Malaya. The objective of the survey is "to identify the elements of product design contributed by the user which are significant to the success of a product". I would really appreciate it if you could complete this survey. Any information obtained in connection with this study that can be identified with you will remain confidential. In any written reports or publication, nobody will be identified and only group data will be presented.
Thank you

Section A: Respondent's Background (Please tick where appropriate)
Latarbelakang Pemberi maklumat (Sila tanda di mana yang berkaitan)

For office use only

A1 Gender / *Jantina*

☐ Male / *Lelaki* ☐ Female / *Perempuan* — A1 ☐

A2 Age / *Umur*

☐ 20-29 years ☐ 30-39 years
☐ 40-49 years ☐ >50 years — A2 ☐

A3 Highest Qualification / *Pendidikan Tertinggi*

☐ SPM/Certificate ☐ Diploma ☐ Degree
☐ Master ☐ PhD — A3 ☐

A4 Designation / *Jawatan*

☐ Supporting Staff / *Staf sokongan* ☐ Officer / *Pegawai*
☐ Manager / *Pengurus* ☐ Director / *Pengarah*
☐ CEO / *Ketua Pegawai Eksekutif* ☐ Others / *Lain-lain* — A4 ☐

A5 Years of Experience / *Tempoh perkhidmatan*

☐ < 5 years ☐ 6-10 years ☐ 11-20 years
☐ 21-30 years ☐ 31-40 years ☐ > 41 years — A5 ☐

A6 Monthly Gross Income / *Pendapatan bulanan*

☐ RM 1000-1900 ☐ RM 4000-5900 ☐ RM8000-9900
☐ RM 2000-3900 ☐ RM 6000-7900 ☐ >RM10000 — A6 ☐

A7 Company Business Type / *Jenis Perniagaan Syarikat*

☐ Government /*Kerajaan* ☐ Private / *Swasta* ☐ Self-Employee / *Bekerja sendiri* — A7 ☐

Section B: User Knowledge / *Pengetahuan Pengguna*

Please answer only one by placing a tick in the answer box
Sila jawapan satu sahaja dengan menanda dalam kotak jawapan

No	Question	For office use only

B1 What is the brand of the mobile phone that you use? (please answer one only)
Apakah jenama telepon mudahalih yang anda miliki?(sila jawab satu sahaja)

☐	NOKIA	☐	SAMSUNG	B1 ☐
☐	SONY ERICSSON	☐	LG	
☐	MOTOROLA	☐	BLACKBERRY	
☐	HTC	☐	APPLE	
☐	Other/lain-lain ----------			

Model name:
Nama model: _____

B2 What is the mobile phone brand that you prefer to buy in the future? (please answer one only)
Apakah jenama telepon mudahalih yang anda ingin beli akan datang? (sila jawab satu sahaja)

☐	NOKIA	☐	SAMSUNG	B2 ☐
☐	SONY ERICSSON	☐	LG	
☐	MOTOROLA	☐	BLACKBERRY	
☐	HTC	☐	APPLE	
☐	Other/lain-lain ----------			

Model name
Nama model: _____

B3 What is the most stylish mobile phone that you would prefer in the future based on the selected brands? (please answer one only)
Apakah jenis gaya telepon mudahalih yang anda inginkan pada masa akan datang berdasarkan jenama yang telah dipilih? (sila jawab satu sahaja)

☐	Modern	☐	Contemporary	B3 ☐
☐	Classic	☐	Hi-technology	
☐	Others:			

Section C

The Categorical Scale

1=Not Important	**2**=Less Important	**3**=Neutral	**4**=Important	**5**=Strongly Important

Please rate in response scale by placing number either (1,2,3,4 or 5) in the answer box

Sila kategorikan aras jawapan dengan meletakkan nombor samada (1,2,3,4 atau 5) dalam kotak jawapan

No **Question** **For office use only**

C1 What are the factors that influenced you in buying a mobile phone? *(please rate in response scale)*
Apakah faktor yang mempengaruhi keputusan pembelian anda pada telepon mudahalih? *(sila kategorikan dalam aras jawapan)*

☐	Design / *Reka bentuk*	☐	Function / *Fungsi*	C1 ☐
☐	Technology/ *Teknologi*	☐	Brand / *Jenama*	
☐	Price / *Harga*	☐	Safety / *Keselamatan*	
☐	Other/*Lain-lain:*			

C2 What are the elements that influenced your "buying decision" of a mobile phone? *(please rate in response scale)*
Apakah elemen yang mempengaruhi anda membuat keputusan semasa membeli telepon mudahalih? (sila kategorikan dalam aras jawapan)

☐	Form / *Bentuk*	☐	Durability / *Ketahanan*	C2 ☐
☐	Color / *Warna*	☐	Technology / *Teknologi*	
☐	Appearance / *Penampilan*	☐	Performance / *Prestasi*	
☐	Interface / *Paparan 2D*	☐	Ergonomic / *Keselesaan*	
☐	Texture / *Texture*	☐	Reliability / *Keboleh percayaan*	
☐	Shape / *Rupa*	☐	Lifetime / *Jangka hayat*	
☐	Component / *Komponan*	☐	Effectiveness / *Keberkesanan*	
☐	Brand / *Jenama*	☐	Safety / *Selamat*	
☐	Size / *Saiz*	☐	Usability / *Keboleh gunaan*	
☐	Identity / *Identiti*	☐	Maintenance/ *Penyelenggaraan*	
☐	Style / *Gaya*	☐	Material / *Bahan*	
☐	Image / *Imej*	☐	Quality / *Kualiti*	
☐	Other/lain-lain: _____			

C3 Do you think that it is important to consider user requirements and preferences in design development? *(please rate in response scale)*
Adakah anda fikir kehendak dan keinginan pengguna penting diberikan perhatian dalam pembangunan sesuatu produk? (sila kategorikan dalam aras jawapan)

Answer [ ] C3 [ ]

C4 Do you think that knowledge provided by user is important and contribute to the success of a new product? *(please rate in the response scale)*
Adakah anda fikir pengetahuan yang diberikan oleh pengguna penting untuk menyumbang kepada kejayaan sesuatu produck baharu? (sila kategorikan dalam aras jawapan)

Answer [ ] C4 [ ]

End of the questions

Thank you, I appreciate your kindness in sparing your times in completing this questionnaire.

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Department of Engineering Design and Manufacture,
Faculty of Engineering,
University of Malaya, 50603 Kuala Lumpur

Tel: 013 2761028 Email: hassanalli@hotmail.com / halli@putra.upm.edu.my

Dear Respondent

This survey is a part of my PhD study at the Faculty of Engineering, University of Malaya. The objective of the survey is "to identify the elements of product design contributed by the user that are significant in the success of a product". I would really appreciate it if you could complete this survey. Any information obtained in connection with this study that can be identified with you will remain confidential. In any written reports or publication, nobody will be identified and only group data will be presented.
Thank you

Section A: Respondent's Background (Please tick where appropriate) *Latarbelakang Pemberi maklumat (Sila tanda di mana yang berkaitan)*

For office use only

A1 Gender / *Jentina*

☐ Male / *Lelaki* ☐ Female / *Perempuan* **A1** ☐

A2 Age / *Umur*

☐ <29 years ☐ 30-39 years
☐ 40-49 years ☐ >50 years
A2 ☐

A3 Highest Qualification / *Pendidikan Tertinggi*

☐ SPM/Certificate ☐ Diploma ☐ Degree
☐ Master ☐ PhD
A3 ☐

A4 Designation / *Jawatan*

☐ Supporting Staff / *Staf sokongan* ☐ Officer / *Pegawai*
☐ Manager / *Pengurus* ☐ Director / *Pengarah*
☐ CEO / *Ketua Pegawai Eksekutif* ☐ Others / *Lain-lain*
A4 ☐

A5 Years of Experience / *Tempoh perkhidmatan*

☐ < 5 years ☐ 6-10 years ☐ 11-20 years
☐ 21-30 years ☐ 31-40 years ☐ > 41 years
A5 ☐

A6 Monthly Gross Income / *Pendapatan bulanan*

☐ <RM 1900 ☐ RM 4000-5900 ☐ RM8000-9900
☐ RM 2000-3900 ☐ RM 6000-7900 ☐ >RM10000
A6 ☐

A7 Company Business Type / *Jenis Perniagaan Syarikat*

☐ Government /*Kerajaan* ☐ Private / *Swasta* ☐ Self-Employee / *Bekerja sendiri*
A7 ☐

Section B: User Knowledge / *Pengetahuan Pengguna*

Please answer one only by placing a tick in the answer box
Sila jawab satu sahaja dengan menenda dalam kotak jawapan

No	Question	For office use only
B1	What are the main criteria when you are purchasing a living room sofa? *(please answer one only)* *Apakah kriteria utama bila anda membeli sebuah sofa untuk ruang tamu? (sila jawab satu sahaja)*	
	☐ Brand / *Jenama* ☐ Function / *Fungsi* ☐ Technology / *Teknologi* ☐ Price / *Harga* ☐ Design / *Reka bentuk* ☐ Safety / *Keselamatan*	B1 ☐
B2	What arrangement of the sofa do you prefer for a living room? *(please answer one only)* *Apakah pemilihan posisi kedudukan sofa untuk ruang tamu anda?(sila jawab satu sahaja)*	
	☐ 3 + 1 + 1 ☐ 3 + 2 + 1 ☐ L – Shape ☐ 3 + 2 + 1 + 1 ☐ Single *(for 2 or 3 seat)* ☐ Other: _____	B2 ☐
B3	What is the material that you prefer for a living room sofa? *(please answer one only)* *Apakah bahan yang anda inginkan untuk sofa ruang tamu?(sila jawab satu sahaja)*	
	☐ Fabric ☐ Full Leather ☐ Metal ☐ Other: _____ ☐ Semi Leather ☐ Wooden ☐ Composite Material	B3 ☐
B4	What is the concept that you prefer for a living room sofa? *(please answer one only)* *Apakah konsep yang anda inginkan untuk sofa ruang tamu? (sila jawab satu sahaja)*	
	☐ Contemporary ☐ Modern Classic ☐ Antique ☐ Ultra-Modern ☐ Classic ☐ Retro	B4 ☐

Section C

The Categorical Scale

1=Not Important	**2**=Less Important	**3**=Neutral	**4**=Important	**5**=Strongly Important

Please rate in the response scale by placing a number either (1,2,3,4 or 5) in the answer box
Sila kategorikan aras jawapan dengan meletakkan nombor samada (1,2,3,4 atau 5) dalam kotak jawapan

No	Question	For office use only

C1 What are the factors that influenced you in buying a living room sofa? *(please rate in response scale)*
Apakah faktor yang mempengaruhi keputusan pembelian anda pada sebuah sofa ruang tamu? *(sila kategorikan dalam aras jawapan)*

☐	Design / *Reka bentuk*	☐	Function / *Fungsi*	C1 ☐
☐	Technology/ *Teknologi*	☐	Brand / *Jenama*	
☐	Price / *Harga*	☐	Safety / *Keselamatan*	
☐	Other / *Lain-lain*:			

C2 What are the elements that influenced your "buying decision" for a living room sofa? *(please rate in response scale)*
Apakah elemen yang mempengaruhi anda membuat keputusan pembelian pada sebuah sofa ruang tamu? (sila kategorikan dalam aras jawapan)

☐	Form / *Bentuk*	☐	Durability / *Ketahanan*	C2 ☐
☐	Color / *Warna*	☐	Technology / *Teknologi*	
☐	Appearance / *Rupa paras*	☐	Performance / *Prestasi*	
☐	Interface / *Paparan grafik*	☐	Ergonomic / *Keselesaan*	
☐	Texture / *Texture*	☐	Reliability / *Keboleh gunaan*	
☐	Shape / *Rupa*	☐	Lifetime / *Jangka hayat*	
☐	Component / *Komponan*	☐	Effectiveness / *Keberkesanan*	
☐	Brand / *Jenama*	☐	Safety / *Selamat*	
☐	Size / *Saiz*	☐	Usability / *Keboleh gunaan*	
☐	Identity / *Identiti*	☐	Maintenance/ *Penyelenggaraan*	
☐	Style / *Gaya*	☐	Material / *Bahan*	
☐	Image / *Imej*	☐	Quality / *Kualiti*	
☐	Other / *lain-lain:* _____			

C3 Do you think that it is necessary to consider the user requirements and preferences in design development? *(please rate in response scale)*
Adakah anda fikir kehendak dan keinginan pengguna perlu diberikan perhatian dalam pembangunan sesuatu produk? (sila kategorikan dalam aras jawapan)

Answer [ ] C3 [ ]

C4 Do you think that knowledge provided by the user is important and contribute to the success of a new product? *(please rate in response scale)*
Adakah anda fikir pengetahuan yang diberikan oleh pengguna ialah penting untuk menyumbang kepada kejayaan sesuatu produk baharu? (sila kategorikan dalam aras jawapan)

Answer [ ] C4 [ ]

End of the questions

Thank you, I appreciate your kindness in sparing your times in completing this questionnaire.

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Appendix A-3-3: End User (automotive) Survey

Dear Respondent

This survey is a part of my PhD study at the Faculty of Engineering, University of Malaya. The objective of the survey is "to identify the elements of product design contributed by the user that are significant in the success of a product". I would really appreciate it if you could complete this survey. Any information obtained in connection with this study that can be identified with you will remain confidential. In any written reports or publication, nobody will be identified and only group data will be presented.

Thank you

Section A: Respondent's Background (Please tick as appropriate) *Latarbelakang Pemberi maklumat (Sila tanda di mana yangberkaitan)*

For office use only

A1 Gender / *Jentina*

☐ Male / *Lelaki* ☐ Female / *Perempuan* **A1** ☐

A2 Age / *Umur*

☐ <29 years ☐ 30-39 years
☐ 40-49 years ☐ >50 years
A2 ☐

A3 Highest Qualification / *Pendidikan Tertinggi*

☐ SPM/Certificate ☐ Diploma ☐ Degree
☐ Master ☐ PhD
A3 ☐

A4 Designation / *Jawatan*

☐ Supporting Staff / *Staf sokongan* ☐ Officer / *Pegawai*
☐ Manager / *Pengurus* ☐ Director / *Pengarah*
☐ CEO / *Ketua Pegawai Eksekutif* ☐ Others / *Lain-lain*
A4 ☐

A5 Years of Experience / *Tempoh perkhidmatan*

☐ < 5 years ☐ 6-10 years ☐ 11-20 years
☐ 21-30 years ☐ 31-40 years ☐ > 41 years
A5 ☐

A6 Monthly Gross Income / *Pendapatan bulanan*

☐ <RM 1900 ☐ RM 4000-5900 ☐ RM8000-9900
☐ RM 2000-3900 ☐ RM 6000-7900 ☐ >RM10000
A6 ☐

A7 Company Business Type / *Jenis Perniagaan Syarikat*

☐ Govenment /*Kerajaan* ☐ Private / *Swasta* ☐ Self-Employee / *Bekerja sendiri*
A7 ☐

Section B: User Knowledge / *Pengetahuan Pengguna*

Please answer one only by placing a tick in the answer box
Sila jawab satu sahaja dengan menanda dalam kotak jawapan

No	Question	For office use only

B1 What is the brand of the car that you use? *(please answer one only)*
Apakah jenama kereta yang anda miliki?(sila jawab satu sahaja)

☐	PROTON	☐	PERODUA	B1 ☐
☐	TOYOTA	☐	HONDA	
☐	KIA	☐	HYUNDAI	
☐	BMW	☐	MERCEDES BENZ	
☐	VOLVO	☐	NISSAN	
☐	PEUGEOT	☐	MITSUBISHI	
☐	FORD	☐	DAIHATSU	
☐	WOLKSWAGEN	☐	MAZDA	
☐	AUDI	☐	SUZUKI	
☐	Other/lain-lain ----------			

Model name:
Nama model: _____

B2 What is the car brand that you prefer to buy in future?
(please answer one only)
Apakah jenama kereta yang anda ingin miliki pada masa akan datang? (sila jawab satu sahaja).

☐	PROTON	☐	PERODUA	B2 ☐
☐	TOYOTA	☐	HONDA	
☐	KIA	☐	HYUNDAI	
☐	BMW	☐	MERCEDES BENZ	
☐	VOLVO	☐	NISSAN	
☐	PEUGEOT	☐	MITSUBISHI	
☐	FORD	☐	DAIHATSU	
☐	WOLKSWAGEN	☐	MAZDA	
☐	AUDI	☐	SUZUKI	
☐	Other/*lain-lain* ----------			

B3 What is most stylish car that you would prefer in the future based on selected brand? *(please answer one only)*
Apakah jenis gaya kereta yang anda inginkan pada masa akan datang berdasarkan jenama yang telah dipilih? (sila jawab satu sahaja)

☐	Compact Car	☐	Compact MPV	B3 ☐
☐	Sedan Car	☐	Large Family Car / MPV	
☐	Sports Car	☐	4WD / Truck	
☐	SUV	☐	Wagon / Estate	
☐	Mini Cars	☐	Others:	

Section C

The Categorical Scale

1=Not Important	**2**=Less Important	**3**=Neutral	**4**=Important	**5**=Strongly Important

Please rate in response scale by placing number either (1,2,3,4 or 5) in the answer box

Sila kategorikan aras jawapan dengan meletakkan nombor samada (1,2,3,4 atau 5) dalam kotak jawapan

No	Question	For office use only

C1 What are the factors that influenced you in buying a car? *(please rate in response scale)*
Apakah faktor yang mempengaruhi keputusan pembelian anda pada sebuah kereta? *(sila kategorikan dalam aras jawapan)*

☐	Design / *Reka bentuk*	☐	Function / *Fungsi*	C1 ☐
☐	Technology/ *Teknologi*	☐	Brand / *Jenama*	
☐	Price / *Harga*	☐	Safety / *Keselamatan*	
☐	Other / *Lain-lain*:			

C2 What are the elements that influenced your "buying decision" for a car? *(please rate in response scale)*
Apakah elemen yang mempengaruhi anda dalam membuat keputusan pembelian pada sebuah kereta? (sila kategorikan dalam aras jawapan)

☐	Form / *Bentuk*	☐	Durability / *Ketahanan*	C2 ☐
☐	Color / *Warna*	☐	Technology / *Teknologi*	
☐	Appearance / *Rupa paras*	☐	Performance / *Prestasi*	
☐	Interface / *Paparan grafik*	☐	Ergonomic / *Keselesaan*	
☐	Texture / *Texture*	☐	Reliability / *Keboleh gunaan*	
☐	Shape / *Rupa*	☐	Lifetime / *Jangka hayat*	
☐	Component / *Komponan*	☐	Effectiveness / *Keberkesanan*	
☐	Brand / *Jenama*	☐	Safety / *Keselamatan*	
☐	Size / *Saiz*	☐	Usability / *Keboleh gunaan*	
☐	Identity / *Identiti*	☐	Maintenance/ *Penyelenggaraan*	
☐	Style / *Gaya*	☐	Material / *Bahan*	
☐	Image / *Imej*	☐	Quality / *Kualiti*	
☐	Other / *lain-lain*: _____			

C3 Do you think that user requirements and preferences are important to be considered in design development? *(please rate in response scale)*
Adakah anda fikir kehendak dan keinginan pengguna penting diberikan perhatian dalam pembangunan sesuatu produk? (sila kategorikan dalam aras jawapan)

Answer [ ] C3 [ ]

C4 Do you think that knowledge provided by the user is important and contribute to the success of a new product? *(please rate in response scale)*
Adakah anda fikir pengetahuan yang diberikan oleh pengguna ialah penting untuk menyumbang kepada kejayaan sesuatu produk baharu? (sila kategorikan dalam aras jawapan)

Answer [ ] C4 [ ]

End of the questions

Thank you, I appreciate your kindness in sparing your times in completing this questionnaire.

Hassan Alli
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University of Malaya,50603 Kuala Lumpur

Tel: 013 2761028 Email: hassanalli@hotmail.com / halli@putra.upm.edu.my

Appendix A-4: End user (professional user)

Dear Respondent

This survey is a part of my PhD study at the Faculty of Engineering, University of Malaya. The objective of the survey is "to investigate the key characteristics of product success". I would really appreciate if you could complete this survey. Any information obtained in connection with this study that can be identified with you will remain confidential. In any written reports or publication, nobody will be identified and only group data will be presented.

Thank you

Section A: Respondent's Background (Please tick where appropriate) — For office use only

A1 Gender

☐ Male ☐ Female — A1 ☐

A2 Designation

_____ — A2 ☐

A3 Years of working Experience

☐ <2 years ☐ 3-5 years ☐ 6-10 years ☐ >11 years — A3 ☐

A4 Experience of Mobile Application Use

☐ <3 months ☐ 3-6 months
☐ 7-12 months ☐ >12 months — A4 ☐

Section B: Respondent's Knowledge — For office use only

Name of Mobile Phone: Please tick one

BlackBerry Bold ☐
Apple iPhone4 ☐
Samsung Galaxy Tab 7.0 plus ☐

Please indicate the extent of your agreement by circling in the appropriate answer

No	Question	Not Important	Less Important	Neutral	Important	Strongly Important
		1	**2**	**3**	**4**	**5**
B1.	What are the important factors that influence the success of mobile?					
	a) Good Design	1	2	3	4	5

B5a ☐

b) Multi-Function	1	2	3	4	5	B5b
c) Advanced Technology	1	2	3	4	5	B5c
d) Good Brand	1	2	3	4	5	B5d
e) User Friendly	1	2	3	4	5	B5e
f) Environmentally Friendly	1	2	3	4	5	B5f
g) Good performance	1	2	3	4	5	B5g

B2. In your opinion, what are the product design specifications that might contribute to the success of mobile?

a) Technology	1	2	3	4	5	B6a
b) Durability	1	2	3	4	5	B6b
c) Reliability	1	2	3	4	5	B6c
d) Safety	1	2	3	4	5	B6d
e) Ergonomic	1	2	3	4	5	B6e
f) Quality	1	2	3	4	5	B6f
g) Performance	1	2	3	4	5	B6g
h) Lifetime	1	2	3	4	5	B6h
i) Effectiveness	1	2	3	4	5	B6i
j) Size	1	2	3	4	5	B6j
k) Components	1	2	3	4	5	B6k
l) Form	1	2	3	4	5	B6l
m) Shape	1	2	3	4	5	B6m
n) Color	1	2	3	4	5	B6n
o) Interface	1	2	3	4	5	B6o
p) Texture	1	2	3	4	5	B6p
q) Brand	1	2	3	4	5	B6q

r) Style	1	2	3	4	5	B6r
s) Appearance	1	2	3	4	5	B6s
t) Image	1	2	3	4	5	B6t
u) Identity	1	2	3	4	5	B6u
v) Emotion	1	2	3	4	5	B6v
w) Semiotic	1	2	3	4	5	B6w
x) Semantic	1	2	3	4	5	B6x
y) Material	1	2	3	4	5	B6y

End of the question

Thank you, I appreciate your kindness in sparing your times in completing this questionnaire.

Hassan Alli
Department of Engineering Design and Manufacture,
Faculty of Engineering
University of Malaya,50603 Kuala Lumpur

Tel: 013 2761028 Email: hassanalli@hotmail.com / halli@putra.upm.edu.my

Dear Respondent

This survey is a part of my PhD research at the Faculty of Engineering, University of Malaya. The objective of the survey is "to investigate the elements of product design that contribute to the success of a product". I would really appreciate if you could complete this survey. Any information obtained in connection with this study that can be identified with you will remain confidential. In any written reports or publication, nobody will be identified and only group data will be presented.

Thank you

Section A: Respondent's Background (Please tick where appropriate)

For office use only

A1 Gender

☐ Male ☐ Female **A1** ☐

A2 Age

☐ <29 years ☐ 30-40 years
☐ 41-50 years ☐ >51 years
A2 ☐

A3 Highest Qualification

☐ Degree ☐ Master ☐ PhD **A3** ☐

A4 Year of Experience in Product Development

☐ 10-1 5 years ☐ 16-20 years ☐ 21-25 years
☐ >26 years
A4 ☐

A5 Designation

☐ Senior Designer ☐ Design Manager
☐ Director ☐ Others ____
A5 ☐

A6 Company Business

☐ Consumer Product Design ☐ Furniture Design
☐ Automotive Design
A6 ☐

A7 Business Activity

☐ Design Consultant ☐ Manufacturer
☐ Sales/Marketing
A7 ☐

Product Characteristics

Product characteristics are the attribute or property of the product that describes the product's ability to satisfy its purpose and refers to the product specification. The purpose of product characteristics is to explain, interpret and describe in the context of the product function.

Section B: Refer to the questions below, please indicate the extent of your agreement by placing a tick in the appropriate box

No	Question	For office use only

B1 How do you define the characteristics of a product?

- ☐ Function
- ☐ Planning & Strategy
- ☐ Lifecycle & lifetime
- ☐ Aesthetics
- ☐ Sales & Marketing

B1 ☐

B2 How do you obtain the design information in order to establish the characteristics of a product?

- ☐ From User
- ☐ From Existing Product
- ☐ From Market Survey
- ☐ From Supplier
- ☐ From Observation
- ☐ From Online Source

B2 ☐

B3 What are the most important elements in the success of a product?

- ☐ Function
- ☐ Performance
- ☐ Durability
- ☐ Technology
- ☐ Other (please specify) _____
- ☐ Aesthetics
- ☐ Quality
- ☐ Reliability
- ☐ Image & Brand

B3 ☐

B4 Two elements were identified as important in product design. Please indicate the sub elements of product design by placing a tick in the appropriate box.

1) Aesthetical Requirements	2) Functional Requirements
☐ Reliability	☐ Reliability
☐ Effectiveness	☐ Effectiveness
☐ Lifetime	☐ Lifetime
☐ Component	☐ Component
☐ Interface	☐ Interface
☐ Semantic	☐ Semantic
☐ Technology	☐ Technology
☐ Shape	☐ Shape
☐ Form	☐ Form
☐ Texture	☐ Texture
☐ Usability	☐ Usability

B4 ☐

☐ Size	☐ Size
☐ Material	☐ Material
☐ Color	☐ Color
☐ Semiotic	☐ Semiotic
☐ Appearance	☐ Appearance
☐ Ergonomic	☐ Ergonomic
☐ Safety	☐ Safety
☐ Emotion	☐ Emotion
☐ Quality	☐ Quality

B5 What information is often required from the user?

☐ User Need	☐ User Problem
☐ User Preference	☐ User Experience
☐ Other (please specify) _____	

B5 ☐

End of the questions

Thank you, I appreciate your kindness in sparing your times in completing this questionnaire.

Hassan Alli
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Faculty of Engineering
University of Malaya,
50603 Kuala Lumpur

Tel: 013 2761028 Email: hassanalli@hotmail.com / halli@putra.upm.edu.my

Dear Respondent

This survey is a part of my PhD study at the Faculty of Engineering, University of Malaya. The objective of the survey is "to investigate the extent of user involvement and their contribution in product development that results in the success of a new product". I would really appreciate if you could complete this survey. Any information obtained in connection with this study that can be identified with you will remain confidential. In any written reports or publication, nobody will be identified and only group data will be presented.

Thank you

Section A: Respondent's Background (Please tick where appropriate) | For office use only

A1 Gender

☐ Male ☐ Female | A1 ☐

A2 Designation

_____ | A2 ☐

A3 Years of Experience

☐ <2 years ☐ 3-5 years ☐ 6-10 years ☐ >11 years | A3 ☐

A4 Business Activity

☐ Design Consultant ☐ Manufacturer
☐ Sales & Marketing ☐ Other _____ | A4 ☐

Section B: Respondent's Knowledge | For office use only

The Categorical Scale

1=Not Important **2**=Less Important **3**=Neutral **4**=Important **5**=Strongly Important

Please indicate the extent of your agreement by ticking the appropriate response scale

No	Question	Not Important	Less Important	Neutral	Important	Strongly Important
B1.	Is user involvement important in car design?	1	2	3	4	5

B1 ☐

B2. Is user involvement important in determining the success of car design? B2

1 2 3 4 5

B3. How do you rate the importance of user contribution in the success of car design? B3

1 2 3 4 5

B4. During product development, in which stage is user involvement important in car design?

a) Product Definition *(e.g. requirement specification)*	1	2	3	4	5	B4a
b) Product Concept *(e.g. idea concept)*	1	2	3	4	5	B4b
c) Product Testing & Validation	1	2	3	4	5	B4c
e) Product Specification *(Final design stage)*	1	2	3	4	5	B4d

B5. What are the important key factors in determining the success of Perodua MyVi?

a) Design	1	2	3	4	5	B5a
b) Multi-Function	1	2	3	4	5	B5b
c) User Friendly	1	2	3	4	5	B5c
d) Good performance	1	2	3	4	5	B5d
e) Brand	1	2	3	4	5	B5e
f) Others ……..	1	2	3	4	5	B5f

End of the questions

Thank you, I appreciate your kindness in sparing your times in completing this questionnaire.

Hassan Alli
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Appendix C-1

Table 7.5: The XS-Detailed Description for the three smartphones

Successful product characteristics	Product design specification	Technical Specification	
Multi-Function	Usability	Must Have	
		Apple iPhone4	Camera 8 megapixel insight camera/ auto focus/ tap to focus/ face detection in still image/ LED flash / Assisted GPS and GLONASS/ digital compass/ WIFI/ cellular / Video HD 1080 p up to 30 frames per second/ video stabilization / Front camera VGA quality photo / Photo and video geo tagging / Audio format AAC (80 to 320 kbps) protected AAC, HE-AAC, MP3, MP3 VBR / User configurable maximum volume limit/ headphone / Mail support; jpg, Tift, gif, doc, html etc / Sensor three-axis gyro, Accelerometer, proximity sensor, ambient light sensor
		BlackBerry Bold	3D network support/ email and text messaging/ Instant messaging/ phone/ browser/ social network / Camera 2.0MP/ flash/ 2x digital zoom / Media player MPEG4/ Audio MP3/ MIDI/ AMR-MB AAC/ AAC+/ eAAC+, WMA / WIFI/ GPS/ organizer/ Bluetooth / Expandable memory/ tethered modem
		Samsung Galaxy Tab 7.0 Plus	Samsung Touch wiz UX/ Samsung Hub-music/e-books/newspapers/ email / Video Full HD / MPEG4 H.263, H.264, WMV, DivX / Audio MP3, OGG, AAC, WIMA, WAC, FLAC / Camera: Back HD 720p/ front 2MP/ instant SNS sharing-email / messaging / Photo and video editor and maker / Browser: Android/ Adobe flash support / A GPS
	Size	Must Have	
		Apple iPhone4	115.2 x 58.6 x 9.3 mm / 137g weight
		Should Have	
		BlackBerry Bold	109 x 60 x 14 mm / 122g weight
		Samsung Galaxy Tab 7.0 Plus	193.65 x 122.37 x 9.96 mm / 345g weight
	Components	Should Have	
		Apple iPhone4	Built-in rechargeable Lithium-Ion battery / Built-in speaker and microphone
		BlackBerry Bold	Removable Lithium-Ion battery / Built-in speaker and microphone
		Samsung Galaxy Tab 7.0 Plus	Built-in Lithium-Ion battery 4000mAh / Built in speaker and microphone

Advanced Technology	Technology	Must Have	
		Apple iPhone4Bold	UMTS/ HSDPA/ HSUPA (850, 900. 1900, 2100 MHz) /GSM / EDGE (850, 900, 1800, 1900 MHz) / CDMA EV-DO Rev. A (800, 900 MHz) / 802.11 b/g/n WIFI (802.11 n 2.4 GHz) / Bluetooth 4.0 wireless technology
		BlackBerry Bold	Tri-band HSDPA (2100/ 1900/ 850 MHz) /Quad-band GSM/ GPRS/ EDGE (850, 900, 1800, 1900 MHz) / WIFI 802.11 b/g /WPA/ WPA2 personal and enterprise / WIFI access to Blackberry internet bundle / Bluetooth V.2.1 / stereo audio (A2DP/ AVCRP) DUN
		Samsung Galaxy Tab 7.0 plus	HSPA + 21 900/1900/2100 / EDGE / GRPS 850/ 1800/ 1900 / WI-FI 802.11 a/b/g/n, Dual-band / 802. 11n WIFI channel bonding / WIFI direct, all share / Bluetooth V.3.0, USB 2.0 Host
Good Performance	Durability	Must Have	
		Apple iPhone4	Anti-scratch protection / Anti-smudges and fingerprint / High definition clarity / Fingerprint – resistant oleophobic coating on front and back glass
		BlackBerry Bold	Heavy duty and lightweight / exquisite surface for durability performance / durability of the keyboard
		Samsung Galaxy Tab 7.0 plus	Anti-scratch protection / Anti-smudges and fingerprint / High definition clarity / Bright display / Realistic color /Lightweight
	Reliability	Must Have	
		Apple iPhone4	Keyboard , dictionary and language support e.g. Malay, English Chinese etc.
		BlackBerry Bold	Built-in for social network communication e.g. face book, twitter
		Samsung Galaxy Tab 7.0 plus	Practicality and consistency with mobile office and Google mobile service
	Performance	Must Have	
		Apple iPhone4	1GHz Apple A4 / Power VR SGX535 GPU (200 MHz) / 512 MB DRM
		BlackBerry Bold	1.2 GHz processor / 768 MB RAM / 8 GB on-board
		Samsung Galaxy Tab 7.0 plus	1.2GHz Dual-core processor 1GB (RAM), 16/32GB

	Effectiveness	Must Have		
		Should Have	BlackBerry Bold	Half VGA 480 x 320 pixel color display / High resolution 480 x 360 pixel color display / Transmissive TFT LCD / Front size (user selectable) / Light sensing screen
		Not Necessary to Have	Apple iPhone4	Retina display / 3.5 in (diagonal) wide screen multi-touch display / 960 x 640 pixel resolution at 526 ppi / 800:1 contract ratio (typical) / 500 cd/m2 max brightness (typical) / Support for display of multi language and characters simultaneously
		Should Have	Samsung Galaxy Tab 7.0 plus	PLS LCD capacitive touch screen, 16M color 600 x 1024 pixels, 7.0 in wide screen (170 ppi pixel density) / touch Wiz UX UI / 4 way rotation

Appendix C-2

Correlation Test for Multi-Function Characteristics (Sales and Features Variable)

Subject	X	Y	X-MinX	Y-Min Y	(X-MinX)^2	(Y-MinY)^2	(X-MinX)(Y-MinY)	
1	2	6124	-6	-42722.8	36	1825237640	256336.8	
2	4	20254	-4	-28592.8	16	817548211.8	114371.2	
3	8	33254	0	-15592.8	0	243135411.8	0	
4	12	86402	4	37555.2	16	1410393047	150220.8	
5	14	98200	6	49353.2	36	2435738350	296119.2	
SUM	40	244234			104	6732052661	817048	
Min	8	48846.8						
							B	7856.230769
							A	-14003.04615
							y = (*if >16X*)	111696.6462

* *X=features variable, Y=sales (million)*

The results indicate: Y = -14003.05 + 7856.23X

Appendix C-3

Correlation Test for Advanced Technology (Sales and Technology Variable)

Subject	X1	X2	Y	X1Y	X2Y	X1X2	X1^2	X2^2	Y^2
1	2	163	6124	12248	998212	326	4	26569	37503376
2	2	163	20254	40508	3301402	326	4	26569	410224516
3	3	163	33254	99762	5420402	489	9	26569	1105828516
4	5	326	86402	432010	28167052	1630	25	106276	7465305604
5	8	326	98200	785600	32013200	2608	64	106276	9643240000
SUM	20	1141	244234	1370128	69900268	5379	106	292259	18662102012
Min	4	228.2	48846.8						

ry1	ry2	r12	β1	β2	Sy	S1	S2
0.9741547	0.94648692	0.966417231	0.900294872	0.076426438	68304.65213	5.14781507	270.3049

	b1	b2	A
	11945.71429	19.31256474	-3343.184416
Y=		98518.42597	

* X=technology variable, Y=sales (million)

The results indicate that: $Y = -3343.18 + 11945.71X_1 + 19.31X_2$

Appendix C-4

Correlation Test for Good Performance (Sales and Performance Variable)

Subject	X1	X2	X3	Y	X1Y	X2Y	X3Y	X1X2	X1X3	X2X3	X1^2	X2^2	X3^2	Y^2
1	62	103	128	6124	379688	630772	783872	6386	13184	13184	3844	10609	16384	37503376
2	62	103	128	20254	1255748	2086162	2592512	6386	13184	13184	3844	10609	16384	410224516
3	833	150	256	33254	27700582	4988100	8513024	124950	38400	38400	693889	22500	65536	1105828516
4	1000	200	512	86402	86402000	17280400	44237824	200000	102400	102400	1000000	40000	262144	7465305604
5	1000	200	512	98200	98200000	19640000	50278400	200000	102400	102400	1000000	40000	262144	9643240000
SUM	2957	756	1536	244234	213938018	44625434	106405632	537722	269568	269568	2701577	123718	622592	18662102012
Min	591.4	151.2	307.2	48846.8										

ry1	ry2	ry3	r12	r13	r23	β1	β2	β3	Sy	S1	S2	S3
0.952794	0.928721988	0.035605188	0.930106512	0.207853764	0.971292697	0.659617439	0.315207513	-0.169771292	68304.65213	821.8237341	175.8678	394.5225

	b1	b2	b3	A
	54.82311819	122.4222606	-29.39292216	6943.667782
	Y=	47291.9097		

* *X=technology variable, Y=sales (million)*

The results indicate that: $Y = 6943.67 + 54.83X_1 + 122.42X_2 – 6943.67X_3$

Appendix C-5

Correlation Test for User Friendly Characteristics (Sales and Interface Variable)

Subject	X	Y	X-MinX	Y-Min Y	(X-MinX)^2	(Y-MinY)^2	(X-MinX)(Y-MinY)	
1	3	6124	-5.6	-42722.8	31.36	1825237640	239247.68	
2	4	20254	-4.6	-28592.8	21.16	817548211.8	131526.88	
3	10	33254	1.4	-15592.8	1.96	243135411.8	-21829.92	
4	13	86402	4.4	37555.2	19.36	1410393047	165242.88	
5	13	98200	4.4	49353.2	19.36	2435738350	217154.08	
SUM	40	244234						
Min	8.6	48846.8			93.2	6732052661	731341.6	
							B	7847.012876
							A	-18637.51073
							y = (*if FA 15*)	99067.6824

* *X=features variable, Y=sales (million)*

The results indicate: Y = -186914.70 + 7847.01X

APPENDIX D: Sample Size and Case Study

No	Authors / Journal Title	Case Study	Subjects
1	Lai, H-H., Lin, Y-C., Yeh, C-H., & Wei, C-H. (2006). User-oriented design for the optimal combination on product design. *International Journal of Production Economics*, vol. 100(2), pp. 253-267 **(Q1 Journal)**	Mobile phone	- 15 subjects for selecting representative KWs - 15 subjects for design evaluation
2	Chen, C-C., & Chuang, M-C. (2008). Integrating the Kano Model into a robust design approach to enhance customer satisfaction with product design. *International Journal Production Economics*, vol. 114(2), pp. 667-681 **(Q1 Journal)**	Mobile phone	- 60 subjects (35 males, 25 females) - Age 18 to 24
3	Kuang, J., & Jiang, P. (2009). Product platform design for a product family based on Kansei Engineering. *Journal of Engineering Design*, vol. 20(6), pp. 589-607 **(Q1 Journal)**	Mobile phone	- 40 subjects
4	Akay, D., & Kurt, M. (2009). A neuro-fuzzy based approach to affective design. *International Journal of Advanced Manufacturing Technology*, vol.40(5-6), pp. 425-437 **(Q2 Journal)**	Mobile phone	- 132 university students (76 males and 56 females with the average age of 22
5	Hsiao, S-W., Chiu, F-Y., & Lu, S-H. (2010). Product-form design model based on generic algorithms. *International Journal Industrial Economics*, vol. 40(3), pp. 237-246 **(Q1 Journal)**	Drip coffee maker	- 100 subjects
6	Yang, C-C., & Shieh, M-D. (2010). A support vector based prediction model of affective responses for product form design. *Computers & Industrial Engineering*, vol. 59(4), pp. 682-689 **(Q2 Journal)**	Mobile phone	- 30 subjects (15 males, 15 females)
7	Yang, C-C. (2011). Constructing a hybrid Kansei engineering system based on multiple affective responses: Application to product form design. *Computers & Industrial Engineering*, vol. 60(4), pp. 760-768 **(Q2 Journal)**	Mobile phone	- 30 subjects (15 males, 15 females)
8	Wang, K-C. (2011). A hybrid Kansei engineering design expert system based on grey system theory and support vector regression. *Expert Systems with Applications*, vol. 38(7), pp. 8738-8750 **(Q1 Journal)**	CNC machine tools	- 60 subjects (30 males, 30 females) - 10 subjects (5 males, 5 females)

9	Yang, C-C. (2011). A classification-based Kansei engineering system for modeling consumers' affective response and analyzing product form features. *Experts System with Application*, vol. 38(9), pp. 11382-11393. **(Q1 Journal)**	Digital camera	- 60 subjects (36 males, 24 females) for the questionnaire experiment I - 42 subjects for the questionnaire experiment. II
10	Yang, C-C., & Chang, H-C. (2012). Selecting representative affective dimension using procrustes analysis: An application to mobile phone design. *Applied Ergonomics*, vol. 43(6), pp. 1072-1080 **(Q1 Journal)**	Mobile phone	- 18 subjects (10 males, 8 females)
11	Yan, H-B., Huynh, V-H., & Nakamori, Y. (2012). A group nonadditive multiattribute consumer-oriented Kansei evaluation model with an application to traditional crafts. *Annals Operations Research*, vol. 195(1), pp. 325-354 **(Q2 Journal)**	Kutani cups	- 60 subjects
12	Huang, Y., Chen, C-H., & Khoo, L. P. (2012). Kansei clustering for emotional using a combined design structure matrix. *International Journal of Industrial Economics*, vol. 42(5), pp. 416-427 **(Q1 Journal)**	Wireless battery drills	- 60 subjects

APPENDIX E: List of Journals

Journal Paper E-1

Z, Taha., H, Alli., & SH, Abdul-Rashid. (2011). Users' involvement in new product development process: A designer's perspectives. *Journal of Industrial Engineering and Management System*, vol. 10(3), pp. 191-196.

Journal Paper E-2

Z, Taha., H, Alli., & SH, Abdul-Rashid. (2012). Users' requirements and preferences in the success of a new product: A case study of automotive design. *Journal Applied Mechanics and Materials*, vol. 215-216, pp. 484-488

Journal Paper E-3

Z, Taha., H, Alli., & SH, Abdul-Rashid. (2013). The Characteristics of a New Product through User Knowledge in the Early Stage of a Design Process. *Accepted for publication in the Journal of Advanced Material Research*

APPENDIX F: List of Conference Papers

Conf. Paper E-1

Zahari, Taha. & Hassan, Alli. (2010). An Exploratory Study on the Practice of Involving Users in New Product Development. Melaka City, Melaka: *Proceedings from IDECON: The International Conference on Design and Concurrent Engineering*, Sept. 20-21

Conf. Paper E-2

Zahari, Taha., Hassan, Alli., & Salwa Hanim, Abdul-Rashid. (2010). The Role of Involving Users in New Product Development Process: A Designers' Perspective. Melaka City, Melaka: *Proceedings from APIEMS: The 11th Asia Pacific Industrial Engineering and Management Systems*, Dec. 7-10.

Conf. Paper E-3

Zahari, Taha., Hassan, Alli., & Salwa Hanim, Abdul-Rashid. (2011). Product Characteristics Development in the Early Stages of Design Process: A Designers' Approach. Rome, Italy: *Proceedings from the 5th International Conference on Design Principal & Practices*, Feb. 2-4

Conf. Paper E-4

Zahari, Taha., Hassan, Alli., & Salwa Hanim, Abdul-Rashid. (2012). Users' Requirements and Preferences in the Success of a New Product: A Case Study of Automotive Design. Taiyuan, China: *International Conference on Advanced Design and Manufacturing Engineering,* Aug. 24-26

Conf. Paper E-5

Zahari, Taha., Hassan, Alli., & Salwa Hanim, Abdul-Rashid. (2013). The Characteristics of a New Product through User Knowledge in the Early Stage of a Design Process. Beijing, China: *World Congress on Industrial Materials-Application, Product, and Technologies*, April 1-2