

DECISION-MAKING FOR PRODUCT DESIGN DEFINITION METHOD IN THE EARLY STAGE OF DESIGN PROCESS OF A SUCCESSFUL NEW PRODUCT

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ABSTRACT

Most product failure in the market is caused by the incompetence to integrate users' requirements and preferences in the early stage of a new product development process. User involvement in the early stage of the design process is knowledgeable and opens possibilities for new product ideas, improves product innovation, decreases the product risks and prevents from irrelevant design. It also a pleasurable for the product developer to identify and verify the characteristics of a new product. This paper is evaluated on the decision-making process for the product definition phase of the product design and development stage, in which there is a need to incorporate the element of product design to establish the new product design characteristics. It extends the knowledge from product designers and users as a strategy for improving the efficiency of generating a new product idea and increases product quality and success in the market. Product Design Definition Method (PPDM) is explains the theory and procedure used in the decision making process. A very successful product is selected as a case study for validation in substantiating the significance of the method. The end of paper concluded the significant of method use for product designers in the product definition phase of product design and development stage that contributed to the success of a new product.

Keywords: *New product development, user involvement, design method, and successful product.*

1. INTRODUCTION

Knowing success factors will provide an opportunity that allows a new product to become successful in the market. Many product developers nowadays have become more aware that they need to be more responsive to market needs to minimise the risk of product irrelevance, reduce development, time and increase better product outcome. In the manufacturing industry, new product development activities are more focused on developing a new product that purposely works according to their specifications. In addition, the empirical studies also implied the outcome of consolidating product development activities and resources with users mainly in the early stage of new product development has resulted in the success of a new product. Besides, the user is most valuable to enhance the development process and increase the likelihood of product success (Awa, 2010; Benedicic et. al., 2012; Taha et. al., 2012; Alli, 2014; Ulrich & Eppinger, 2016; Alli, 2018). Many authors recognised that the involvement of the user in the design process is highly required to produce the perfect new product (Lee, 2008; Awa, 2010; Taha et al. 2013; Alli, 2018). They have also become an effective new strategy in the product development process that can offer a unique solution for the intention of a new product.

User information is essential to identify the characteristics of a new product. Nevertheless, understanding user information has also been recognised as a pressing challenge for product developers. Furthermore, the quality

and type of information needed from the user are also difficult to determine (Elfving, 2007; Bruch, 2007; Awa, 2010; Taha et al. 2013; Alli, 2018). As a result, the product designer mostly made mistakes or misjudgements in several aspects during the development of product design. Recently, many product developers are still facing difficulties with developing and selecting a new strategy for a successful new product (Taha et al., 2012; Alli, 2018). This is attributed to numerous factors such as an effective product development process, an appropriate product characteristic, newness technology, and liability of marketing and organisation. It also caused of the acceptability of a product on the market to still be daunting for many product developers as it depends too much on user acceptance. Previous studies have also found and concluded that understanding the user needs is a challenge as it is complex and a burden for many product developers. But, they are recognised as a good mechanism, which enables both users and product developers' interests to be sought, elicited and reflected for better decision-making for a company. A good relationship between the product developers and users will help to identify the requirements and preferences of a new product.

The purpose of user involvement in the product development process is to provide information about their needs, wants, and desires. This information is valuable to identify the product specifications in which, the product designer will take into consideration in establishing the characteristics of a new product in the early stage of the design process. In addition, their involvement is not only important in generating new product ideas but also in co-creating them with product developers, in the testing finished products, and in providing end-user product support. Their involvement also was identified significantly in the early stage of the design process that will give a better opportunity to increase the product value, quality and probability of product success (Taha et al., 2013; Alli, 2014). Users have an important role in new product development to determine the characteristics of a new product by offering their perspectives and knowledge. However, the involvement of users needs to be thoroughly considered and efficiently applied to gather user requirements and preferences from the real product development contexts.

This paper highlighted two significant objectives of the study that need to be addressed, 1) to identify the characteristics of successful product design through users' requirements and preferences in relation to the establishment of the characteristics of a product, and 2) to apply the Product Design Definition Method for facilitating the product designer in the early stage of the product development process that can contribute to product success.

2. RESEARCH BACKGROUND

A product is made up of a variety of elements of product design, which contains both physical and non-physical variables. The physical variable refers to the function of the product, while the non-physical variable is based on the aesthetic of the product. According to Ottosson (2006), the functional elements purposely ensure trouble-free product functions in the short term and the long term of its use. Meanwhile, the aesthetic elements are demonstrated as perceptual values, which mainly consist of showing that the product semantics are good, well-designed, and ergonomically made. The characteristics of a product are constructed by a set of variables that are also known as product design specifications. However, each product is built from many variable facets, which, ultimately, give the product its personal and individual character. According to Janlert & Stolterman (1997), characteristics are a coherent set of characters and attributes that apply to both appearance and behaviour alike, cutting across different functions, situations and value systems, such as aesthetical, technical, ethical, and providing support for anticipation, interpretation, and interaction.

2.1 Process for Sustainable a New Product Development

The recent paradigm shift with concerning design activity marks the beginning of a new era in which the user's role in the design process has been changed from being a problem provider and solution-evaluator to be being one of proactive involvement and even autonomous decision making in product direction. It is thus, the product development always requires a collaborative involvement to minimise and solve the complex process especially in the early stage of the design process, where it is most important to develop a new product that is significant for its success. Since the product goes through a complex process, it is required for product developers to fulfil the user requirements and product expectations. Indeed, the design activities need to be coordinated in a logical and flexible workflow that can integrate with the product designer tasks, technology, and market needs.

Product development is referred to as a process to identify and find a solution for a new product (Ulrich & Eppinger, 2016; Alli, 2018). This process also attempts to full the requirements and preferences of the user, market needs, and environmental consideration. Through the product definition stage of the design process, which also known as the early stage of the design process where a new product start is born and the phase is important to be identified and to be developed according to the specifications of a new product (Taha et al., 2013; Alli 2014). In addition, it covers the upfront product development activities that are more considered for understanding user needs, market

analysis, priority decision criteria list, organisational, support and others. The early stage of new product development process refers to the design process, which is known as the process for creating tangible form. In addition, it also consists of a series of design development activities in or to produce a useable product and provide a solution that can later be applied in the development of a specific product concept. The activities in this stage lead to innovative ideas, recognisable product specification, and the enhancement of the performance of the product function.

The empirical studies implied the outcome of coordinating product development activities and resource with users in the early stage of new product development. It is a valuable means of enhancing the development process and increasing the likelihood of product success. According to Lee (2008), product designer-user collaboration in the early stage of the design process is considered as a process to identify and transfer the user knowledge into a new product. Users have become a strong factor in the success of a new product and they are also influential in the decision-making process (Taha et al., 2012; Alli, 2018). The user is also recognised as a new strategy to create a profitable sale and respond to social and environmental problems (Lundkvist & Yakhlef, 2004). 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. In addition, involving the user in the early stage of product development will also help to identify several elements of product design, such as effectiveness, reliability, durability, safety, ergonomic and others. However, direct interaction with the user does not guarantee a successful outcome if the product developers do not know how to involve the user in product development. The involvement of the user is still more or less a broad concept and always applicable by using various kinds of approaches.

Figure 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. 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. Nowadays, many methods and strategies have implemented by product developer in the new product development process but many of them is solely dependent on its purpose and product type. In addition, several studies also found that a lack of integration between product design and user bring conflict and failure on a new product idea. Hence, for a new product to achieve significant and rapid market penetration, it must map the users’ requirements and preferences as a new feature, and provide superior quality,

a new look, be unique, and have attractive pricing. The development of a new design methodology is important to support the design activities and also a decision-making process in the early stage of the design process.

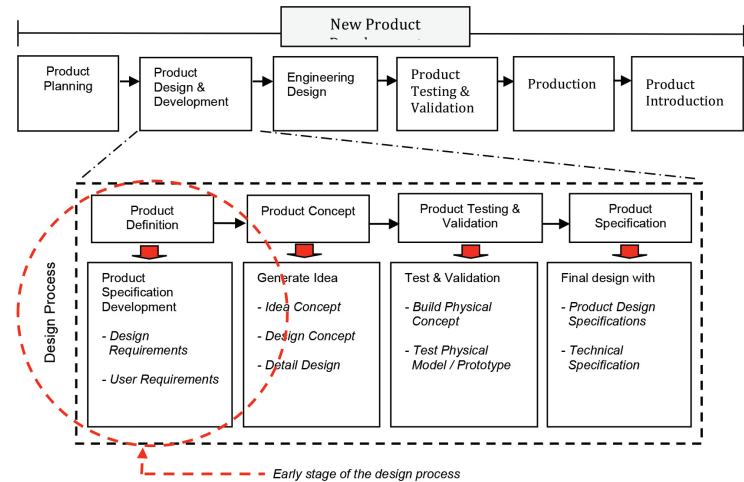


Figure 1: Product Design and Development Stage

2.2 Decision-making in Product Definition Stage

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 (Taha et al., 2013; Alli, 2014; Alli, 2018). However, the main problem in the development of a methodology is to identify the rights users to involve and identify the right trends. 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 have satisfied, and identified by the user needs.

This study introduced a new design methodology known as the Product Design Definition Method (PDDM). 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. The PDDM is 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.

Figure 2 shows the Product Design Definition Method (PDDM) and process. There are four steps that the product designer should follow to use the proposed PDDM framework to establish successful product design characteristics (SPDC). The application of the method commences with: a) getting the user input according to successful product design characteristics (SPDC) map, b) prioritising successful product characteristics (SPC), c) verifying product design specification (PDS), and d) building SPDC into the XS-Detailed description.

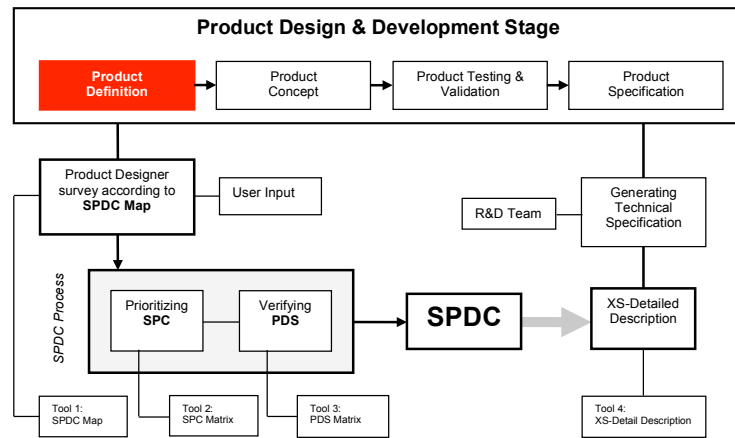


Figure 2: Product Design Definition Method and Process

a) 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 (see Figure 3). This process involves several product users to grade the significance of the seven successful product characteristics (SPC) and 27 item product design specifications (PDS). This process attempts to rank the most important of both the SPC for the intended new product. The user input can be gained through a survey using several methods or tools, such as interviews, questionnaires, focus groups, group discussions or observation. Whichever data collection method is used, the product designer must capture the data for both SPC and PDS.

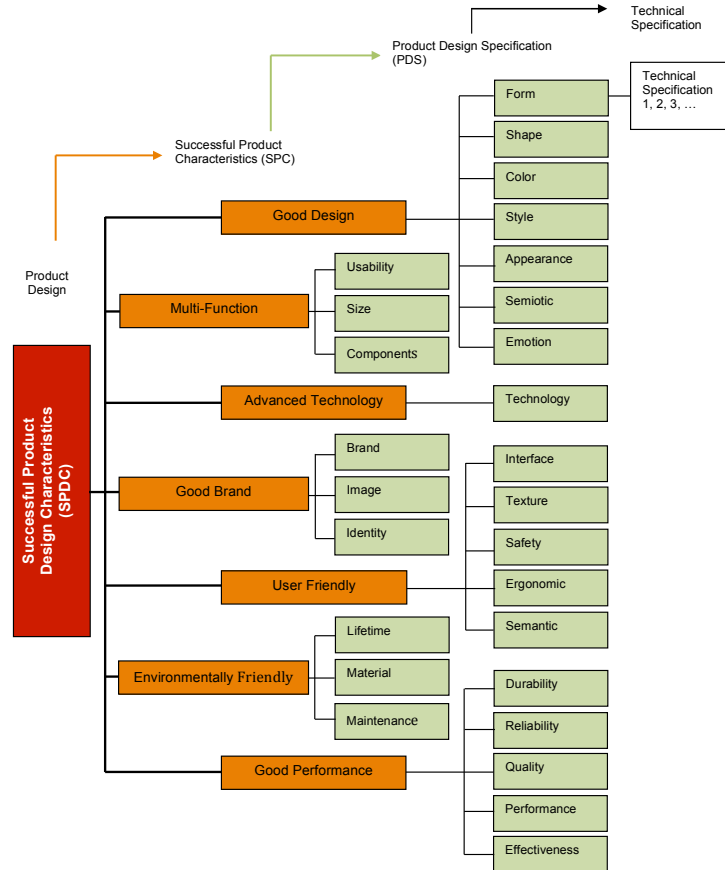


Figure 3: Successful Product Design Characteristics (SPDC) Map

b) Prioritizing successful product characteristics

Successful product characteristics (SPC) can be viewed as an expression and recognized as the fundamental option of users. They also express the essential properties of what the product must have, and desired properties of what the users like to have. 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 1.

Table 1: Successful Product Characteristics Matrix

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

c) Verifying product design specification

In order to establish the product design specification (PDS), the requirements that were identified on the SPDC map must be cluster into four categories of the PDS matrix (see Table 2): 1) Must Have (MH) – where the product design specifications are essential for the success of a product, 2) Should Have (SH) – the product design specification that can increase the likeliness of product success, 3) Not Necessary to Have (NNH) – the product design specification that do not have a major impact on product success, and 4) Must Not Have (MNH) – the product design specification that has a harmful impact on product success.

Table 2: Clustering Process for Product Design Specification

Functional Requirements	Aesthetical Requirements
Must Have (MH) – Level 1 (80-100%)	
Should Have (SH) – Level 2 (60-79%)	
Not Necessary to Have (NNH) – Level 3 (40-59%)	
Must Not Have (MNH) – Level 4 (0-39%)	
↓	↓
Product Design Specification (PDS)	

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 specification of Not Necessary to Have (NNH) categories as part of the product characteristics. The selection of NNH as product design specifications will results, 1) increase

in the product process and cost, and 2) differentiate it from other products. Therefore, product designers should not employ what is listed as specifications in MNH as a product specification because it harm product success. Finally, to the end of the clustering process, the product designers obtain product design specifications out of 27 product design specifications. The decision-making model for the product design specification is defined by the formula:

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

FR = Functional Requirements (elements)
AR = Aesthetical Requirements (elements)

d) 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 to facilitate the product designer to conclude their new product decision of a product. In addition, this worksheet is also important to be used to identify the technical specification of each product design characteristics. Table 3 shows an example of the XS-Detailed Description.

Table 3: The XS-Detailed Description (example product: Compact car)

Successful Product Characteristics (SPC)	Product Design Specification (PDS)	Technical Specification (TS)
GOOD DESIGN	Must Have (MH)	
	Form	Slightly shorter and curvier, Five-door hatchback
	Color	Lime green (metallic), Dazzling red (metallic) and Ivory white (metallic)
	Should Have (SH)	
	Shape	Full body kit from the front bumper, rear bumper and new interior design which features carbon fiber surface
	Style	Multi-purpose compact car

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, the technical

specifications can concurrently be identified through involving research and development (R&D) team members, such as engineers, marketers, managers, and product engineers.

3. METHOD

The professional end-user survey was performed to validate the significant successful product characteristics and product design specifications, which contributed to the success of a product. The respondent involved in this survey were the users of Apple iPhones. A case study is conducted to identify the success factors of the Apple iPhone5s model. The Apple iPhone5s model was selected from among the other models because of user satisfaction. According to German Online Portal for Statistic (2018), Apple’s iPhone was sold more than 217 million since the first introduced the iPhone model in 2007. The iPhone5s has proven to be a successful model that has contributed to the increasing sales volume compared to the previous model. Also, the iPhone5s is the most popular iPhone, as around 125 million people in the world use this device. Therefore, these products were selected based on their leading edge technology reputation and volume of sales.

A set of questionnaires was distributed to investigate the factors that could influence the success of the product. Snowball sampling techniques were employed in this survey. A total of thirty-two (32) respondents participated in data collection. After the factors that influenced the success of a product were identified from the users, the technical specification was conducted 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 results were analysed using the Statistical Package for Social Science (SPSS). The results were gathered and presented as a conclusion to the study.

4. RESULTS

4.1 Characteristics of Respondents

Table 4 shows the gender of the respondents for the Apple iPhone5s. The results indicate that 56.25 percent of respondents involved in this survey were male and 43.75 percent female.

Table 4: Gender of the respondents for the Apple iPhone5s

Product/ Gender	Male		Female	
	N	Percentage	N	Percentage
Apple iPhone5s	18	56.25	14	43.75

Table 5 shows user experience for the Apple iPhone5s. The results specify that 71.9 percent of the respondents for the Apple iPhone5s had an experience of mobile application use of less in six months, followed by 18.8 percent between 7-12 months, and 9.4 percent more than 12 months.

Table 5: User Experience for the Apple iPhone5s

Experience of mobile use	< 6 months	7-12 months	>12 months
Percentage	71.9	18.8	9.4

4.2 User Based on the Successful Product Characteristics Map

The successful product characteristics of Apple iPhone5s can be identified through the SPC matrix. The results indicate that the users have their criteria for the selection of successful product characteristics for the Apple iPhone5s, as shown in Table 6 below. It showed that the users select the successful product characteristics are follow as: multi-function, advanced technology, good performance, and good brand, user friendly, and environmentally friendly.

Table 6: Successful Product Characteristics for the Apple iPhone5s

Product	Successful Product Characteristics	Percentage
Apple iPhone5s	Multi-function	100.0
	Advanced Technology	96.9
	Good Performance	96.9
	Good Brand	96.9
	User Friendly	90.7
	Good Design	84.4
	Environmentally Friendly	65.6

4.3 Verifying Product Design Specifications of Apple iPhone5s

The product design specification could be identified through formula PDS: [FR] + [AR]. The verification of the product design specifications was divided into four categories: Must Have, Should Have, Not Necessary Have, and Must Not Have. Table 7 shows the product design specification for the Apple iPhone5s. The table indicates 10 functional requirements and 11 aesthetical requirements are classified as Must Have specifications, followed by three functional requirements and three aesthetical requirements as Should Have specifications.

Table 7: Successful Product Characteristics for the Apple iPhone5s

Product	Categories	Product Design Specifications
Apple iPhone5s	MUST HAVE	FUNCTIONAL Technology, quality, performance, usability, ergonomic, safety, durability, reliability, effectiveness, and size.
	SHOULD HAVE	AESTHETICAL Appearance, style, brand, interface, image, material, identity, shape, form, colour, and emotion

4.4 Successful Product Design Characteristics of Apple iPhone5s

Successful product design characteristics for the Apple iPhone5's success can be identified through the formula SPDC: [SPC] + [PDS]. Table 8 shows the successful product design characteristics for the Apple iPhone5s. The table indicates the priority of successful product design for the Apple iPhone5s.

Table 8: Successful Product Design Characteristics for the Apple iPhone5s

Successful Product Characteristics	Categories	Product Design Specifications
1st Priority		
Multi-function	MUST HAVE	Usability and Size
	SHOULD HAVE	Components
Advanced Technology	MUST HAVE	Technology
Good Performance	MUST HAVE	Quality, performance, durability, and effectiveness
Good Brand	MUST HAVE	Brand, image, and identity
User Friendly	MUST HAVE	Ergonomic, safety, and interface
	SHOULD HAVE	Texture and semantic
2nd Priority		
Good Design	MUST HAVE	Appearance, style, shape, colour, and emotion
	SHOULD HAVE	Semiotic
3rd Priority		
Environmentally Friendly	MUST HAVE	Material
	SHOULD HAVE	Lifetime and maintenance

4.5 Technical Specifications of Apple iPhone5s

The XS-Detailed description is important 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 product success. The results indicated several technical specifications of the product that contributed to product success based on the Apple iPhone5s most important successful product characteristics, which are shown in Table 9 below.

Table 9: The XS-Detailed Description for Apple iPhone5s

Successful Product Characteristics	Product Design Specification	Technical Specifications
Multi-function	Usability	GSM/CDMA/HSPA/ EVDO/LTE - Gsm850/ 900/ 1800/ 1900; HSDPA 850/ 900/ 1900/ 2100; LTE band 1(1200), 2(1900), 3(1800), 5(1900), 7(2600), 8(900), 20(800), 38(2600), 39(1900), 40(2300); speed-HSPA 42.2/ 5.76Mbps, LTE Cat3 100/ 50Mbps, EV-Do Rev. A 3.1Mbps.
	Size	123.8 x 58.6 x 7.6 mm / 112g weight.
	Component	Non-removable Li-Po 1560mAh battery (5.92Wh).
Advanced Technology	Technology	8MP, f/2.2, 29mm (standard), 1/3", 1.5µm, AF; Dual LED, Dual-tone flash, HDR: 1080p@30fps, 720@120fps
Good Performance	Quality	Improved overall image quality by expanding by 15% the amount of sensor space the camera uses to capture pictures.
	Performance	iOS7, upgradable to iOS 12.2; Apple A7 (28mm); Dual-core 1.3 GHz Cyclone (ARM v8-based); power VR G6430 (quad-core graphics); 16-bit/44.1kHz; Audio – active noise cancellation with dedicated mic.
	Durability	Built with a plastic shell, and many assumed that the material would boost the phone's durability.
	Effectiveness	Easy to use
Good Brand	Brand	Apple iPhone 5s
	Image	Simple and geniuses design
	Identity	Touch ID with a fingerprint scanner having made the iconic home button.
User Friendly	Ergonomic	Compact and lightweight body.
	Safety	The fingerprint scanning functionality as an alternative to passwords (especially in "bring your own device" scenarios) - authentication systems have only enjoyed wider usage in enterprise environments.
	Interface	IPS LCD capacitive touchscreen, 16M colours, 4.0 inches, 44.1cm ² (~60.8% screen-to-body ratio); 640 x 1136 pixels, 16:9 ratio (~326ppi density); Corning Gorilla Glass, Oleophobic coating.

5. DISCUSSION

Product success is derived from product innovation and product introduction, whereby, innovation was initiated during the design process. To introduce a new successful product in the market, product mapping of the user requirements and preference is necessary. The development of better product outcome should have integrated with many variables, such as designer, manufacturer, marketer, engineer, supplier, and user during the product development process. Then, the systematic structure for product success needs to be designed for an efficient and effective outcome. In addition, the systematic innovation process can prevent and expected results and the failure of product development output, reduce time, and the cost of the process. User involvement in product development is truly essential for the success of a product. Therefore, their involvement in product development will help the product developers to make an opportunity decision, rationale judgments, provide optimum product quality, and a wise purchasing decision.

Several requirements of product design have been found and identified for product design specifications, however, this does not guarantee the success of the product. This study recognised several successful product characteristics (SPC) such as; good design, multi-function, advanced technology, good brand, user friendly, environmental friendly, and good performance. Meanwhile, only 27 product design specifications were identified from the product designers (design requirements) and user requirements. These requirements were acknowledged to be the product design specifications (PDS), which were categorised into functional requirements (FR) and aesthetical requirements (AR), (see Table 10). The PDS was also acknowledged to be an important element in the establishment of successful product design characteristics and would help to increase the success of a new product. However, the different products were ranked differently for all product specification below, e.g. technology was ranked highly for consumer products but less for furniture design, and brand were also a high priority of product design in consumer product compared to quality and form in furniture design and automotive design.

Table 10: Twenty-Seven product design specification

Functional Requirements (FR)	Aesthetical Requirements (AR)
Quality	Form
Safety	Appearance
Performance	Brand
Durability	Shape
Ergonomic	Style
Lifetime	Identity
Maintenance	Images
Effectiveness	Colour
Technology	Texture
Reliability	Interface
Usability	Material
Size	Semantic
Components	Semiotic
	Emotion

Many factors influence the success of a new product. 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 fulfil a user satisfaction, but also attract more users, and must also feel good to use and have an appealing design. The success of a new product is sufficient profit if the product developer can fulfil the user requirements. In order to increase the success of a new product, the product developer 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. In this study, the success of a new product can be defined as:

$$XS = SPDC [SPC + PDS] + TS$$

The novelty of this study 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. Therefore, the PDDM is also helps the product developer to minimise the possibility of creating an irrelevant design concept, reduce the operating cost, and shorten the time frame for the product to enter the market.

6. CONCLUSION

This study 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 Product Design Definition Method is designed in order to facilitate the product designer to establish successful product design characteristics. Furthermore, the knowledge from both the product designer and user are essential not only to identify the specification of a new product but also to increase the product success. A good understanding of both will bring opportunities to the success of a new product on the market.

Further research should be conducted to introduce this method in a mathematical model that attempts to ensure the tool can be used easily and that it is user friendly. The results could be more informative through collaborative teamwork, which enables 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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