Interim Product Design Guidelines and Strategies

by

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A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Industrial Design

Auburn, Alabama
August 7, 2021

Keywords: smart home, interim product,
innovation diffusion, product development

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Abstract

With the improvement of technology, more and more radical products, which provide unprecedented customer benefits, have appeared in the market these years, but the diffusion of them is slow and still a big challenge for firms. However, a new type of innovative product, called an interim product, can offer radical products' features but diffuses faster. Each interim product is more affordable but can still create unprecedented features by combining them with an existing mainstream product. Consequently, more people can have the advantages of radical products by adopting interim ones designed by referring to their counterpart radical products. On the other hand, from a commercial perspective, the development of interim products is more efficient than radical ones. When companies design an interim product, they have clearer directions during product concept development because they can refer to an existing radical one. Therefore, this study will organize the patterns and attributes of existing interim products and create an interim product design guideline and strategies. Finally, this study demonstrates the application of the guideline and makes conclusions.

Acknowledgments

I would like to thank my committee, Clark Lundell, Richard Britnell, and Christopher Arnold, for all their assistance during the process of writing and finalizing this thesis. Special thanks go to Richard for lending me his sewing machine. Thanks to Chad Bailey for helping me make prototypes with 3D printers. I would like to extend my thanks to the whole Industrial Design faculty and the Wallace Hall staff for all the support I have received. I appreciate every bit.

Personal Thanks go out to my family, especially my Mom, my Dad, and my two brothers. Because of your mental and financial support, I have this opportunity to pursue a master's degree and complete it in the United States. I love you all. Thanks to Ching-Tzu for all encouragement and assistance, now and before. Thank to Tin-Man and Clark for GTA awards. Thanks to the scholarship offered by Taiwan ministry of education.

Software Used

Style manual or journal used:	APA Style, Sixth Edition
Computer software used:	Microsoft Office 2016
	Adobe Photoshop 2021
	Adobe Illustrator 2021
	SolidWorks 2020

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List of Abbreviations

DIY	Do-It-Yourself
SHT	Smart Home Technology
WDSHD	Wired Smart Home Device
WLSHD	Wireless Smart Home Device
WFSHD	Wire Free Smart Home Device

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Radical products are one type of innovative products and offer unprecedented consumer benefits to improve life. However, these radical products have potential risks or unpredictable side effects, such as uncertain performance and a higher cost. Consequently, only consumers in high-end markets have had the capacity to adopt radical products early until they diffuse widely. However, radical products generally take many years to become commonplace. Therefore, this study will investigate interim products, a new type of innovative product. They offer unprecedented benefits similar to radical products but reduce potential risks to help consumers in mainstream or low-end markets gain benefits similar to adopting radical products.

1.2 Need for Study

A part of radical products can offer unprecedented consumer benefits, but only people on high-end markets can have advantages from this kind of radical products due to some negative factors, similar to costly price. However, there is a kind of innovative product, interim products, that can offer similar benefits but overcome resistance to innovation. Consequently, people in the mainstream and even low-end markets are more willing to adopt them to gain unprecedented benefits, compared to radical products.. However, fewer studies are related to interim products.

In order to allow more people to benefit from radical products' advantages, interim products will be investigated as a way to achieve this aim. Interim products are a strong solution to make benefits offered by radical products more inclusive. They can help consumers in mainstream and low markets have unprecedented consumer benefits without requiring them to assume potential dangers caused by adopting radical products.

1.3 Objective of Study

The objective of this thesis is first to demonstrate the linkages between interim products and innovation. With these established, interim products will be examined in order to understand their attributes and patterns. With this understanding, a guideline can be developed that provides important goals of interim products. Strategies that build on these guidelines will be identified and generated in order to make the guidelines more actionable for designers. Finally, strategies will be demonstrated through a product design example that shows how to design an interim product.

1.4 Assumption

This study assumes a new type of innovation can offer benefits similar to radical products but with less innovation resistance. Besides, these products have the same patterns. Based on these patterns, a new design guideline would be proposed.

1.5 Scope and Limits

This study is fairly general in the scope of innovation, so the study is limited to an examination of innovations that have a physical presence. Consequently, the guideline proposed

by this study can only apply to product design with a physical presence, too. Moreover, radical products can provide unprecedented performance benefits, considerable cost reductions, or the ability to create new businesses (Leifer, O'connor, & Rice, 2001; Slater, Mohr, & Sengupta, 2014). This study excludes radical products that transform existing markets by significant improvement in cost because they diffuse fast and possibly become mainstream product fast.

1.6 Anticipated Outcomes

The outcomes of this study are that interim products can be defined by discovering the same patterns in existing markets. Based on the definition, there will be a set of guidelines for designing an interim product. With these guidelines, strategies can be theorized or identified that can be applied to product development in order to help consumers in mainstream or low-end markets benefit from unprecedented product performance similar to radical products.

1.7 Definition of Terms

Diffusion: It is the overall spread of an innovation, the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003).

Home Automation: It is defined as the capability to automate and control multiple disparate systems (Douligeris, Khawand, & Khawand, 1991).

Innovation: It is an idea, practice, or object that is perceived as new by an individual or other unit of adoption (Rogers, 2003).

Innovativeness: The degree to which an individual is relatively earlier in adopting an innovation than other people, instead of perceiving an innovation earlier (Midgley & Dowling, 1978).

Interim period: A period before an interim product's counterpart radical product become commonplace in the market.

Interim product: A product that can offer unprecedented consumer benefits similar to a non-commonplace radical product by combining a mainstream product, and can quickly enter existing or new market because of its great affordability, compatibility, observability and familiarity.

Product development: It is the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product (Ulrich, 2003).

Rejection: It is defined as a passive form of behavior resulting in an ultimate decision not to adopt or to ignore an innovation (Kuisma et al., 2007).

Resistance: It is regarded as an active behavior, which may occur in every adoption process but does not necessarily result in non-adoption (Ram, 1987).

Smart home: A residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond (Harper, 2006).

CHAPTER 2

LITERATURE REIVIEW

In this chapter, the link from innovation back to interim products will be made. At first, this study initially defines "interim product" by investigating smart home devices because they are a few interim products that have more relevant literature. Next, literature related to innovations is discussed in order to construct a link between interim products and innovations. A little literature about product development is investigated to propose a strategy.

2.1 Smart Home

"Smart home" can be defined as a residence equipped with computing and information technology that responds to the needs of the residents, working to promote their comfort, convenience, security and entertainment through the management of technology within the home (Harper, 2006). The concept of smart home plays a crucial role in the planning of future housing-based models of care. Nowadays, numerous people are familiar with this term because it benefits human beings considerably. Compared with decades ago, more people are more willing to adopt smart homes. However, it is not a new concept. It was first used officially in 1984 by the American Association of House Builders (Harper, 2006). Initially, the smart home was defined as the integration of different services within a home by using a common communication system (Lutolf, 1992). Actually, the first similar term, "wired homes," was proposed in the early 1960s. Even though this concept appeared many decades ago, it started to be more commonplace in the 2010s.

What are the differences between the concept of the smart home during these decades? What makes individuals more willing to adopt it? Furthermore, what is the "interim product?" Why is a smart home categorized as a typical interim product? The following paragraphs introduce the smart home by way of a quick history and outline the crucial points. Afterward, the end of this paragraph takes the smart home as an example to initially define "interim product."

2.1.1 The Popularity of Smart Home.

The concept of wired home was proposed around the 1960s, but numerous people considered it as science fiction. During the 1980s, commercial interest in home automation had grown successfully for the National Association of Home Builders in the USA to found a special interest group called "Smart House" (Harper, 2006). This group considerably boosted innovative and necessary technologies into the design of new homes. Venkatesh (1996) showed five main changes in the technological environment at the end of the 1980s. Firstly, more people were familiar with technological terms, such as virtual reality, multimedia, and interactivity, and so on. Secondly, more areas in households were targeted for new technologies. Thirdly, computer technologies and software for home were available to meet consumer needs, and the knowledge and skills required to use these technologies and software were easier to acquire. Fourthly, people had a better acceptance of computers as a domestically useful technology. Fifthly, people realized the full potential of new technologies for home. According to Gann, Barlow, and Venables (1999), two reasons caused the changes in technologies environment. Since the 1980s, consumer electronics and electrical equipment firms had been developing digital systems and components suitable for users in domestic buildings. Also, new communication networks, such as integrated services digital network (ISDN) internet and new end devices, such as web TV and video phones,

built foundations for smart home. The mentioned reasons are the bases for the development of smart home.

The term “home automation” was proposed in the 1970s because of the following reason (Lucero & Burden, 2010). It was more closely described as available technology, compared to smart home. Home automation was defined as the capability to automate and control multiple disparate systems. Its systems could offer consumers improved security and safety, economic benefit through energy management, and convenience by giving their control over every piece of housed appliances (Douligeris et al., 1991). In fact, in the late 1970s and 1980s, home automation and office automation systems had already been introduced to the market, such as energy management systems, security systems, lighting control systems, etc. (Douligeris et al., 1991). Although home automation provides many advantages with users, it has not yet achieved broad acceptance similar to expectation. There are some barriers. One crucial factor is related to the small ratio between the features offered and the considerable cost of the current solutions (Nunes & Delgado, 2000). Other factors also have significant influences on acceptance, such as the lack of powerful standard technology, and complex user interaction (Gann et al., 1999).

In the 1990s, the smart home was a complete “enabling system” that offered the common resources needed for home automation in a multi-product. It was a multi-vendor environment, including a system controller, a house-wide wiring network, communications protocols, standard interfaces for connecting other products, and basic user controls such as programmable wall switches and dual-tone multi-frequency telephone (Stauffer, 1991). The typical application areas of the smart home included security and safety, energy management, comfort control, communication services, and audiovisual entertainment (Lutolf, 1992). The application areas of the smart home are shown in Figure 1. The smart home during this period utilized wired smart

home devices (WDSHDs) for new construction only, and it and home automation included almost similar application areas, so automated homes can be seen as stepping stones to smart home devices.

The typical of areas	Description
Security and safety	Burglar alarm systems, safe operation of technical equipment or medical assistance in case of emergency
Energy management	Efficient use of energy and load management in heating, ventilation, air conditioning, and lighting applications
Comfort control	Programmable switching of lighting, shutters, blinds, doors, different kind of home appliances and their remote control
Communication services	Private branch exchange (PBX) and integrated services digital network (ISDN)
Audiovisual entertainment	Radio, television, video and hi-fi systems

Figure 1. The typical application areas of the smart home before the 1992 year

During the 1990s, Lutolf (1992) pointed out the smart home become more convenient to use with only one cable to connect all appliances and control elements together. In the past, these systems required three multiconductor cables installed during original construction instead of conventional house wiring. However, users still had to pay the considerable installation costs of the smart home (Harper, 2006). Stauffer (1991) showed smart home enabling systems during this period were intended mainly for new home construction, though a retrofit design was under development. Also, Harper (2006) said these smart services and devices lack motivation to improve productivity in domestic work and focus on stand-alone appliances in the design of new technology instead involving the users of the technology in the design process.

Moreover, during the 1990s, it was the first time that the concept of the smart home become popular culture. Smart home articles began to appear in lifestyle magazines such as *Boys' Life*, *Vanity Fair*, and *House Beautiful*. Also, the widespread diffusion of the high-speed Internet provided a great opportunity for the smart home to be popularized in the late 1990s. However, it was not the case until the late 2000s when smartphones were popularized (Yang, Lee, & Lee, 2018). People were still unready to welcome such uncertain technology into their own homes at the end of the 20th century (Harper, 2006).

At the beginning of the 2000s, neither home automation nor smart home had been widely adopted. Both of them were still located in high-end markets. ABI Research estimated that only 204,000 home automation systems were shipped globally in 2009 (Lucero & Burden, 2010). Brush et al. (2011) concluded four barriers that had to be overcome before home automation becomes broad acceptance.

(1) The high cost of ownership: The cost of ownership of home automation was too high, namely hardware and consulting fees. In addition to monetary cost, its installation required a high time cost. The management or maintenance was considerably hard for do-it-yourselfer (DIY) households, so most home automation adopters could only pay consultants to manage or maintain their system.

(2) Inflexibility: It was difficult for users to integrate different brands of devices with their home automation system. Also, perhaps one of the biggest challenges to broad adoption was the structural changes required to install home automation. Building or remodeling a house was an ideal time to install or put home automation systems in place, due to the installation of wiring.

(3) Poor manageability: The systems only iterated the same tasks following hard rules, so users could not adjust or change the set-ups of the systems. Besides, users usually felt frustrated when systems showed unreliable behavior or when faced with their complex user interfaces. Moreover, when encountering problems, users had to ask consultants for assistance because it was difficult for users to learn it. As a result, it also restricted users' ability to customize. Actually, not all of the consultants were reliable.

(4) Difficulty achieving security: Remote control was convenient for users, but it was also a double-edged sword due to the security of passwords. For example, door locks and cameras were not safe and convenient enough for users during this period.

During years in the 1990s and in the early 2000s, WDSHDs still faced many barriers. Barlow and Gann (1998) proposed some similar suggestions for future relevant smart home technologies. First, the smart home systems should be adapted to a variety of dwellings. Secondly, the industry had to offer solutions that satisfied real user needs. Secondly, smart home systems required to be tailored to individuals and household requirements. Thirdly, the solutions must provide ease of use, affordability, reliability, maintainability, upgradability, and ease of installation. These suggestions seemed to predict the success of wireless smart home devices (WLSHDs) and wire free smart home devices (WFSHDs) after the late 2000s.

When smartphones became popularized in the late 2000s, the smart home started to be installed (Yang et al., 2018). Also, Al-Qutayri and Jeedella (2010) showed the emergence of advanced wireless technologies played a vital role in offering possibilities to embed the various level of smartness in the home, such as Radio Frequency Identification (RFID), Bluetooth, and Wireless Fidelity (Wi-Fi). During this period, the developments of the wireless internet and smartphones have extended the concept of a smart home to services that can be remotely controlled

anytime and anywhere. Furthermore, innovative WLSHDs appeared. These innovations can be adapted to various types of residences and household appliances instead of only a new or remolding construction. Furthermore, advanced battery technology intrigued the development of WFSHDs. These WFSHDs did not require being wired up to a power supply because their battery life was long enough to meet practical uses.

After the year 2010, the smart home adopted AI technology to offer more intelligent services, such as Amazon's intelligent personal assistant "Alexa," Apple's AI speaker, and China smart home manufacturer "Xiaomi"(Yang et al., 2018). These AI devices make smart home services fulfill users' demands more by automatically detecting user behaviors or habits. Therefore, smart home services are developing and proliferating by adopting the internet of things (IoT) and artificial intelligence (AI). The evolution of smart home can be seen in Figure 2.

Year	Phase	Technical background	Main function
1990s	Home automation	Broadband Internet	Household automation
2000s	Home network	Smart phone and app	Remote monitoring & control
2010s	Smart home	IoT and AI	Context awareness

Figure 2. Evolution of smart home services(Yang et al., 2018).

2.1.2 The Wired Smart Home Devices (WDSHDs), Wireless Smart Home Devices (WLSHDs) and Wire Free Smart Home Devices (WFSMDs)

Before the 2010s, most of the smart homes had to be integrated into new or remodeled buildings. This study categorizes this kind of smart home devices into WDSHDs because most of them require pre-wiring work during construction or reconstruction. Although some have wireless transmitters and receivers, they still required to be wired in walls to build receiver modules. As a

result, few smart homes had been built and sold until around the year 2010. Individuals resisted WDSHDs because of the following reasons (Harper, 2006): (1) The initial investment of the smart home for consumers was high, so it restricted consumers in mainstream or low-end markets. (2) It was difficult and expensive for manufacturers to find solutions for retrofitting existing housing then networking a home during construction. (3) The smart home industry in Europe only focused on simple on-off switching systems for single applications. (4) Suppliers paid too little attention to understanding the need of users and usually emphasized technology-push products. As a result, the usability of these products was not evaluated well.

However, after the 2010s, a number of do-it-yourself (DIY) platforms were available to create a smart home system quickly and easily with a low cost but high performance, such as Wi-Fi and Bluetooth (Gunge & Yalagi, 2016). Consequently, plentiful new types of smart home devices emerged in the market, and the number of users adopting them increased rapidly. This study categorizes them into WLSHDs and WFSHDs because they are mostly or completely separated from electrical contacts. The former still require a power supply by being wired, but the latter can be installed on any surface with no wire or boxes inside the wall. Both of these advanced devices dramatically sped up the diffusion of smart home. Gunge and Yalagi (2016) concluded the following reasons why there are more adopters of WLSHDs and WFSHDs. (1) They saved cost of installation cables. (2) Wireless internet and mobile phones improved the convenience of smart control devices. (3) Because of the wireless internet, the smart home system becomes scalable and expandable. Users can install, update and expand smart devices by themselves. (4) Integrating both of them with houses can effectively improve home security. Bao, Chong, Ooi, and Lin (2014) also show that more Chinese people are adopting smart home because of the following factors. (1) They are familiar with smart home technologies (SHT). (2) Social influence affects the adoption of the

smart home positively since more people perceive its usefulness. (3) They perceive SHTs' ease of use. They can be integrated into the user's existing residence and household appliances. (4) The adoption of the smart home improves home security. Moreover, Wright and Shank (2019) illustrated that SHT was commonly applied to energy-saving measures in industries or firms. Wilson, Hargreaves, and Hauxwell-Baldwin (2017) showed that prospective users of SHTs have positive perceptions of the multiple functionalities of SHTs, namely managing energy use, controlling the domestic environment, and improving security. Also, the main value of SHTs focuses on cost, control, and convenience. Park, Cho, Han, and Kwon (2017) used the technology acceptance model (TAM) to evaluate user acceptance of IoT in a smart home environment and concluded that perceived compatibility and cost showed notable impacts on use intention. Therefore, innovative WFSHDs and WLSHDs significantly impact markets. They offer new and better incentives to attract consumers to adopt smart homes. These mentioned incentives are organized and demonstrated in Figure 3.

Incentive	Description
Affordability	WLSHDs and WFSHDs require easier installation and maintenance without arduous cabling and consulting fees.
Convenience	Wireless internet and mobile allow users to control WLSHDs and WFSHDs anytime and anywhere.
Compatibility	WLSHDs and WFSHDs can be compatible with consumers' existing household appliances and be adapted to a wide variety of dwellings.
Ease of use (Lower complexity)	Users are aware that it is easy to install, adjust, and use WFSHDs by themselves.

Flexibility	Consumers can install or extend WLSHDs and WFSHDs by themselves.
Automation	Advanced WLSHDs and WFSHDs have sensors that can detect human behavior to make suitable responses automatically.
Better performances	WLSHDs and WFSHDs offer better energy management, security, and usability.
Reliability	SHTs become more mature and reliable.
Familiarity	The concept of the smart home has existed for more than 30 years, so people begin to be familiar with WFSHDs.
Social influence	More people perceive the usability of the smart home.

Figure 3. The incentives to make more individuals adopt WLSHDs and WFSHDs

2.1.3 The Definition of Interim Product

According to the previous paragraphs, both of WDSHDs, WLSHDs and WFSHDs, can offer consumers similar product functions. Their main difference is that WDSHDs require a box and wire in the wall and is for a new or remodeling construction. In contrast, WLSHDs and WFSHDs are mostly or completely separated from electricity contacts and adapted to a wide variety of dwellings. Both of them have better incentives, so more consumers are willing to adopt them, such as better compatibility, affordability, and familiarity. WLSHDs and WFSHDs provide an alternate solution for consumers who are interested in smart homes. Users can combine them with their existing household appliances and house, and the combination can offer new features similar to WDSHDs. Therefore, WLSHDs and WFSHDs are called “interim products.” WDSHDs are their counterpart radical product. This study briefly defines interim product as “a product that

can substitute for an uncommonplace radical product by consumers because it overcomes negative factors, such as unaffordability, unfamiliarity, and/or incompatibility." When a radical product is not widely accepted due to some negative factors such as unaffordability, unfamiliarity, and/or incompatibility, an interim product can overcome these factors by using different technologies and offering an individual features similar to the radical product by combining it with a mainstream product to pass a period when the radical product is not popularized, as shown in Figure 4. However, this is only an initial definition. After investigating literature and conducting case study, this study offers the complete definition of term "interim product."

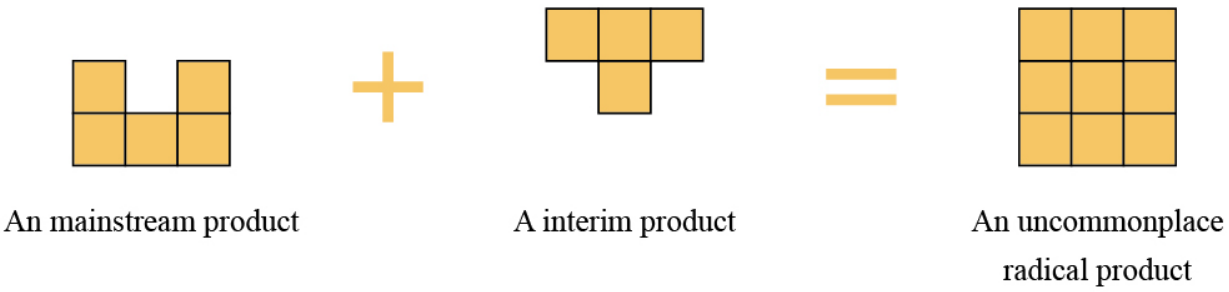


Figure 4. The concept of the definition of transition product

During this period, consumers can use an interim product to substitute for its counterpart radical product. For example, WLSHDs and WFSHDs can be substituted for WDSHDs to pass an "interim period" when WDSHDs are not commonplace. Consequently, an interim period is defined as "a period before an interim product's counterpart radical product become commonplace in markets." The concept of an interim period is shown in Figure 5.

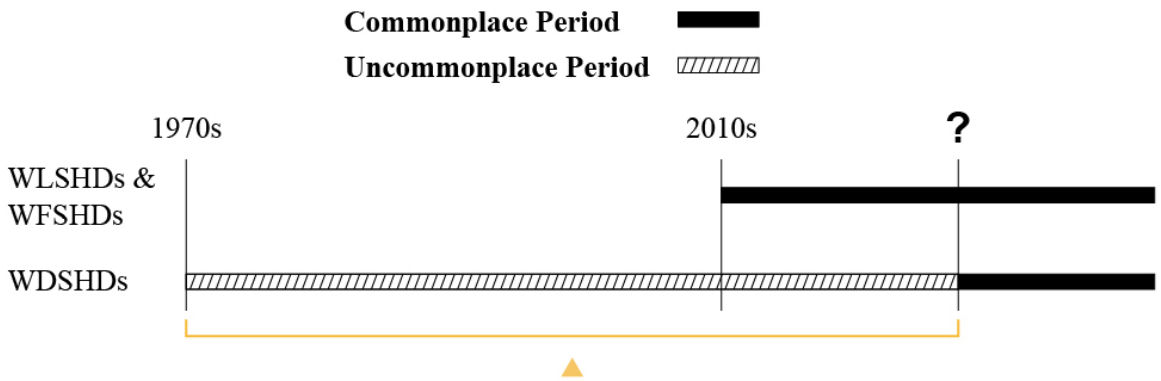


Figure 5. The concept of definition of interim period

Interim products are more inclusive than radical products. It helps more individuals have the capacity to get benefits similar to ones from uncommonplace radical products. However, fewer researchers study interim products. In the following paragraphs, this study investigates references about innovation to build a link between it and interim products.

2.2 Innovation

Innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption (Rogers, 2003). Successfully bringing innovations to markets is critical for most companies. However, it is a complex and challenging task, so many companies fail to launch their new products in the market. Before a new product successfully exists in a market, it can only be treated as a concept. A new product failure occurs only when the firm management abandons the concept before it becomes successful (Crawford, 1987). Many studies said the average product failure rate is more than or equal to 80 percent (Crawford, 1987; Schlossberg, 1990). However, Castellion and Markham (2013) showed that 80 percent figure of new product failure rates are as common as it is incorrect, and the real new product failure rate is around 40 percent. Baker and

Hart (2016) indicates a recent study notes the new product failure rate is lower than 80 percent, but companies still find ways to improve the success rate in new product development. Besides, many innovations require a lengthy period, often of many years and even decades, to be widely adopted (Rogers, 2010; Stoneman, 2001). Therefore, how to speed up the diffusion of innovations is a great challenge for firms. Diffusion is the overall spread of an innovation, the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003). Uncertainty is a primary obstacle to the diffusion of innovations because innovation's consequences may create uncertainty (Rogers, 2003). These consequences are unstable, and they might occur in an individual or a social system and cause a consumer to adopt or reject an innovation.

2.2.1 Innovation Type

Innovation refers to the creation of a product, service, or process (Veryzer Jr., 1998). From a firm's perspective, the definition needs to be more focused on commercial activities since innovation is defined as the application of new ideas to the products, which is perceived by the consumer as new (Ram, 1987; Rogers & Rogers, 1998). In this study, innovation is more related to commercial activities and the application of new ideas to products with a physical presence.

Innovations can be categorized into two main types, continuous and discontinuous innovation. The former has the connotation of improvement, evolution, increment. Lianto, Dachyar, and Soemardi (2018) propose the definition of continuous innovation, that is, as an innovation process and activity performed continuously, regularly, repeatedly, over an extended period, which results in beneficial impact for a company. On the contrary, for discontinuous innovation, there are numerous terminologies being used, such as "radical," "disruptive," "really

new innovation," "discontinuities" and so on. However, disruptive innovation and radical innovation are adopted more commonly (Tellis, 2006). Also, Leifer et al. (2000) classify innovations into incremental innovation and radical innovation. Incremental innovation usually emphasizes cost or feature improvement in existing products or services. In contrast, a radical innovation is a product or process with features having unprecedented performance or offering significant improvement in performance or cost that transform existing markets or create new ones (Dosi, 1988). Radical innovations refer to products and processes that result from advances in knowledge (Mole & Elliott, 1987). Innovation radicalness refers to the extent to which an innovation differs from existing alternatives (Knight, 1967). Slater et al. (2014) show radical product innovations can provide unprecedented customer benefits, substantial cost reductions, or the ability to create new businesses. However, this study focuses on radical products with unparalleled benefits because they are exclusive. Only customers in high-end markets have a capacity to adopt them and assume uncertainties. Moreover, Dahlin and Behrens (2005) conclude three criteria for identifying an innovation as radical;

- Criterion 1: The invention must be novel: It needs to be dissimilar from prior inventions.
- Criterion 2: The invention must be unique: It needs to be dissimilar from current invention.
- Criterion 3: The invention must be adopted: It needs to influence the content of future invention.

Researchers argue radical innovations are more critical to firms and societies than incremental innovations because they are able to create completely new industries and destroy existing ones(Golder, Shacham, & Mitra, 2009). Radical innovations change the relationship between customers and suppliers, restructure marketplace economics, displace existing products and create completely new product categories. However, Montaguti, Kuester, and Robertson

(2002) and Leifer et al. (2000) argue that higher uncertainty and complexity involved in radical product innovation make it difficult to shorten product development time, compared to incremental innovations.

A large amount of research deals with how to represent the levels of innovation. Crawford (2008) discuss three levels of innovation: pioneering, adaption, and imitation. This scheme categorizes innovation based on the degree to which technology is applied in a new way and to some extent the degree to which it is based on an existing product. Kleinschmidt and Cooper (1991) also categorize innovations into three levels, high, medium and low. However, discontinuous innovation is based on new technology and aimed at a unfamiliar market (Meyers & Tucker, 1989). Veryzer Jr. (1998) proposes a useful way of representing innovation that is shown in Figure 6. Two critical dimensions are used in it to delineate the various levels or degrees of innovation, a technological capability and a product capability. According to Veryzer Jr. (1998), the technological capability dimension refers to the degree to which the product involves expanding product functions beyond existing boundaries; the product capability dimension refers to the benefit(s) of the product as perceived and experienced by the customer or user. Cooper, Edgett, and Kleinschmidt (2001) also use two dimensions, product newness and market newness, to evaluate innovation and make strategic portfolio approach for funding allocation (Figure 7). Furtherly, discontinuous innovations are categorized into disruptive innovation and radical innovation. However, these two innovations have some similar characteristics and cause a little confusion (Hang, Neo, & Chai, 2006):

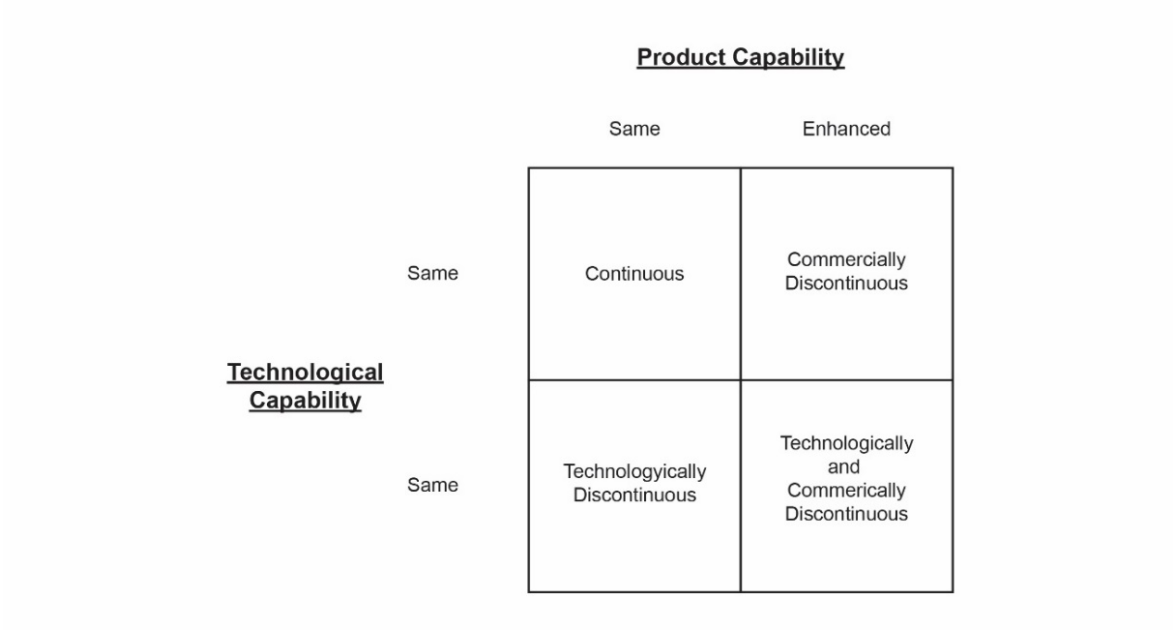


Figure 6. Types of product innovation

	Low Market Newness	**High Market Newness**
Low Product Newness	Improvement to Existing Products (35%)	Additions to Existing Product lines (20%)
Medium Product Newness	Cost Reductions (20%)	New Product Lines (15%)
High Product Newness	Repositioning (20%)	New-to-the World Products (4%)

Figure 7. Portfolio management for new products

(1) They are discontinuous innovations and have too much uncertainties and risks for incumbent companies, so the companies prefer to develop continuous or incremental innovation to get short- and medium-term growth.

(2) It is extremely difficult for companies to execute them.

(3) They face tremendous market uncertainty. For example, new customers need to be cultivated and discovered. Also, conventional market surveys would not generate meaningful results.

(4) When they are developed, they frequently accompany a need of innovative business model.

In order to identify radical innovation and disruptive innovation, Christensen, Raynor, and McDonald (2015) showed unique characteristics of disruptive innovations:

(1) Disruptive innovations originate in low-end or new market footholds and are aimed at the most profitable and demanding customer with ever-improving product and services.

(2) Disruptive innovations are initially considered inferior by most of an incumbent's customers. They do not catch on with mainstream customers until their quality catches up to their demands.

Reinhardt and Gurtner (2015) conclude two points of disruptive innovations. First, not all disruptive innovations have a lower price but introduce an additional performance dimension, compared to existing solutions. Second, disruptive innovations imply not only a higher level of newness because of a new performance dimension but also increase the adoption risk for customers.

On the other hand, Norman and Verganti (2014) argued radical innovations are driven by technology changes, without any design research or formal analysis of needs. Hang et al. (2006) point out the characteristics of radical innovations:

(1) Radical innovations are driven mainly by technological breakthroughs.

(2) Radical innovations typically enter the marketplace at the higher-end where performance is more important than cost.

(3) It is similar to the idea that radical innovations cause any incumbents which are ill-prepared for the technological breakthrough to be paralyzed completely.

(4) Incumbents having abilities to develop radical innovations are large established companies because these innovations take more time and excessive resources, compared to disruptive innovations.

In conclusion, radical innovation addresses the high-end niche market initially and are driven by technological breakthroughs. Continuous or incremental innovations are aimed to the mainstream market and based on cost or feature improvement. Disruptive innovations are targeted specifically at low-end or new market footholds and are amid the most profitable and demanding customers with ever-improving product and services. The concept of innovation is shown in Figure 8.

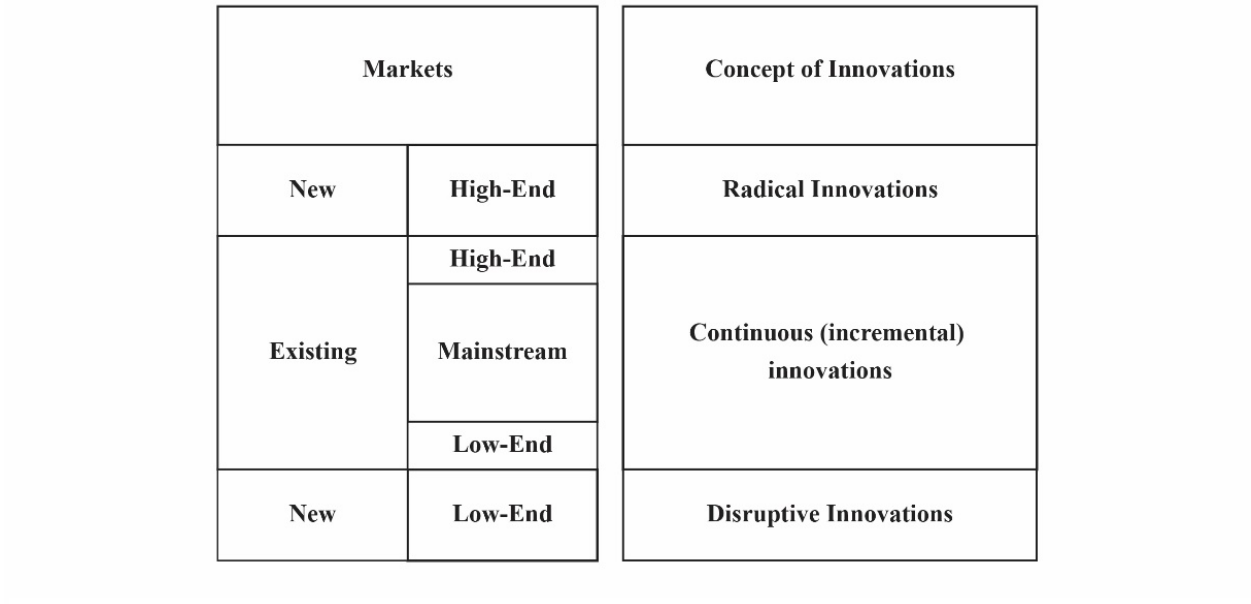


Figure 8. The concept of innovations

Furthermore, Verganti (2008) categorize innovations into four types, through the two dimensions of technology and meaning changing, as shown in Figure 9:

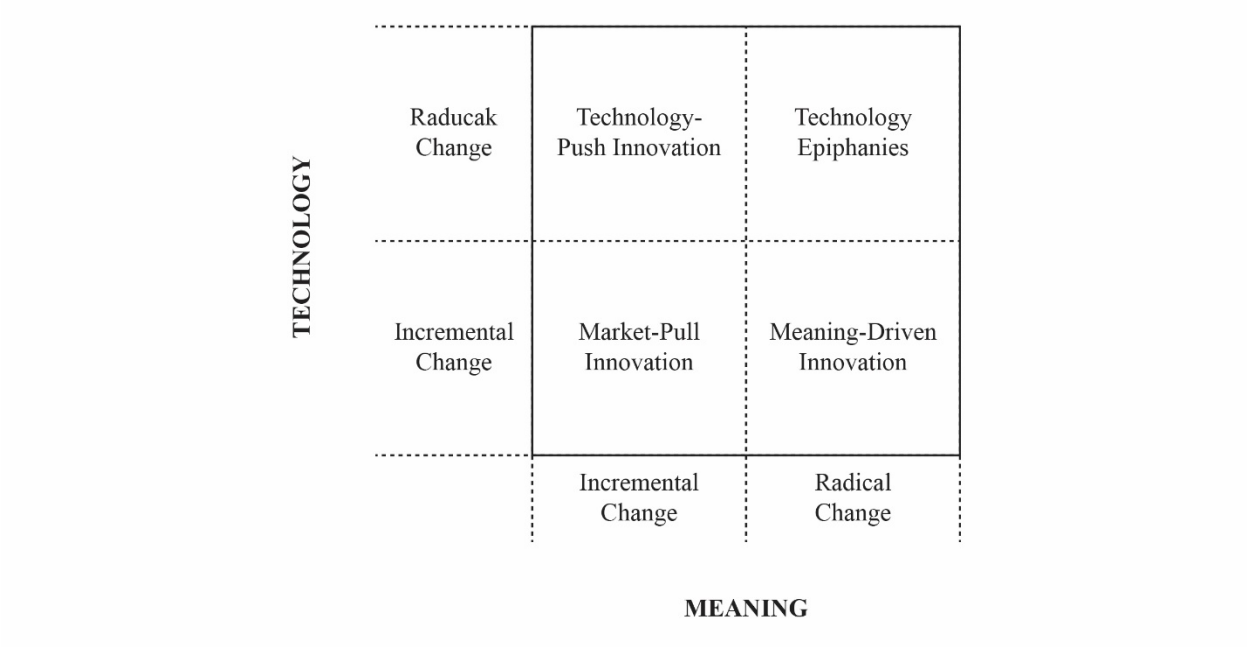


Figure 9. The two dimensions and four types of innovation.

1. *Technology-push innovation* comes from radical changes in technology without any change in the meaning of products, such as the invention of color television set, compared to the existing black and white sets.
2. *Meaning-driven innovation* starts from the comprehension of subtle and unspoken dynamics in socio-cultural models and results in radically new meaning and languages—often implying a change in socio-cultural regimes. Taking the invention of the mini skirt in the 1960s as example, it was not a different skirt, but a radically new symbol of women's freedom.
3. *Technology epiphanies* bring a radical change in meaning, enabled by the emergence of new technologies or the use of existing technologies in totally new contexts.
4. *Market-pull innovation* starts from an analysis of user needs and then develops products to satisfy them.

Most radical innovations are driven by technology instead of market factors, which mainly drive incremental innovations (Dell'Era, Marchesi, & Verganti, 2010). However, there is the third type of innovation, design-driven innovation. Design-driven innovation offers its users radical innovation of meaning (Verganti, 2009), as shown Figure 10. Design-driven innovations with a different and unexpected meaning make consumers feel better than existing solutions. The meaning, unsolicited, is what people were actually waiting for. Take Wii as an example. Wii stimulated active physical entertainment and overturned the meaning of game consoles, compared to Sony PlayStation 3 and Microsoft Xbox360 with more-powerful graphics and performance (Verganti, 2009).

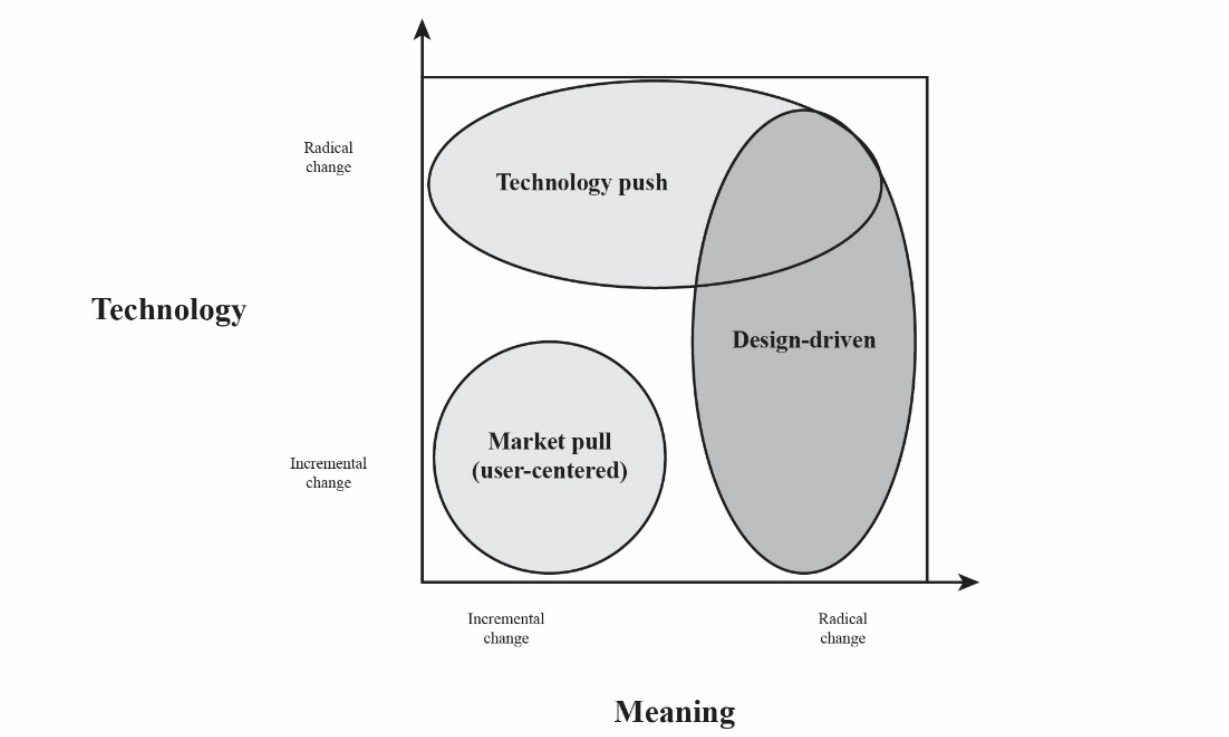


Figure 10. The strategy of design-driven innovation as the radical change of meanings

2.2.2 Interim Innovation

However, there exist numerous anomalies which cannot be accurately accounted for in the current categorization. These anomalies are interim products. Take SHT as an example. Now, WDSHDs are equipped with advanced technologies and have high cost. They are only installed in a new or remodeling construction by professional consultants. On the other hand, WDSHDs allow users to pay zero effort, get complete and systematic solutions and have ongoing maintenance and support. Consequently, the most adopters of WDSHDs are in high-end market. As a result, based on these characteristics, WDSHDs are categorized into radical innovations. In contrast, sophisticated wireless internet and smartphone technology boost the development of WLSHDs and WFSHDs. They allow users to install them by themselves and integrate them into their existing residence. Both of them also reduce cost substantially, compared to WDSHDs, but offer similar smart home functions. For instance, people can buy a smart light switch to install in their existing residence, and then it can offer users a remote-control function. Installing Google Nest can make an existing home provide an energy management feature by connecting with wireless internet. However, although they adopt new technology, they are aimed at consumers in mainstream market or even low-end market. Moreover, WLSHDs and WFSHDs are fairly less costly than WDSHDs. One of the capacities of radical innovations is to reduce substantial cost and furtherly replace with previous radical products and even become mainstream products (Slater et al., 2014). However, WLSHDs and WFSHDs do not substitute for WDSHDs. WDSHDs have a solid position in high-end markets. As a result, WLSHDs and WFSHDs are not categorized into radical innovations. Both of them are similar to alternative solutions for WDSHDs.

Based on the mentioned characteristics of WLSHDs and WFSHDs, they do not belong to any existing categorizations of innovations. Interim products are designed with a certain degree of technology. They are aimed at users among mainstream, high-end and even low-end markets if the cost of a product is low enough for consumers in low-end markets to afford. These individuals are interested in or curious about radical innovations, but there might be other factors causing them not to adopt radical innovations immediately. For example, they might not be able to afford radical innovations' costs or be unwilling to take risks of uncertainties related to innovations. Also, they are likely to adopt interim products because they are compatible with their current life. Therefore, this study proposes an entry strategy related to a new technological innovation framework based on features, performances, price and time. This study defines "an interim innovation is invented by referring to a radical innovation to offer similar unprecedented functions but more inclusive and compatible with current life." It distinguishes itself through the direct market entry into the mainstream, high-end and even low-end markets through a new intermediate category, which this study calls interim innovation. Most interim innovations might be eliminated through competition with their counterpart radical innovations after the latter goes through a cost-reduction trajectory and receives the most attention from markets. The final aim of an interim innovations is to quickly and temporarily achieve market domination, so it might be possible to enter the mainstream, high-end and even low-end market directly and attract

innovative customers among these three markets. The concept of interim innovation is shown in Figure 11. Furthermore, Kline and Rosenberg (2010) show that success in innovation demands not only the right cost and performance combination, but also judging just when the timing is right for the product's introduction. Norman and Verganti (2014) also show innovations should be launched at the correct time to prevent failures because social determinism plays a major role in diffusion innovation. Most existing interim innovations are commercialized later than their counterpart radical innovation, so this timing helps them overcome some uncertainties. Consequently, they enter markets easier than radical innovations.

However, there are still many confusions about interim innovations. Therefore, this study will continue to discuss the characteristics of innovation in the following paragraphs. Also, this study defines the term of interim innovation completely in the following.

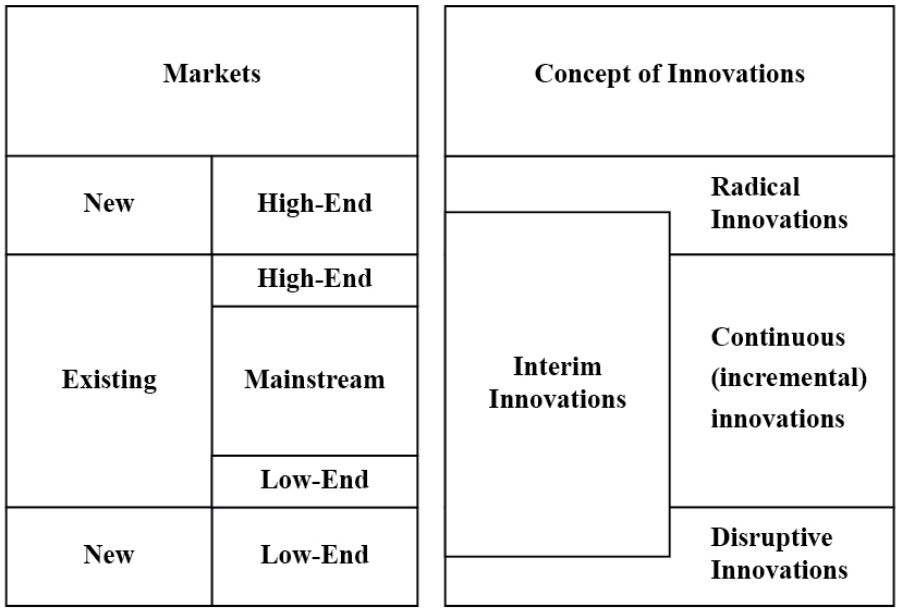


Figure 11. The concept of interim innovation

2.2.3 The Adopter of Innovation

defined innovativeness was defined as "the degree to which an individual is relatively earlier in adopting an innovation than other people," (Midgley & Dowling, 1978; Rogers & Shoemaker, 1971, p. 27) instead of perceiving an innovation earlier. According to Hirschman (1980), an individual with innovativeness means he or she desires to not only acquire new information but also adopt a new product. Other study shows consumer innovativeness is often viewed as a personality trait reflecting a willingness to change (Hurt, Joseph, & Cook, 1977). It is crucial for firms to succeed in commercializing innovations, so revenue from new products adopted by innovative consumers plays a critical role for many companies (Cowart, Fox, & Wilson, 2008). Innovative consumers are aimed at by these companies wanting to launch and market new products successfully. San Martín and Herrero (2012) investigated users' psychological status during the process of adoption of new information technologies; they proposed the more innovative the individual is in the technological area, the higher his/her intention is of using the new technology in the future. Therefore, more and more firms make efforts to understand and research consumer innovativeness to contribute to their new products. From a firm's perspective, the innovation process can only be considered a success when the innovation is accepted and integrated into users' lifestyles. Also, target adopters demonstrate commitment by continuing to use the product over a certain period (Bhattacherjee, 1998).

Rogers (2003) defined the adopter categories as "the classifications of members of a social system depend on innovativeness." This classification includes (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards. Sometimes, a sixth group is added: (6) non-adopters. For Rogers, innovativeness helped in understanding the desired and main behavior in the innovation-decision process. Figure 12 shows the distribution of adopters is a normal distribution.

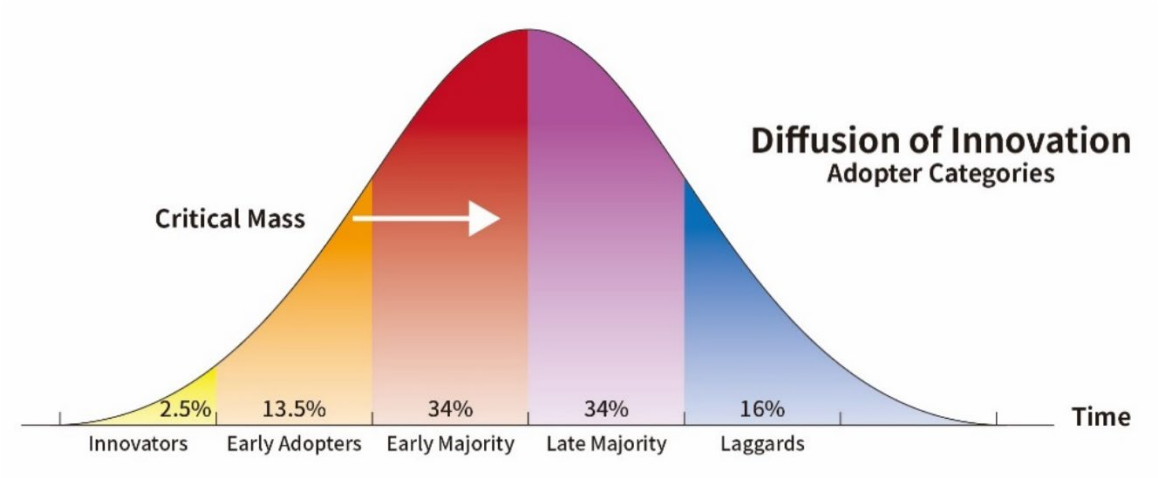


Figure 12. Adopter Categorization on the Basis of Innovativeness (Rogers, 2003)

However, when WLSHDs and WFSHDs had just launched, they diffused faster than WDSHDS. There might be more innovators and early adopters. Consequently, the diffusion of interim innovation might be different from the diffusion of normal innovation. The distribution of the adopters of interim innovation is shown in Figure 13.

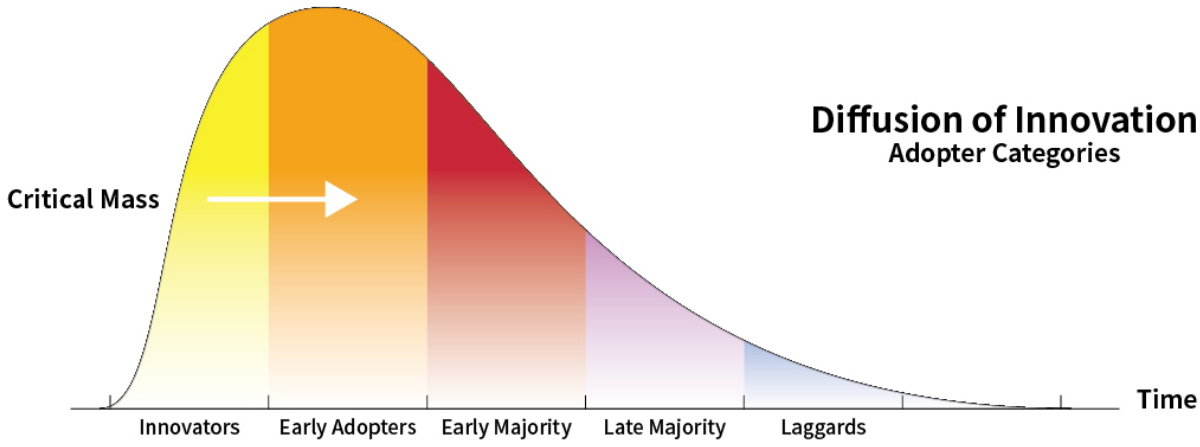


Figure 13. The Adopter of Interim Innovation Categorization on the Basis of Innovativeness

Many studies have focused on variables that explain the attributes of early adopters. For instance, early adopters normally have higher income, higher education, and are younger; and have greater social mobility and a favorable attitude toward risk (adventuresome); greater social participation, and higher opinion leadership (Gatignon & Robertson, 1985). Im, Bayus, and Mason (2003) analyzed the relationship between innate consumer innovativeness and new product adoption behavior. They found that income and age, in combination with innate consumer innovativeness, have an obvious link with the ownership of new consumer electronics products. According to Im et al. (2003)'s research, age and income are major factors in the adoption of new products. Szmigin and Carrigan (2000) suggested that the cognitively young older consumer was most likely to be an innovator since they normally have higher socio-economic status. Kaya (2017)

shows the characteristics of innovators and early adopters include high economic value, high opinion leadership, positive technology orientation, and have more prior experience, more network, more knowledge, and high technical skills. In conclusion, income, age and knowledge of technology play pivotal roles in influencing consumers to adopt innovations. Moreover, some researchers investigate the differences among the early adopters of different type of innovations. The early adopters of disruptive innovation possess more in-depth knowledge of the product category than later adopters; in contrast, early adopters of sustaining innovations do not feel more knowledgeable than later adopters, but are more involved in the product category than early adopter of disruptive innovations because of enthusiasm about prior product generation (Goldsmith & Newell, 1997; Reinhardt & Gurtner, 2015).

2.2.4 The Success of Innovation

Why do some innovations succeed in the market, but others do not? Cooper and Kleinschmidt (1987) showed firms must make effort in the search for a differentiated product with significant customer benefits. These benefits could be categorized into four types: (1) a customer-oriented product; (2) a high-quality product; (3) a product offering users unique benefits; and (4) a product that addresses customers' problems or performs a unique task. Moreover, before developing a new product, defining a project well is critical for firms to succeed, included (1) a clear target market, (2) customers' needs, wants, preferences, and product requirements, (3) the expected type and function of product, and (4) the product's specifications and requirements (Cooper & Kleinschmidt, 1987).

2.2.5 The Innovation-Decision Process

Rogers (2003) studied how individuals make decisions about innovation adoption and described the innovation-decision process as "an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation" (p. 172). The innovation-decision process contains five steps: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. These stages typically follow each other in a time-ordered manner (Rogers, 2003). This process is shown in Figure 14.

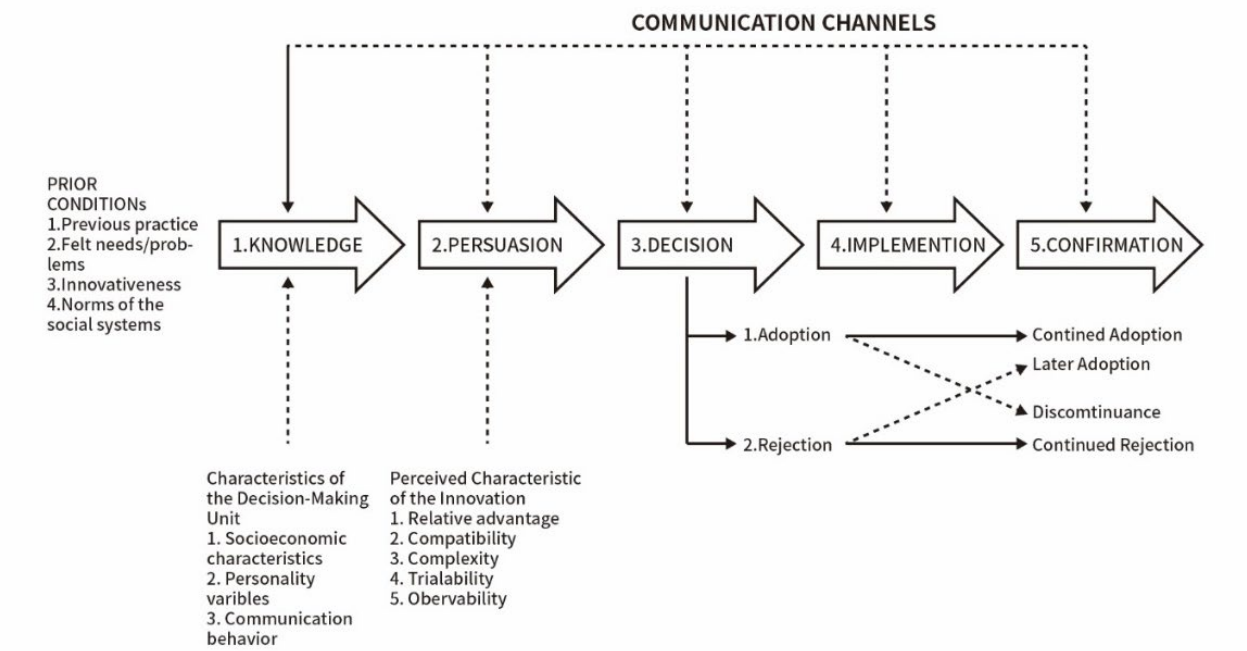


Figure 14. A Model of Five Stages in the Innovation-Decision Process (Rogers, 2003)

The following paragraphs illustrate these five steps separately and in detail. Also, this study compared the differences between usual innovations and interim innovations when consumers face them during the innovation-decision process.

- *The Knowledge Stage*: The innovation-decision process begins with the knowledge stage. In this step, an individual learns about an innovation. During this phase, the individual attempts to determine "what the innovation is and how and why it works" (Rogers, 2003). However, interim innovations might be different from other innovations in this stage. Take WLSHDs and WFSHDs as an example. They evolved from WDSHDs, so they have similar main features. Consequently, individuals might be more familiar with them and willing to adopt WFSHDs immediately when they are launched.
- *The Persuasion Stage:* The persuasion step occurs when the individual has a negative or positive attitude toward the innovation, but "the formation of a favorable or unfavorable attitude toward an innovation does not always lead directly or indirectly to adoption or rejection" (Rogers, 2003). After an individual understands the innovation fully, he or she shapes his or her attitude.
- *The Decision Stage:* At the decision stage, the individual decides to adopt or reject the innovation (Rogers, 2003). If individuals can try an innovation, it might be usually adopted more quickly because most of them want to test out innovation in their own situation before making an adoption decision. Consequently, if an innovation can offer provide better trialability for consumers, it can diffuse faster. It seems that some interim innovations have better trialability compared to other innovations. Take WLSHDs and WFSHDs as an instance. Consumers can spend less money to experience WFSHDs, compared with WDSHDs, so the former might diffuse faster due to better trialability.
- *The Implementation Stage:* At the implementation stage, an innovation is put into practice. However, an innovation brings the newness in which "some degree of uncertainty is involved in diffusion" (Rogers, 2003). An implementer might still face

uncertainty about the outcomes of the innovation at this stage. Thus, the implementer may need technical assistance to reduce the degree of uncertainty in the process of implementation.

- *The Confirmation Stage:* At the confirmation stage, the innovation-decision already has been made, but the individual decides to continue or discontinue adopting the innovation or discontinue doing it. Rogers (2003) showed depending on the support for adoption of the innovation and the attitude of the individual, later adoption or discontinuance occurs during this stage.

2.2.6 Innovation Resistance

Innovations would benefit human beings, but they also force individuals to learn new skills and knowledge or change their current lifestyle. Because of it, individuals might create innovation resistance (Ram & Sheth, 1989). Kuisma et al. (2007) said rejection is different from resistance and defined both terms. Rejection is defined as a passive form of behavior resulting in an ultimate decision not to adopt or to ignore an innovation. Resistance, on the other hand, is regarded as an active behavior, which may occur in every adoption process but does not necessarily result in non-adoption, as shown in Figure 15. In addition to rejection, Szmigin and Foxall (1998) showed resistance to an innovation has other two forms, postponement and opposition. The former refers

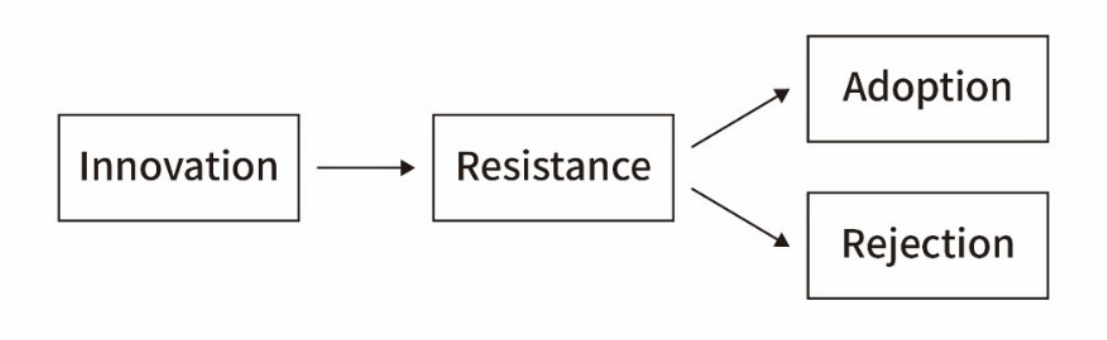


Figure 15. The relationship between resistance and rejection (Kuisma, Laukkanen, & Hiltunen, 2007)

to postpone the adoption decision to the future, whereas the latter refers to protesting the innovation or searching for further information after the trial.

Resistance is the general consumer response to an innovation. Adoption may begin only after initial resistance has been overcome (Ram, 1987). In other words, some resistance always exists before adoption. Moreover, adoption and resistance may also coexist. Also, resistance and ultimate rejection may occur at any stage of the adoption process. Consequently, identifying the reasons generating resistance is the key to succeed in diffusing innovations.

2.2.7 Innovation Barrier

Ram and Sheth (1989) concluded that customers encounter several barriers that paralyze their desire to adopt innovation, and these barriers can be categorized into two groups: functional and psychological barriers. These barriers also are factors to generate consumer resistance to innovation. Functional barriers include three areas: product usage, product value, and risks related to product usage. These barriers are more likely to occur if consumers perceive considerable changes from adopting innovations. The psychological barriers result from two reasons: the traditions and norms of the customers, and perceived product image. These barriers are more

frequently built through conflict with customers' prior beliefs. These barriers are shown in Figure 16. Next, this study specifies these barriers.

Functional barriers	
Usage barrier	Innovation's incompatibility with consumer's practices or habits
Value barrier	Innovation's inability to produce economic-or performance-based benefits
Risk barrier	(1) Physical risk (2) Economic risk (3) Functional risk (4) Social risk
Psychological barriers	
Tradition barrier	Magnitude of change caused by the innovation
Image barrier	Negative image related to the innovation

Figure 16. Barriers to innovation adoption (Ram & Sheth, 1989)

- *Usage Barrier:* An innovation not compatible with consumers' existing workflows, practices, or habits is the most common reason why consumers set up innovation resistance (Ram & Sheth, 1989). Consumers require a relatively long development process before accepting an innovation because innovations create changes in the consumers' day-to-day existence and disrupt their established routines. For example, Kuisma et al. (2007) showed internet banking had been widely adopted in developed countries, but many people do not still adopt it because many of them prefer the old routine of ATM use and do not wish to change their current lifestyle. Moreover, tofu is another product erecting usage barriers to American consumers (Ram & Sheth, 1989) since cooking it requires considerable efforts and time. As a result, tofu manufacturers

have succeeded in coping with these this barrier by processing and packaging the product in the form of ready-to-eat frozen dessert.

- *Value Barrier:* This barrier depends on an innovation's value. If an innovation offers a strong performance-to-price value compared with product constitutes, consumers will have a great incentive to adapt to the changes of innovation adoption (Molesworth & Suortti, 2002; Ram & Sheth, 1989). For instance, Laukkanen, Sinkkonen, Kivijarvi, and Laukkanen (2007) proposed mobile banking might also be perceived by consumers to be too expensive. As a result, some mobile banking services intensify customers' feelings of control over financial affairs (Laukkanen & Lauronen, 2005). Therefore, when an innovation cannot offer strong performance-and-price value compared with product substitutes or be based on new technologies, which usually create high discontinuity, consumers have resistance to innovation (Ram & Sheth, 1989).
- *Risk Barrier:* All innovations, to a certain extent, exist uncertainty and have potential and unpredictable side effects (Ram & Sheth, 1989). Customers who are aware of the risks might put off adopting an innovation until they can be more familiar with it. For example, when beginning internet users buy an automobile in online stores, they might worry about uncertainty, such as the quality and availability of serving and after-sale support (Molesworth & Suortti, 2002). The uncertainty creates a risk barrier for consumers. It implies that risk reduction strategies will play a key role in diminishing consumer resistance toward innovations (Kleijnen, Lee, & Wetzels, 2009). Ram and Sheth (1989) concluded risk barrier contain four types.
    1. Physical risk: An innovation might harm customers or their properties, such as new drug or chemical fertilizer with side effects.

2. Economic risk: The higher the cost an innovation has, the higher customers are likely to perceive economic risk, such as the latest high-tech product.
3. Functional risk: Customers usually worry about an innovation's performance uncertainty if they cannot test it.
4. Social risk: Customers may resist an innovation since adopting it causes them to experience social ostracism, discrimination, or peer ridicule.

- *Tradition Barrier:* The first psychology barrier is related to cultural change. If an innovation requires customers to shift from their established norm or tradition, it will be resisted (Ram & Sheth, 1989). Some non-adopters resisting mobile banks are unwilling to change the status quo or even to learn new ways of action due to the habitual use of ATMs (Kuisma et al., 2007). Evanschitzky, Eisend, Calantone, and Jiang (2012) point out that consideration of national culture is important when firms attempt to improve success rates of new product development.
- *Image Barrier:* It is related to the origin of an innovation such as product class, industry, brand, or the name of a company (Ram & Sheth, 1989). Kuisma et al. (2007) said some non-adopters usually bear markedly negative images regarding mobile banks and are against the trend of moving services onto the Internet.

2.2.8 Strategies for Breaking the Innovation Barriers

Ram and Sheth (1989) proposed that strategies for breaking the barriers can be grouped into five categories: product strategy, communication strategy, pricing strategy, market strategy, or coping strategy. A summary of these strategies is shown in Figure 17. As can be seen, most of

the strategies relate directly to the product or the use of communication. Ram and Sheth (1989) showed customer resistance to usage barriers can be reduced by the use of one

Source of Resistance (Barrier)	Marketing Strategy Product Strategy	Communication Strategy	Price Strategy	Market Strategy	Coping Strategy
Functional Barriers					
1.Usage Barrier	Develop a system perspective (packaging) Integrate innovation with preceding activity (packaging)			Mandate usage (market development)	
2.Value Barrier	Improve product performance (modification and development) Improve produce positioning		Reduce price by lowering costs		
3.Risk Barrier	Use a well-known brand name	Elicit endorsements and testimonials		Facilitate trial (increase market exposure)	
Psychological Barriers					
1.Tradition Barrier		Educate customers Use change agents			Understand and respect traditions
2.Image Barrier	Borrow a good image (brand name)	Make fun of negative image Create a unique image			

Figure 17. A Classification of Marketing strategies to Overcome Consumer Resistance to Innovation (Ram & Sheth, 1989)

of three strategies: developing a system perspective, integrating the innovation with preceding activity, and mandating usage through governmental legislation. Value barriers can be reduced through one of three strategies: improving product performance, positioning the product successfully, and lowering price to the consumer through cost efficiency.

Risk barriers can be lowered with the following strategies: using a well-known brand name, eliciting endorsements and testimonials from users, and facilitating product trials. Recently, some research shows an increase in familiarity by bundling a radical and an incremental innovation is helpful to reduce risk barriers. Crowdfunding campaigns that feature more radical innovativeness are generally costly to learn about, less beneficial and riskier for crowd funders and, therefore, attract less funding; in contrast, campaigns with greater incremental innovativeness offer more consumption benefits and result in favorable funding outcomes, as these campaigns are familiar, beneficial, and feasible (Chan & Parhankangas, 2017). When a radical product is bundled together with a complementary existing product, it creates a context in which consumers recognize the relationship between the products (Reinders, Frambach, & Schoormans, 2010). Apparently, the decrease in distance between radical and familiar products enable customers to recognize the utility of the innovation. This study supposes that interim products bundled with existing mainstream products more deeply than their counterpart radical products might reduce their usage barrier. However, Reinders et al. (2010) point out product bundling might cause negative effects on comprehensive, evaluation and adoption intention when consumers perceive a lower fit between the products in a bundle. Also, product bundling only positively influence customers with lower prior knowledge because others with high prior knowledge in a product domain think that they already know how a new product works and therefore tend to more selectively process information and rely more on self-generated inferences.

Tradition barriers can be transcended by educating consumers and using agents. Sometimes, respecting and realizing the traditions and norms of users is the best solution to overcome tradition barriers. Strategies for overcoming image barriers are borrowing a good image (such as a known brand name), or make fun of the negative image for the innovation. These strategies for innovations are also beneficial for interim products to diffuse. This study discusses the relationship between them in the following chapters. Moreover, Ogawa and Piller (2006) concluded that there some companies that integrated consumers into their design process to meet customers' requirements and avoid costly product failures, but some companies, such as specialized industrial markets and manufactures, hardly carry out the process this way.

2.2.9 The Characteristics of Innovation

Rogers (2003) described the innovation-diffusion process as "an uncertainty reduction process," (p. 232) and he proposes the attributes of innovations that help to decrease uncertainty about the innovation. Rogers (1983) analyzed and perceived consumers in the United States, and then organized five characteristics which help to explain their different rate of innovation adoption. Five attributes of innovations are (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability;

1. *Relative advantage:* Rogers (2003) defined relative advantage as "the degree to which an innovation is perceived as being better than the idea it supersedes" (p. 229). Advantages considered can be economic, social, or utilitarian factors. The greater the relative advantage of an innovation has, the more rapid its rate of adoption is. However, only having the relative advantage does not guarantee widespread adoption (Oldenburg & Glanz, 2008). Moreover, according to user groups' needs and the given perceptions, there

are different rules for what constitutes a relative advantage (Robinson, 2009). MacVaugh and Schiavone (2010) point out making new technology considered useful in the individual, community, industry or market domain is beneficial to its adoption.

2. *Compatibility:* Rogers (2003) stated that "compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (p. 15). Bao et al. (2014) showed since present smart homes have better compatibility and fit users' current life more, more consumers are willing to adopt them. If an idea is incompatible with consumers' values, norms, or practices, it will not be adopted as rapidly as a compatible innovation. MacVaugh and Schiavone (2010) also show when new technology meets the significant technological, social, and learning conditions, this connection encourages its adoption by reducing the risk of low and slow user adoption due to radical innovation.
3. *Complexity:* Rogers (2003) defined complexity as "the degree to which an innovation is perceived as relatively difficult to understand and use" (p. 15). The complexity of an innovation, as perceived by members of a social system, is negatively related to its rate of adoption.
4. *Trialability:* Rogers (2003) "trialability is the degree to which an innovation may be experimented with on a limited basis" (p. 16). An innovation that is a trialable creates less uncertainty for the potential adopters. If people can trial an innovation, then the uncertainty of the outcome is reduced, which leads to a more positive reception of the innovation. Hayes, Eljiz, Dadich, Fitzgerald, and Sloan (2015) showed trialability is the most important individual factor influencing the hospital's adoption of innovation

through computer simulation. In the study, the intended users commented trialability saves them from making mistakes and gives them confidence when facing the innovation.

5. *Observability:* Rogers (2003) defined observability as "the degree to which the results of an innovation are visible to others" (p. 16). The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Hayes et al. (2015) displayed the use of the animated computer simulation program allowed staff to not only discuss their opinions but also quickly see the expected result of changes that are highly likely to happen after innovation adoption.

In conclusion, Rogers (2003) mentioned that if an innovation provides adopters more relative advantages, compatibility, simplicity, trialability, and observability, it will be adopted faster than other innovations.

However, based on a different type of a new product or service, researchers add the characteristics of innovation to investigate it. Al-Jabri and Sohail (2012)'s past research on understanding the adopters of mobile banking mainly relies on considering mobile banking as a technological innovation. In addition to the five mentioned characteristics, they took perceived risk into consideration.

- *Perceived risk:* This attribute refers to the degree of risks in using an innovation (Al-Jabri & Sohail, 2012, p. 382; Ram & Sheth, 1989). Adopting mobile banking has perceived risks, such as the threat of privacy and security concerns, the fear of loss of PIN codes, and the hackers (Al-Jabri & Sohail, 2012). Therefore, perceived risk is more likely to affect mobile banking adoption negatively.

Moreover, Chang, Fu, and Jain (2016) add familiarity as mediators to evaluate the online shopping behavior because consumers who are more familiar with a product or website and have lower

perceived risk may have a greater intention to purchase online . Also, when consumers are more familiar with a particular product, they tend to seek new information more actively to update their knowledge of the product category (Johnson & Russo, 1984).

- *Familiarity*: According to Gefen, Karahanna, and Straub (2003), familiarity is defined as the degree to which one comprehends an entity.

2.2.10 The Application of Innovation Diffusion Theory (IDT)

This study organizes some past studies related to the application of IDT because this study is going to adopt IDT to evaluate the characteristics of interim products in the chapter of the research method.

IDT in the context of innovation is crucial because an innovative product or idea affects different levels of stakeholders: individuals, communities, organizations, and countries, regardless of the form of innovation (Lee, Hsieh, & Hsu, 2011). Since IDT has been applied to various disciplines, including marketing, economics, sociology, and technology management, the notion of innovation has been related to new products, ideas, services, methods, and inventions.

Al-Jabri and Sohail (2012) studied many factors affecting mobile banking adoption, analyzed actual mobile banking users based on IDT, and concluded that relative advantage, compatibility, and observability have a positive influence on adoption. However, Al-Jabri and Sohail (2012) made two conclusions: (1) perceived risk harms adoption, so bankers must search for approaches to reduce risk perceived by their customers by offering specific guarantees protecting them and taking their complaints seriously and urgently; and (2) the findings cannot be generalized since the majority of the sample size is young respondents, between 18 and 25 years old.

Lee et al. (2011) combined IDT with the technology acceptance model to evaluate business employees using the e-learning system in Taiwan. This study employed the five characteristics of innovation as determinants to evaluate perceived usefulness, perceived ease of use, and behavioral intention to use. The research result helped system developers, designers, and institutional purchasers of e-learning systems carefully consider the needs of employees and ensured that selected systems effectively meet these demands (Lee et al., 2011).

However, Lyytinen and Damsgaard (2001) mentioned IDT misses some important facets in the diffusion of complex technologies. Therefore, researchers should cautiously apply IDT to technological innovations, such as recognizing the complex, networked, and features of technology, focusing on process features (including histories) and key players in the diffusion arena. Consequently, Lyytinen and Damsgaard (2001) proposed a guideline to innovation diffusion theory researchers when they study complex networked technologies.

1. Seek to understand the local complex, networked, and learning-intensive features of technology.
2. Seek to understand the critical role of market-making and institutional structures in shaping the diffusion arena.
3. Focus on critical process features and all key players in the diffusion arena.
4. Develop multi-layered theories of diffusion that factor out mappings between different layers and locales.
5. Use alternative theoretical perspectives that help extend the analysis beyond and questions of efficient choice. Good candidates include political models, institutional models, and theories of team behavior in cooperative conflict games.

6. Recognize the need for varying time scales when seeking to account for what happened and why.
7. Develop theories at the site and with multiple levels of analysis.

2.2.11 Product Development

This study is going to formulate design strategies for designers, so it is critical to investigate differences between interim products and others during product development.

Product development is the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product (Ulrich, 2003). There are five dimensions commonly employed to assess the performance of a product development effort: product quality, product cost, development time, development cost, and development capability (Ulrich, 2003). Ulrich (2003) divides the product development process into five phases: concept development, system-level design, detail design, testing and refinement, and production ramp-up. These five phases are shown in Figure 18.

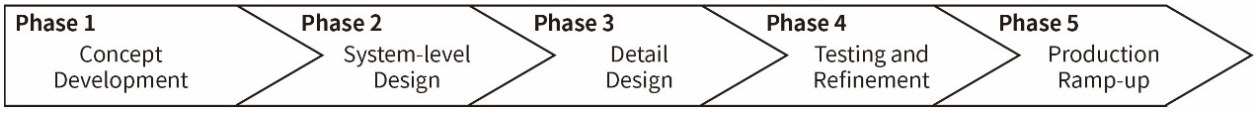


Figure 18. The product development process (Ulrich, 2003)

Based on different development processes, new products can be divided into four types: technology-push products, platform product, process-intensive products, and customized products, whose characteristics resulted in deviations from the generic process as summarized in Figure 19 (Ulrich, 2003).

	Generic (Market Pull)	Technology-Push	Platform Products	Process-Intensive	Customization
Description	The firm begins with a market opportunity, then finds an appropriate technology to meet customer needs.	The firm begins with a new technology, then finds an appropriate market.	The firm assumes that the new product will be built around the same technological sub-system as an existing product.	Characteristics of the product are highly constrained by the production process.	New products are slight variations of existing configurations.
Distinctions with respect to generic process		Additional initial activity of matching technology and market. Concept development assumes a given technology.	Concept development assumes a technology platform.	Both process and product must be developed together form the very beginning, or an existing production process must be specified from the beginning.	Similarity of projects allows for a highly structured development process. Development process is almost similar to a production process.
Examples	Sporting goods, furniture, tools.	Gore-Tex rainwear, Tyvek envelops.	Consumer electronics, computers printers.	Snack food, cereal, chemicals, semiconductors	Switches, motors, batteries, containers.

Figure 19. Summary of variants of generic development process (Ulrich, 2003)

Furthermore, Ulrich (2003) expanded the concept development phase into the front-end process. The front-end process generally contains the following distinct activities roughly shown in Figure 20. The following paragraphs illustrate this process.

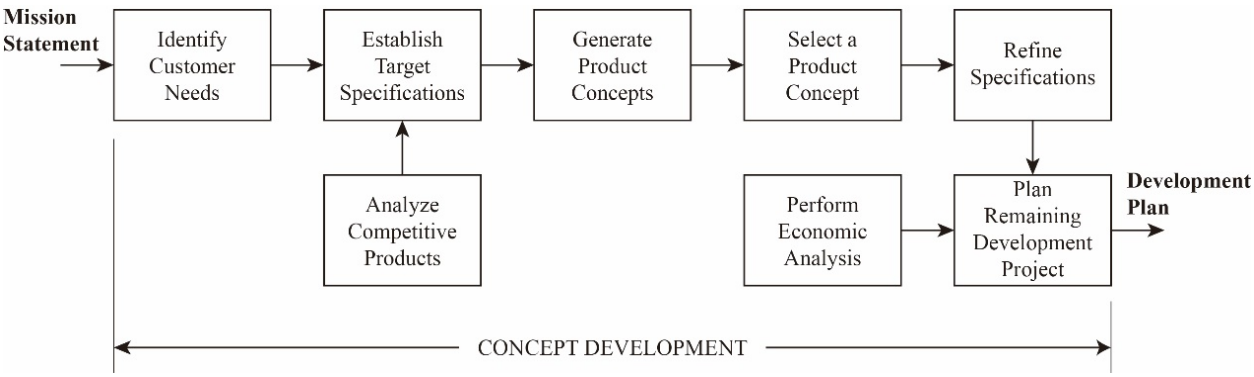


Figure 20. Concept development: the front-end activities (Ulrich, 2003)

1. *Analysis of competitive products:* To successfully position an innovation and offer a rich source of ideas for product and production process design, a comprehending of competitive products is essential (Ulrich, 2003). Analysis of competitive products is also called competitive benchmarking. Competitive benchmarking is beneficial for specification activities as well as concept generation and concept selection.
2. *Concept generation:* The purpose of concept generation is to investigate completely the space of product concepts that may be applied to satisfy the customer requirements(Ulrich, 2003). Concept generation includes a mix of external search, creative problem solving within the team, and systematic exploration of the various solution fragments the team generates (Ulrich, 2003). The outcome of this activity is usually a set of 10 to 20 concepts, each typically represented by a sketch and brief descriptive text.
3. *Concept selection:* During the process of concept selection, individuals analyze and eliminate various product concepts to choose a preferred concept (Ulrich, 2003). The process usually requires several iterations and may regenerate and refine additional concepts.

4. *Refinement of specifications:* At this point, the team must commit to specific values of the metrics reflecting the constraints existing in the product concept, limitations identified through technical modeling, and trade-offs between cost and performance (Ulrich, 2003).
5. *Economic analysis:* The team usually has financial analysts to construct an economic model for a new product. This model is used to justify the continuation of the overall development program and to resolve specific trade-offs among, for instance, development costs and manufacturing costs (Ulrich, 2003).
6. *Project planning:* In this final activity of concept development, the team draws up a detailed development schedule, plans a strategy to minimize development time, and identifies the resources required to finish the project (Ulrich, 2003). The major results of the front-end activities can be usefully captured in a contract book that contains the mission statement, the customer needs, the details of the selected concept, the product specifications, the economic analysis of the product, the development schedule, the project staffing, and the budget (Ulrich, 2003).

This study assumes the concept development of interim products is different from other products, so case studies are conducted to investigate existing interim products in the following chapters to formulate design strategies based on Ulrich's research for designers during product concept development.

CHAPTER 3

RESEARCH METHOD

In consideration of the objective set up for this paper, the methodological approach adopted is descriptive. This approach is here applied as a combination of a literature review and a multiple case study method because the phenomenon under investigation is new.

3.1 Case Study

It is hard to find similar research related to interim products, and this study attempts to increase researchers' understanding of such phenomenon (Eisenahardt, 1989). To find patterns among existing interim products, multiple sources have been used and compiled into a case study database to make subsequent descriptions of the chain of evidence (Yin, 2017).

This study will analyze multiple cases including smart home devices, electronic interim products, non-electronic interim products and interim innovations in the following paragraphs. Every case study of an existing interim product is in the sequence of a radical innovation, its interim product and the comparison between them. Interim products and their counterpart radical innovation will be compared and analyzed by the seven innovation characteristics, including relative advantage, compatibility, complexity, trialability, observability, perceived risk and familiarity (Al-Jabri & Sohail, 2012; Chang et al., 2016; Rogers, 2003).

3.1.1 Smart Home Device

Why are smart home devices categorized into a particular part instead of electrical interim products? Smart home devices have developed from the 1970s, so they have a detailed and long product evolution. As a result, it is worthwhile to discuss them separately.

As mentioned in the previous chapter, smart home products can be categorized into three main types, WDSHDS, WLSHDs and WFSHDs.

WDSHDs are defined as a type of smart home devices that requires electrical contacts and wire in the wall, so it is usually installed by experts and needs pre-wiring work during construction. Although it is costly, users make zero effort, and they have a complete and professional electronics system, with reliable quality and ongoing maintenance and support.

WLSHDs and WFSHDs are defined as another type of smart home devices that are almost or fully separated from electrical contacts. Its wireless transmitter can be installed on any surface without wire or boxes insides the wall, so it can be compatible with users' existing house or home appliance. One of their main advantages is their low cost.

Compared to WLSHDs and WFSHDs, WDSHDs are not adopted widely and costlier, although both of them can offer some similar features. Consequently, WLSHDs and WFSHDs are categorized into radical innovation. In following paragraphs, this study starts to analyze smart home product categories thoroughly and compares WDSHDs, WLSHDs and WFSHDs.

3.1.1.1 Smart Light Switch

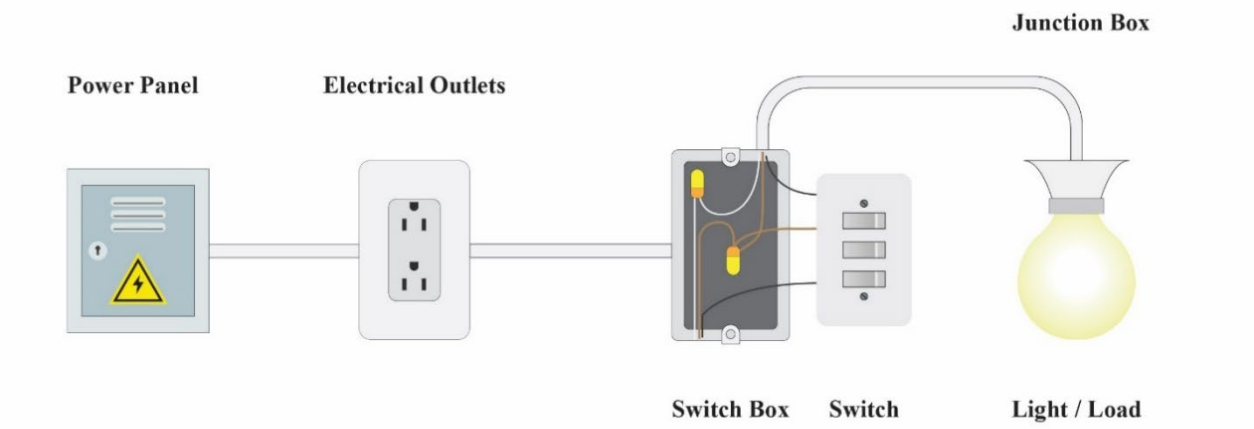


Figure 21. Conventional wired light switch

At first, this study takes light switches as an example to illustrate the comparison of SHT. A traditional wired light switch opens and closes an electrical circuit, which allows electrical current to flow from a power panel to lights and appliances, as shown in Figure 21. Although these switches are stable, they are wired up to a switch box inside the wall, which makes installation costly and complicated.

In the late 1990s, manufacturers advanced light switches by integrating with radio-wireless transmitters and receivers. This new type of wireless light switches is categorized as WDSHDs. In the wired-wireless system, portable switches transmit on, off, and dim commands to a receiver or

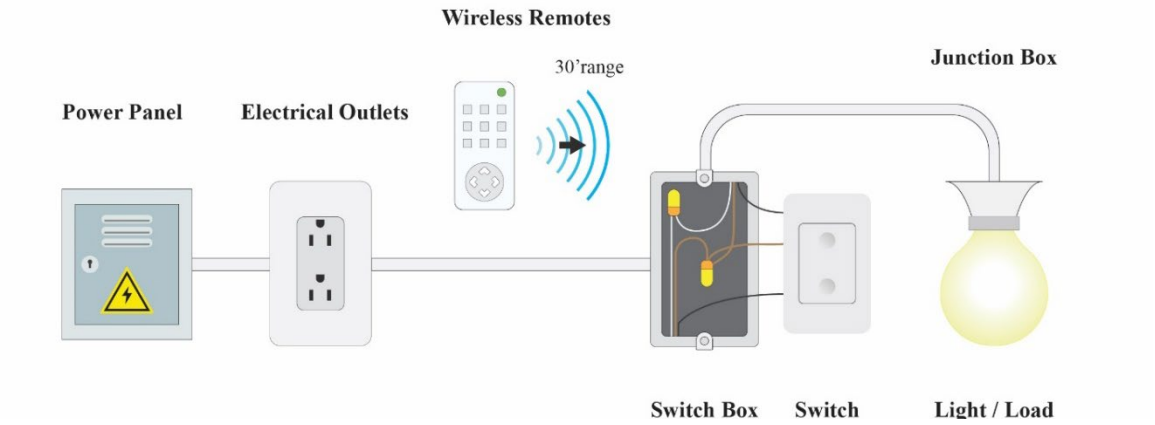


Figure 22. Wired light switch

switch module. This switch module interrupts the power going to the light fixture. However, wire-wireless switches offer portability, but their switch box and wire still require to be installed in the wall, as shown in Figure 22. However, due to its cost and complexity, it is not adopted widely. It is categorized as a radical innovation.

Wire-free switches completely isolate the switch and electrical contacts, as shown in Figure 23. This type of wire-free light switch is categorized as WFSHDSs. The wireless transmitter switch can be installed on any surface without wire or boxes insides the wall. The receiver/controller is wired into the circuit and installed in an electrical box. Wire-free switch transmitters can be battery-powered or use piezoelectric power. Wire-free switches can be combined with existing houses and offer a remote-control function similar to wireless switches, and it complies with the interim product patterns which are mentioned in Chapter 2. As a result, wire-free switches are categorized as an interim product.

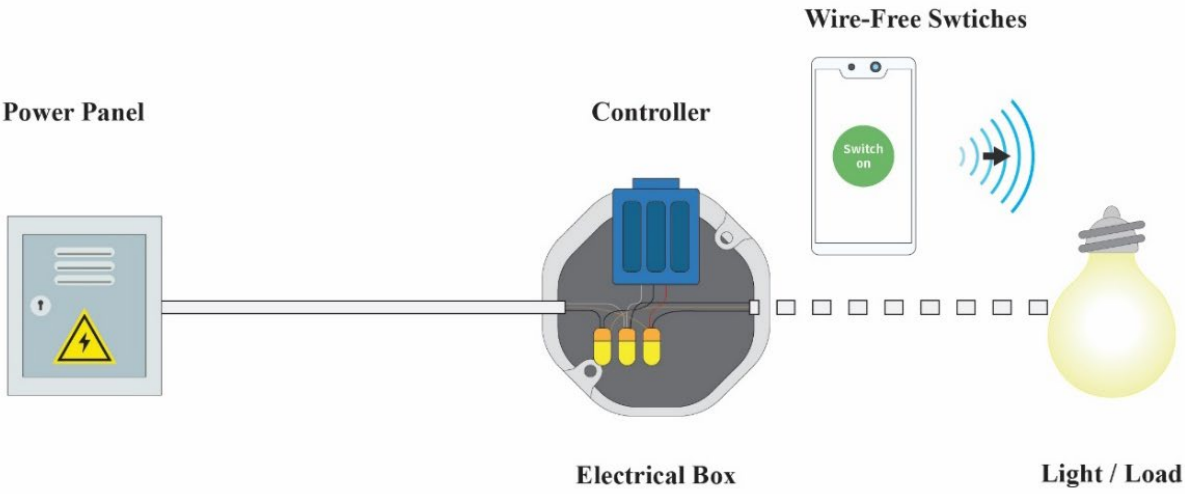


Figure 23. Wireless light switch

Figure 24. The scenario of SwitchBot Bot (Wonderlabs, 2020)

Furtherly, Wonderlabs incorporation developed a new type of wireless light switches product, SwitchBot Bot, as shown in Figure 24. SwitchBot is a smart button pusher and works with just about any rocker switch and button of any appliance. Bot lets user retrofit all existing light switches or appliances instead of replacing them. They can tape it right next to a rocker switch or button with a 3M sticker, shown in Figure 25. By using the SwitchBot app, users can remotely open or close existing light switches or appliances.

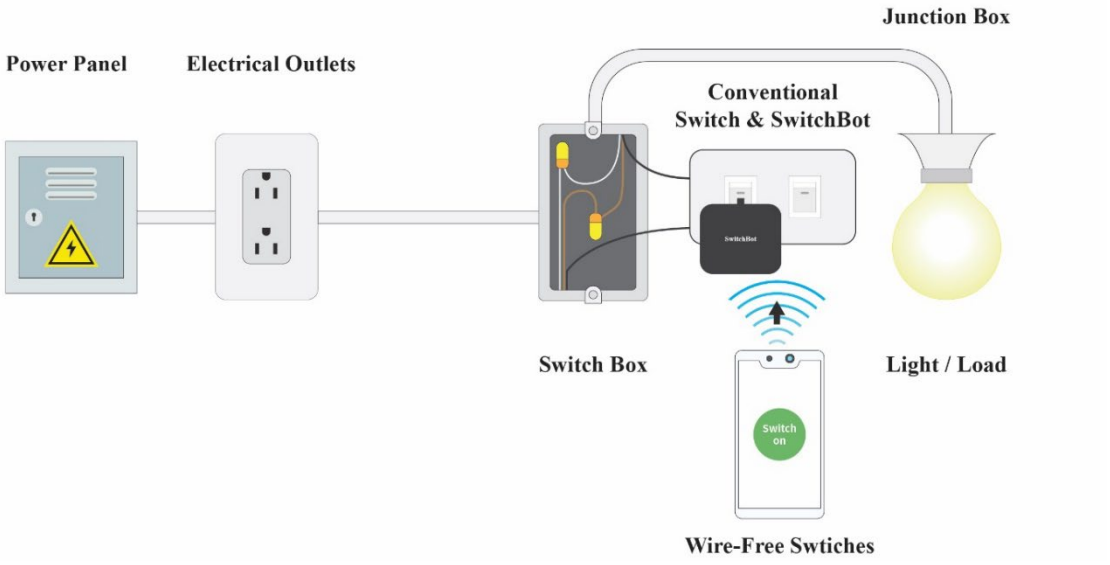


Figure 25. Conventional switch with SwitchBot

Next, these three types of smart light switches are compared by seven innovation characteristics, shown in Figure 26.

(1) Relative advantages: Installing wireless switches commonly require experts to make pre-wiring work, so they are costly. In contrast, users can easily install wire-free light switches and SwitchBot Bot by themselves. Also, they are cheaper. Decora Smart Wi-Fi Switch is a wire-free light switch and 54.99. SwitchBot Bot is 29.00 dollars. Wireless switches require a remote control, but wire-free switches and SwitchBot Bot use cellphones as a remote control.

(2) Compatibility: wireless light switches require new wiring. However, wire-free light switches can be adapted to existing light switches. SwitchBot Bot can be attached to existing light switches.

(3) Complexity: Wireless light switches usually require doing pre-wiring work in construction, so their installation requires experts. On the contrary, consumers can install wire-free light switches and SwitchBot Bot by themselves. The former is adapted to conventional light switch wiring. The latter can be directly installed on the conventional light switches. Also, consumers can download their app and use their cellphone as a remote control.

(4) Trialability: Consumers can visit model smart home to experience wireless light switches. However, wire-free light switches and SwitchBot Bot offer a certain trial period, so consumers might try to use them easier.

(5) Observability: Although wireless light switches can offer remote-control function, wire-free light switches and SwitchBot Bot not only offer the same function but also are installed easier and use the cellphone as a remote control.

(6) Perceived risk: Wireless light switches are complex, so consumers usually pay for experts to carry out maintenance. On the other hand, the style of wire-free light switches and SwitchBot Bot might worsen consumers' house, although their maintenance is simpler. In addition, SwitchBot Bot is battery-powered, so users have to charge it regularly.

(7) Familiarity: Wireless smart light switches were designed after wired smart light. The wire-free smart light switches are developed after wireless smart light switches. These sequences allow the latter to take advantage of familiarity. Interim products are developed in a good timing when people are familiar with radical products. Even though interim products are launched just now, consumers are familiar with them because of their counterpart radical products.

Because of developed internet connection, such as Bluetooth and RFID, wire-free light switches and SwitchBot Bot can be easily controlled by cellphone. Also, the technology of light and effective batteries helps SwitchBot Bot be put into practice.

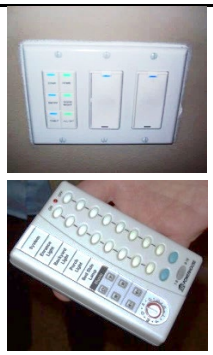
The type of the light switches	Wired light switches and their remote control	Wireless light switches	SwitchBot Bot (wire-free light switches)
Photo			
Mainstream product	-	the wiring of conventional light switches	Conventional light switches
Relative Advantage			
Economic	Fairly costly	$54.99	$29.00
Utilitarian	-	Cellphone is a remote control	Cellphone is a remote control
Compatibility	Require new wiring and a switch box	Be adapted to existing houses.	Be attached to existing light switches.
Complexity	They require a switch box and wire in the wall, so they are usually installed in construction.	Easily replace users' existing single pole or multi-way switch with a wire-free light switch. Use its app to control it.	Tape it right next to a rocker switch or button with a 3M sticker. Use free SwitchBot app to control it.
Trialability	Model smart home	Trial	Trial
Observability	Remote control	Remote control, easy installation, use of cellphone	Remote control, easy installation, use of cellphone
Perceived risk	Maintenance	Improper style	Improper style and died batteries
Familiarity		Developed after WDSHDs	Developed after WLSHDs

Figure 26. The comparison of different type of light switches. (Brush et al., 2011; Leviton, 2020; Wonderlabs, 2020)

3.1.1.2 Smart Doorbell Camera

Doorbell cameras offer security of consumers to supervise their door. Earlier wired doorbell cameras require wiring to connect wall panel to power panel and an outdoor camera installed outside of a house, so they are usually installed by experts via pre-wire work during construction. Their user can check their door view through the wall panel, as shown in Figure 27. Afterwards, because of the development of internet, wired doorbell cameras wire up to connect to the internet, so consumers can supervise their door view through not only the wall panel but also their cellphone. Consequently, they can offer a remote supervision function.

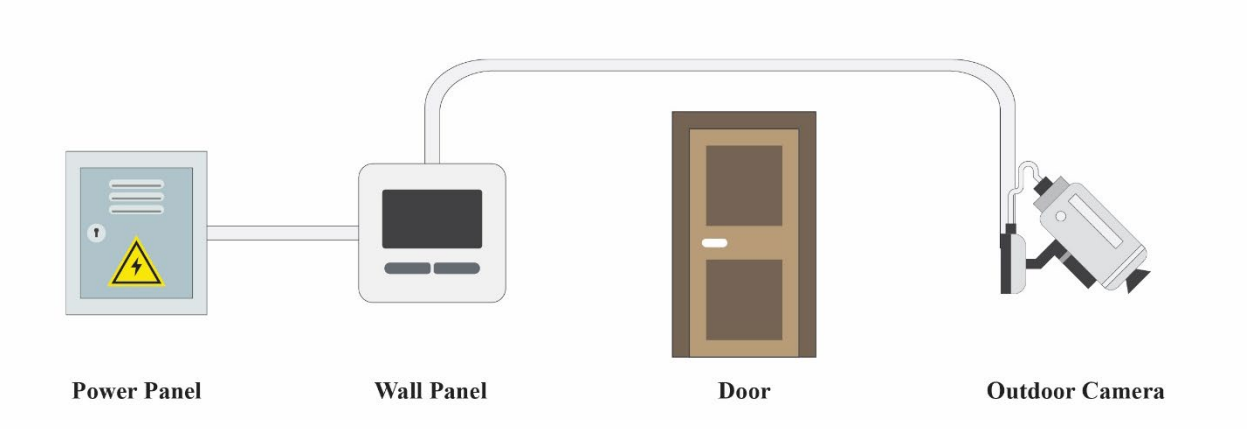


Figure 27. The wired doorbell camera

Wire-free doorbell cameras are completely isolated from electrical contacts and a modem. Wire-free doorbell cameras are battery-powered. With the Wi-Fi router or Bluetooth, they are directly connected to a smartphone, so consumers can supervise the door view on their cellphone, shown in Figure 28.

Figure 28. Wire-free doorbell cameras

Next, both types of doorbell cameras are compared by seven innovation characteristics, shown in Figure 29.

(1) Relative advantages: Wiring for a wired doorbell camera system is complex, so it generally requires experts. In contrast, consumer can install wire-free doorbell cameras. Take Ring Video Doorbell as example. At first, consumers install a mounting bracket in an ideal location beside their door. Then, click a Ring Video Doorbell into place. Finally, download the Ring App on their cellphone to connect to the device. Its price is 199.99 dollars.

(2) Compatibility: A wired doorbell camera system is usually installed in a new house. However, wire-free doorbell cameras can be adapted to most dwellings.

(3) Complexity: A wired doorbell cameras systems requires experts to do pre-wiring work in construction, so it is complex. On the contrary, consumers can install wire-free doorbell cameras

by themselves. They can be easily installed on a wall beside a house' main door. Then, through their app, consumers can use their cellphone as a remote control and monitor.

(4) Trialability: Consumers can visit model smart home to experience wired doorbell camera system, including a wall panel and a doorbell camera. Wire-free doorbell cameras usually offer a certain trial period, so consumers might try them easier and more conveniently.

(5) Observability: Although wired doorbell cameras can offer remote supervision function, wire-free doorbell cameras not only offer the same function but also are installed easier and use their cellphone as a remote control and monitor.

(6) Perceived risk: A wired doorbell camera system is complex, so consumers usually pay for experts to carry out maintenance. On the other hand, the style of wire-free doorbell cameras might worsen consumers' house, although their maintenance is simpler. In addition, they are battery-powered, so users have to charge their batteries regularly.

(7) Familiarity: A wired doorbell camera system is usually for new construction, so it has worse familiarity. In contrast, wire-free doorbell cameras can be installed in most dwellings. As a result, they can be combined with a mainstream product, so they have better familiarity.

Because of developed internet connection, such as Bluetooth and RFID, wire-free doorbell cameras can be easily controlled by cellphone. Also, the technology of light and effective batteries helps them be put into practice.

The type of the light switches	The wall panel of wired doorbell camera	wire-free doorbell camera (Ring Video Doorbell 3)
Photo		
Mainstream product	-	Conventional house
Relative Advantage		
Economic	Fairly costly	$199.99
Utilitarian	-	A smartphone is a remote control and monitor without hub
Compatibility	Require new wiring and a switch box	Be adapted to an existing house.
Complexity	They require a switch box and wire in the wall, so they are usually installed by expert in construction.	Easily attached to a wall beside a door. Use its app to control it.
Trialability	Model smart home	Trial
Observability	Remote supervision	Remote supervision, easy installation, use of cellphone
Perceived risk	Maintenance	Improper style
Familiarity		Developed after the wall panel of wired doorbell cameras

Figure 29. The comparison of wired and wire-free doorbell camera (Brush et al., 2011; Ring, 2018)

3.1.1.3 Remote Controlling Plug

A remote-control pedestal fan offers a remote-control function. Consumers can adjust its speeds and set up time to shut off automatically with the remote control, so it allows them to customize breeze needs and to control the cooling options with high energy-efficiency in their house or office. The cheapest pedestal fan with remote control, PELONIS pedestal fan, is 36.99 dollars on Amazon. However, some individuals might have a conventional pedestal fan at home, so it is a resistance for them to adopt a new pedestal fan with remote control. Consequently, remote controlling plugs emerge in the market.

Remote controlling plugs can be installed on most conventional outlets and be put into the plug of most home appliances. They allow consumers to manage home appliances remotely to set timer and countdown by using their app on their smartphone or their unique remote control. As a result, after a conventional pedestal fan is combined with a remote controlling plug, it offers a remote-control function similar to a remote-control pedestal fan. Moreover, it can be applied to not only a conventional pedestal fan but also other home appliances. Take TECKIN smart plug as an example. It is 11.99 dollars and compatible with Amazon Alexa and Google Assistant. It is a Wi-Fi enabled remote control and offers a timer function without a hub. The comparison of conventional pedestal fans and remote-controlling pedestal fans is shown in Figure 30.

The type of the light switches	PELONIS Pedestal Fan	TECKIN Smart Plug (Remote Controlling Plug)
Photo		
Mainstream product	-	Conventional outlets and plugs
Relative Advantage		
Economic	$36.99	$11.99
Utilitarian	Remotely control	Continue using old conventional pedestal fan and remotely control by a smartphone
Compatibility	-	Be adapted to most conventional outlets and plugs
Complexity	-	Download TECKIN app on a smartphone to connect it and the smart plug
Trialability	Trial	Trial
Observability	Remote Control and set up timer	Remote Control and set up timer
Perceived risk	-	-
Familiarity		Developed after pedestal fans with a remote control

Figure 30. The comparison of conventional pedestal fans and remote-controlling pedestal fans (Amazon, 2020)

3.1.2 Electrical Interim Product

"Electrical interim product" means this type of interim products uses electricity as power. Electrical interim products including electronic products. Although they have more abilities to control the flow of electronics for performing the particular task, they still use electricity as power. In the following paragraphs, this study takes electrical bike conversions, electric handcycle, electric stand-capable desk converters and AirBar as the examples of electrical interim products.

3.1.2.1 Electrical Bike Conversion

E-bikes seem to be widely adopted around the world because of the environmental promotion from governments, especially in China. Public electric bicycle-sharing has become more popular. However, the adopters of e-bike are mainly the older population. E-bike can help them increase convenience, reduce physical exertion and reduce reliance on a vehicle and have fun (Peine, van Cooten, & Neven, 2017), but old adopters of e-bikes in Austria mainly use the e-bike for leisure trips instead of for commuting. Jones, Harms, and Heinen (2016) also shows the main motivation for adopting e-bike in the UK and the Netherlands is suitable for a longer or more complicated journey (typically 10 kilometer or more). Moreover, Jones et al. (2016) point out that one of major barriers to e-biking is its high cost. Dill and Rose (2012) also indicate that e-bikes are more costly than conventional ones in the US, and it is a great resistance to the adoption of e-biking. Dill and Rose (2012) show a e-bike ranges from about $1500 to over $5000 depend on its quality. Consequently, electrical bike conversions are launched in the market.

Compared to electrical bikes, electrical bike conversion kits are much cheaper and start around $500 (Dill & Rose, 2012). Actually, their price on Amazon ranges about $75 to $750 today.

Electrical bike conversion kits have two types, mid drive motor kit and front or rear wheel kit. The former ranges from $75 to $700, depending on the complexity of its battery, motor and display. Consumers use only a few tools to remove a crankset and a center shaft and install the mid-drive motor. The latter is from $200 to about $300. Consumers replace their bike's front or rear wheel with it and install its monitor and controller. The size of their bike's wheel has to comply with the size of a front or rear wheel kit. Consumers can easily convert their pedal bike into a motorized bike by installing an electrical bike conversion. The comparison of electric bike and electric conversion is shown in Figure 31. In Figure 31, the radical innovation is the electric bike, and interim products are electric bike conversions.

The type of the light switches	Electric bike	Electrical bike conversion with a mid-drive motor	Electrical bike conversion with a front or rare wheel
Photo			
Mainstream product	-	the wiring of conventional light switches	Conventional light switches
Relative Advantage			
Economic	From about $1500 to over $5000	From about $70 to about $700	About $200 to $300
Utilitarian	-	Convert pedal bike into motorized one	Convert pedal bike into motorized one
Compatibility	-	Install on consumers' pedal bike	Install on consumers' pedal bike
Complexity	-	Use only few tools to remove a crankset and a center shaft and install mid-drive motor.	Replace the front or rare wheel with its one and install wiring, a battery and a monitor.
Trialability	Trial	Trial	Trial
Observability	E-biking	E-biking and save money	E-biking and save money
Perceived risk	-	Improper style and installation	Improper style and installation
Familiarity		Developed after electric bikes	Developed after electric bikes

Figure 31. The comparison of e-bikes and electrical bike conversions (Amazon, 2020)

3.1.2.2 Electric Handcycle

An electric wheelchair not only dramatically increases users' independence but also their self-identity (Stenberg, Henje, Levi, & Lindström, 2016). Electric wheelchairs eventually become one part of these users to link them to the world. However, electric wheelchairs are too expensive to be afforded by most wheelchair users. In fact, the World Health Organization (WHO) estimate that more than seventy million people need a wheelchair, but only 5 to 15% of them could benefit from a wheelchair (WHO, 2020) because most of them cannot afford a wheelchair, not to speak of ones having access to an electric wheelchair. Consequently, to benefit more of these individuals via an electric wheelchair, electric handcycles emerged in the market. Electric handcycles can be attached on the front of a wheelchair to turn it into a motorized one, but the diameter of wheelchair has to comply with the instruction of each electric handcycle. Electric wheelchairs range from about $1400 to $13000. On average, a power wheel chair cost around $2500. On the other hand, electric handcycles range from about $750 to $1000. As a result, an electric handcycle is a reasonable alternative. The comparison of electric wheelchairs and electric handcycles are shown in Figure 32.

The type of the light switches	Electric Wheelchair	Electric handcycle
Photo		
Mainstream product	-	Manual Wheelchair
Relative Advantage		
Economic	About $2500	From about $750 to $1000
Utilitarian	Increase independence	Increase independence and be attached to a wheelchair
Compatibility	-	Be compatible with most manual wheelchair
Complexity	-	Install it on users' wheelchair
Trialability	Trial	Trial
Observability	Motorized power	Motorized power Lower cost
Perceived risk	-	-
Familiarity		Developed after electric wheelchairs

Figure 32. The comparison of electric wheelchairs and electric handcycles (Amazon, 2020).

3.1.2.3 Electric Stand-capable Desk Converter

Workers in desk-based roles basically have occupational sitting time, but high levels of sedentary behavior are related to unhealthy outcomes. As a result, using sit-stand desks is a great solution to reduce sitting time (Neuhaus et al., 2014). Stand-capable desks not only improve physical health but also increase employees' work productivity (Garrett et al., 2016). Electric sit-to-standing desks allow users to adjust the height with the push of a button. However, they are more expensive and range from $480 to $2000, depending on the quality of construction, features and engineering. As a result, electric sit-to-standing desk converters are an alternative and are made to sit on top of users' current desk. On Amazon, they range from about $150 to $350. They turn users' current desk into a stand-capable desk. On the other hand, the style of electric sit-to-standing desk may not fit in users' desk's style. The comparison of electric sit-to-stand desks and sit-to-standing desk converters are shown in Figure 33. In Figure 33, the radical innovation is electric stand-capable desk. Interim products are electric stand-capable desk converters.

The type of the light switches	Electric Stand-Capable Desk	Electric Stand-Capable Desk Converter
Photo		
Mainstream product	-	Conventional desk
Relative Advantage		
Economic	From About $480 to $2000	From about $150 to $350
Utilitarian	Increase physical health and work productivity	Increase physical health and work productivity, and can be attached on users' current desk
Compatibility	-	Be compatible with users' current desk
Complexity	-	-
Trialability	Trial	Trial
Observability	Adjustable Motorized	Adjustable Motorized Cheaper
Perceived risk	-	Worse the style of a current desk
Familiarity	-	Developed after electric stand-capable desks

Figure 33. The comparison of electric sit-to-standing desks and electric sit-to-standing desk converters (Amazon, 2020)

3.1.2.4 AirBar

Touchscreen feature is usually found on 2-in-one laptops and non-convertible models. The price of non-convertible laptops with a touchscreen starts about $420 on Amazon. However, touchscreens have their pros and cons. Touchscreen feature can offer straightforward navigation and be great for drawing and note-taking. On the other hand, it drains batteries quickly, adds weight to the laptop and has a high price. Consequently, AirBar emerged in the market.

AirBar is an attachable tool and allow users' current non-touchscreen laptop to have touchscreen features. AirBar range from about $59.99 to $72.99, depending on its size. When users first install AirBar, they have to position and press AirBar on the bezel below their laptop's display, with the top of the device three millimeters below the bottom of the display. Two magnet points behind AirBar will be attached to the bottom bezel. After pressing and hold the magnets for ten seconds, users can simply attach AirBar to the magnets. Finally, AirBar will work after users plug its plug in the USB. AirBar projects an invisible light field all over users' screen to detect the movement of users' fingers on the screen.

AirBar has particular system requirements. Users' notebook must have a 16: 9 display in the size 13.3″, 14″ or 15.6″, so it offers three different lengths. Their display needs twenty-two millimeters of flat surface below the bottom edge of the display for mounting the AirBar sensor. In addition, two magnetic points have to be attached on users' laptop, and it might influence aesthetics negatively. According to users' feedbacks, if they forget to remove AirBar from their laptop before closing it, AirBar might cause damage to their laptop. The comparison of touchscreen laptops and AirBar is shown in Figure 34.

The type of the light switches	Touch-Screen Laptop	AirBar
Photo		
Mainstream product	-	non-convertible laptops
Relative Advantage		
Economic	Begin at about $420	From about $59.99 to $72.99
Utilitarian	1. Have touchscreen features	1. Allow a non-touchscreen laptop to have touchscreen features 2. Touch with a finger, glove, paintbrush, and more
Compatibility	-	Be compatible with most users' current non-touchscreen laptop
Complexity	-	Installation
Trialability	Trial	Trial
Observability	1.Offer straightforward navigation 2.Be great for drawing and note-taking	1. Attachable 2. Lower cost
Perceived risk	1. Drain batteries quickly 2.Heavy weight 3. High cost	1.Influence aesthetics negatively. 2.Cause damage to users' laptop if forgetting to remove it before close their laptop.
Familiarity	-	Developed after touch-screen laptops

Figure 34. The comparison of touchscreen laptops and AirBar

3.1.3 Nonelectric Interim Product

"Nonelectrical interim product" means this type of interim product is not operated by electricity. In the following paragraphs, this study takes ergonomically supportive lower and upper back and sunglasses clips as the examples of nonelectric interim products.

3.1.3.1 Ergonomic Back Support

Most people spend almost eight hours sitting on chair for working, and it might cause physical problems on their neck, back or hips because of sitting in an improper position at a desk. As a result, to keep healthy, ergonomic chairs are great solution. An ideal ergonomic chair is able to allow users' neck, shoulders, back and hips to stay aligned and experience less discomfort and pain by reducing stress and pressure on these parts. Van Niekerk, Louw, and Hillier (2012) show chair intervention can effectively reduce musculoskeletal symptoms among workers required to sit for prolonged periods. Also, ergonomic chairs are friendly and adjustable for users' personal needs to stay focus and productive throughout the workday. Abareshi, Yarahmadi, Solhi, and Farshad (2015) point out that reducing musculoskeletal risk factors by accepting ergonomic training can lead to an increase in productivity. However, well-designed ergonomic chairs begin at about $200, and so there might be resistance to adopt an ergonomic chair even though it can benefit users considerably. Therefore, ergonomic back supports emerged in markets.

Ergonomic back supports can prevent users from suffering back pain. Users simply put an ergonomic back support on their current office chair to turn it to an ergonomic chair. Chair back support have two types, mesh back supports and back cushions. The former begins from about $15, and the latter begins from about $25 on Amazon. The comparison of ergonomic chairs and ergonomic back supports is shown in Figure 35.

The type of the light switches	Ergonomic chair	Mesh back support	Back support cushion
Photo			
Mainstream product	-	Conventional office chair	Conventional office chair
Relative Advantage			
Economic	Begin from about $200	Begin from about $15	Begin from about $25
Utilitarian	Support users' back, hip, neck to reduce physical pain	Support users' back to reduce back pain	Support users' back to reduce back pain
Compatibility	-	Most of conventional office chairs	Most of conventional office chairs
Complexity	-	-	-
Trialability	Trial	Trial	Trial
Observability	Ergonomic design	Ergonomic design and lower cost	Ergonomic design and lower cost
Perceived risk	-	Influence aesthetics negatively	Influence aesthetics negatively
Familiarity		Developed after current office chairs	Developed after current office chairs

Figure 35. The comparison of ergonomic chairs and ergonomic back supports

3.1.3.2 Sunglasses clip

Sunglasses are not just a stylish accessory. The most important benefit of wearing them is that they can protect users' eyes from ultraviolet light. A piece of high-quality sunglasses has to offer one hundred percent ultraviolet protection. Other optional features include a wraparound style, polarized lenses and tinting. However, most people have poor eyesight and have to wear prescription glasses, but high-quality prescription sunglasses are considerably costly. The average cost of prescription sunglasses ranges from about $150 to $500, depend on the brand, popularity, size and material of frame, and the tint, material, UV protection level and treatment of lenses. Consequently, sunglasses clips are innovated.

The primary merit of sunglasses clips is they are inexpensive compared to prescription sunglasses. Sunglasses clips begin from about $10 to $20. Users can directly attach a sunglasses clip to their current prescription glasses because of its magnetic clip on. Also, they are suitable for people who move frequently between indoors and outdoors because they can simply put them on or take them off. Some sunglasses clips even allow users to flip them up or down. The comparison of prescription sunglasses and sunglasses clips is shown in Figure 36.

The type of the light switches	Prescription sunglasses	Sunglasses clip
Photo		
Mainstream product	-	Prescription glasses
Relative Advantage		
Economic	Begin from $150 to $500	From about $10 to $20
Utilitarian	Protect eyes from the harm of ultraviolet light	1.Protect eyes from the harm of ultraviolet light 2. can be attached to most of prescription glasses
Compatibility	-	Be compatible with most users' current prescription glasses
Complexity	-	-
Trialability	Trial	Trial
Observability	1.The protection of eyes 2.Fashionable element	1.The protection of eyes 2. Detachable
Perceived risk	-	Influence aesthetics negatively
Familiarity	-	Developed after prescription sunglasses

Figure 36. The comparison of prescription sunglasses and sunglasses clip

3.1.4 Interim Innovation

As the previous chapter mentioned, an interim innovation is defined in this study as "an interim innovation is invented by referring to a radical innovation to offer similar unprecedented functions but more inclusive and compatible with current life." In this paragraph, interim innovations are investigated and detailed. This study takes hybrid vehicles as the example of interim innovations. However, why are hybrid vehicle an interim innovation? According to the definition of an interim innovation, it has to be invented by referring to the partial advantages of a radical innovation. As a result, this study investigates hybrid vehicle by following the sequence, finding the reasons why consumers adopt electric vehicles, discovering the reasons why consumers adopt hybrid vehicles, and comparing their adoption reasons.

Electric vehicles are widely promoted in order to increase energy efficiency and sustainability. Indeed, the early adopters of electric vehicles have higher environmental consciousness. In the Netherlands, the stronger environmental motivation to adopt an electric vehicle a consumer has, the stronger environmental self-identity he or she possess (Peters, van der Werff, & Steg, 2018). Electric vehicles owners bought an electric vehicle because they perceive environmental advantages and financial incentives (Peters & Dütschke, 2014; Vassileva & Campillo, 2017). However, the resistance to adopt electric vehicles is their high cost (Peters & Dütschke, 2014). In addition to high initial cost, electric vehicles are not widely adopted due to short driving range (Chau & Wong, 2002; Lane et al., 2018).

Hybrid electric vehicles, integrating an engine with electric motor, have been introduced as an interim solution before the wide diffusion of electric vehicles (Wakefield, 1998). However, it seems that they attract a certain number of consumers and diffuse faster than electric vehicle. Hybrid vehicles not only extend greatly the electric vehicle driving range and their internal

combustion engine can be rapidly refueled in the same way as conventional vehicles (Chau & Wong, 2002). The greater similarity of hybrid vehicle to conventional vehicle proposes why electric and hybrid vehicles do not diffuse in the same way (Lane et al., 2018). Moreover, although hybrid vehicles do not meet the zero emission idea, they still cause vastly less pollution than conventional vehicles (Chau & Wong, 2002). Therefore, this study categorizes hybrid vehicles into an interim innovation because they have the similarity of an electric vehicle and a conventional vehicle, which meet the definition of interim innovation. These similar attributes motivate consumers to adopt a hybrid vehicle instead of an electric vehicle. Hybrid vehicles play an important role to attract the partial consumers in mainstream and upper vehicle market.

However, what differences are between interim innovations and products? Interim innovations are a complete product and can offer unprecedented consumer benefits by themselves. In contrast, interim products are similar to an incomplete product and offer innovative functions by being combined with a mainstream product. Besides, interim products only investigated in this study are with a physical presence. Based on the previous investigation, this study redefines an interim innovation as "a new kid of innovation with a physical presence which offers unprecedented consumer benefits similar to a radical innovation but also has advantages of a mainstream product." It is an interim solution. However, although innovation refers to the creation of a product, service, or process (Szmigin & Foxall, 1998), this study only discuss innovations with a physical presence.

3.2 The Patterns of Interim Products

Through comparing interim products and their counterpart radical products by innovation diffusion theory, their characteristics and patterns are analyzed and found. Innovation diffusion

theory includes the five characteristics of innovations, (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability (Rogers, 1983). In addition to these five characteristics, this study adds (6) perceived risk and (7) familiarity to compare interim products and their counterpart radical innovations (Al-Jabri & Sohail, 2012; Chang et al., 2016). In the following paragraphs, the patterns of interim products can be discovered and specified.

Relative Advantages: Relative advantage includes economic, social, utilitarian factors. Interim products have considerable economic relative advantages, compared to their counterpart radical product. The cost of most interim products is less than half the price of their counterpart radical innovations. Interim products have the advantage of low cost, so their economic risk can be minimized. However, most interim products do not possess a complete utilitarian advantage, compared to their counterpart radical products. In addition, interim products usually offer one unprecedented consumer benefit similar to their counterpart radical products. However, some radical products can offer more than one benefit. Moreover, these benefits are usually nearly equal to or even worse than their counterpart radical products. However, some interim products are technology-driven innovations, and they usually have utilitarian advantages, compared to their counterpart radical products. For example, wireless and wire-free smart home products adopt wireless technology, which allows them to break the existing limitation of wired smart home products. They are high technology products, so they not only have lower cost but also are easily installed and used by being connected with smart phones.

Compatibility: Interim products have high compatibility because they can be integrated with a users' current mainstream product, such as an electric desk convertor and a conventional desk or an ergonomic back support and a conventional office chair. Besides,

these interim products succeed in markets always avoid harming mainstream products that they can be integrated with. However, every interim product has a certain level of limitation to influence its compatibility. For example, outlets in different regions might have a different shape and standard voltage, so a smart plug is not compatible with all outlets around the world. On the other hand, AirBar require users' current laptop to have a certain size and twenty-two millimeters of a flat surface below the bottom edge of the display for mounting the AirBar sensor. Besides, when combining an interim product and a mainstream product, mainstream product's material might be fragile or not meet the installation requirement, and it causes limitations. Consequently, this study categorizes limitations into three type, 1) regional limitation, 2) dimensional limitation and 3) material limitation. When an interim product reduces limitations more, it has higher compatibility.

Moreover, consumers might generate a kind of positive emotional bond with their current mainstream products. This emotional bond is called product attachment. Product attachment has been defined as "the emotional bond a consumer experiences with a product" (Schifferstein & Zwartkruis-Pelgrim, 2008). Consequently, if a person attaches to a product emotionally and loses it, he or she will experience emotional loss. Compared to radical innovations, adopting interim products is a better solution in order to experience radical features. The product attachment benefits the diffusion of interim products.

Complexity: The complexity of an interim product depends on how difficult a user perceives it to be when understanding or using it. For example, most wireless smart home devices require users to install a particular app on their smart phone to control devices remotely. Installing an app might be difficult for the elderly. In order to obtain benefits offered by electric bikes, installing electrical bike conversions on a conventional bike is

harder for most people than buying an electric bike. However, it is simple to use electric stand-capable desk converters. Users only empty their current desk surface and place it on the desk. Therefore, most nonelectric interim products have lower complexity. In contrast, electric interim products commonly have certain and relative complexity, compared to nonelectric ones. Interim products have an uncertain level of complexity, and it might be a key to influence users to adopt them similar to other products.

Trialability: There no significant differences between the trialability of interim products and their counterpart radical innovations. Both of them commonly have great trialability because most current products offer a trial period for users to experience them and reduce uncertainties. Users even can return these tried products without charges during the trial period if they are unsatisfied with them.

Observability: The easier it is for individuals to see the results of an innovation, the more willing they are to adopt it. Interim products' main functions refer to their counterpart radical innovation, offering users similar functional advantages. As a result, there is no significant difference between an interim product and its counterpart radical product.

Perceived Risk: Although interim products can be combined with users' current mainstream products, they might have worse user experience, compared to adopting their counterpart radical products. For example, electric bike converters might influence the appearance of users' current conventional bike negatively. In addition, the main features of interim products usually are less stable and effective than their counterpart radical innovations. As a result, consumers might easily perceive the risks of interim products, including appearance risk and functional risk.

Familiarity: Familiarity is defined as the degree to which one comprehends an entity. The timing of the development of most interim products is later than their counterpart radical products. If consumers are familiar with a radical product, the familiarity helps its interim product diffuse more quickly because they offer similar unprecedented consumer benefits. Therefore, interim products generally have great familiarity. Even though they might just launch, consumers are familiar with them because of their counterpart radical innovation that diffused in markets for a certain time.

Based on the patterns of interim products, this study redefines an interim product as "a product that can offer unprecedented consumer benefits similar to a non-commonplace radical product by combining with a mainstream product, and can quickly enter existing or new market because of its great affordability, compatibility, observability and familiarity."

CHAPTER 4

INTERIM PRODUCT DESIGN GUIDELINE AND STRATEGIES

Through comparing interim products and their counterpart radical products by innovation diffusion theory, their characteristics and patterns are analyzed and found. Consequently, this study develops interim product design guidelines. Next, interim product design strategies are proposed to help designers create an interim product with a physical presence correctly and effectively.

4.1 Guidelines to Design Interim Products

After clarifying the patterns of interim products, this study proposes interim product design guidelines to help designers and developers design interim products more methodically. There are five directions of interim product design guideline:

(1) At competitive price,

(2) Offer unprecedented consumer a benefit /benefits similar to a radical product,

(3) Can be combined with mainstream products,

(4) Has low complexity, and

(5) Reduce appearance and functional risks.

The following paragraphs interprets the five directions.

(1) Interim products have to possess considerable relative economic advantages in order to compete with their counterpart radical innovations and directly enter markets.

(2) Interim products are designed by referring to a radical product to offer similar unprecedented benefits to consumers. However, interim products generally offer inferior benefits because they adopt lower technology than their counterpart radical innovations in order to reduce their cost. However, some interim products are a technology-push innovation. They adopt higher technology, such as WLSHDs and WFSHDs. Therefore, these technology-driven interim products can offer more or better unprecedented consumer benefits than their counterpart radical products.

(3) Interim products have high compatibility by allowing consumers to combine them with their current mainstream products to offer unprecedented consumer benefits similar to their counterpart radical products, so interim products are compatible with their current life. However, three limitations could lower an interim product's compatibility, including regional, dimensional, and material limitations. Designers should reduce these limitations as much as possible to heighten the compatibility. Furthermore, the way of combining interim products and mainstream products should avoid harming the latter.

(4) The level of complexity is a crucial key to influence consumers' willingness to adopt an interim product similar to other innovations. The way of combining interim products and mainstream products might increase complexity for consumers. For example, it is hard for users to install electrical bike conversions by themselves, so consumers might resist it. Moreover, technology-driven interim products might increase complexity. It is hard for the elderly to use wireless and wire-free smart home device with smartphone apps.

(5) Designers should reduce and appearance and functional risk on interim products. Interim products offer unprecedented benefits by being combined with a kind of mainstream products. However, mainstream products have different styles, so interim

products' style should be designed to blend with them well. Moreover, the performance of interim products is usually inferior to their counterpart radical products, so designers should alleviate consumer's concern about the functional risk from the adoption of interim products. Interim products incur functional risks in product longevity, stability and performance. Therefore, designers should reduce appearance and functional risks to speed up their diffusion.

4.2 Strategies to Design Interim Products

Based on the interim product design guidelines, this study maps out strategies for designers to invent interim products efficiently and correctly. Product development process are divided into five phases: concept development, system-level design, detail design, testing and refinement, and production ramp-up (Ulrich, 2003). In the stage of concept development, designers have to decide the target value of the product attributes, including price, and the core of product concept (Krishnan & Ulrich, 2001). This study formulates interim product strategies based on Ulrich's concept development flow.

Step 1. Discover a Potential Radical Product:

Discover a non-commonplace radical product with a physical presence. It diffuses slowly currently due to innovative barriers, especially a value barrier. The timing of launching an interim product is critical. This radical product needs to be launched for a certain time, so consumers are familiar with its unprecedented benefits.

Step 2. Analyze the Radical Product:

Designers analyze target radical products' innovative features because a radical product possibly has more than one innovative feature.

Step 3. Select Innovative Functions

Designers select more than one innovative function from the target radical product in this step. Some radical products can offer one unprecedented consumer benefit. Designers could carry out user research into potential consumers in the mainstream and low-end markets to focus on popular benefits provided by the target radical product.

Step 4. Identify its Mainstream Products

Designers identify the target radical product's mainstream products. For example, the mainstream products of electric stand-capable desks are conventional desks. The mainstream products of electric bikes are conventional manual bikes.

Step 5. Investigate Mainstream Products

In this step, designers analyze mainstream products to understand their attributes that might become limitations to develop interim products, such as dimensions and materials.

Step 6. Define Target Users

In order to reduce appearance risks, designers should aim at certain users after user research. For example, when designing an electric stand-capable desk converter, it is hard for designers to design a style to blend with various desks. As a result, defining target users is beneficial to establish the style of an interim product that can be blended with mainstream products aesthetically.

Step 7. Generate Product Concept

Designers start to develop ideas that must follow the following interim product design guidelines:

1. These ideas offer unprecedented benefits similar to the target radical product.

2. It can be combined with the mainstream products that are identified in step 4 to increase compatibility.
3. The way of combination should avoid harming mainstream products.

There are not all interim product design guidelines because some of them might restrict ideation.

Step 8. Select an Interim Product Concept

Designers should select an interim product idea that adheres to the interim product design guidelines most.

Step 9. Refine Specifications:

In this step, designers start to validate the idea and identify limitations. Based on the compiled information related to the mainstream products in step 5, designers should reduce regional, dimensional, and material limitations as much as possible to heighten the compatibility. For example, an electric stand-capable desk converter is designed to be placed on a conventional desk, so its base area has to be small enough to be compatible with as many types of desks as possible. They also should minimize appearance and functional risks incurred by the interim product. This study offers two approaches to improve these risks. Firstly, designers can design interim products in different styles, such as materials or colors. Designers can provide interim products in bright and dark styles for consumers. Secondly, designers can redefine or subdivide target users to reduce the amounts of mainstream products' styles.

Step 10. Perform Economic Analysis:

It is critical for an interim product to have a relative economic advantage. According to case studies, this study suggests the cost of an interim product should be less than half the cost of the target radical product.

Step 11. Perform Interim product Evaluation:

Designers require to examine their interim product with interim product design guidelines. This study draws an interim product design guidelines scale that allows designers to evaluate their interim product, as shown in Figure 37. This scale is subjective, and its purpose it to make designers evaluate their interim products efficiently. Designers should evaluate whether their interim products follow the guidelines strongly or not.

1) Have a relative economic advantage, compared to the target radical innovation product.

2) Have utilitarian advantages similar to the target radical product.

3) Have a high compatibility with target mainstream products by being combined with them well.

4) Have lower complexity to allow consumers to install and operate it simply.

5) Reduce appearance risks to enhance compatibility.

6) Reduce functional risks to alleviate consumer's concerns, including product longevity, stability, and performance.

	Ignore →				Strongly follow
1. Competitive Price Suggest the cost of an interim product is less than half the cost of its counterpart radical product.					
2. Utilitarian Advantage Make the interim product's functions or benefits as better than the referred radical product as possible.					
3. Compatibility Reduce limitations to be compatible with as many mainstream products as possible, including regional, dimensional and material limitations.					
4. Low Complexity Make users use or understand the interim product as more easily as possible.					
5. Reduce Appearance Risks Make the interim product fit in a kind of mainstream products as many as possible.					
6. Reduce Functional Risks Better the functions of the combination of an interim product and a mainstream product , including product longevity, stability and performance.					

Figure 37. Interim product design guidelines scale

Step 12. Plan Remaining Development Project

In this final activity of concept development, designers arrange a detailed development schedule, plan a strategy to minimize development time, and identify the

resources required to finish the project. After this stage, designers begin to do the same activity in the general product development.

Based on the previous paragraphs, this study maps out the interim product concept development flow, as shown in Figure 38. The interim product design strategies can be divided into three phases, investigation, ideation and evaluation.

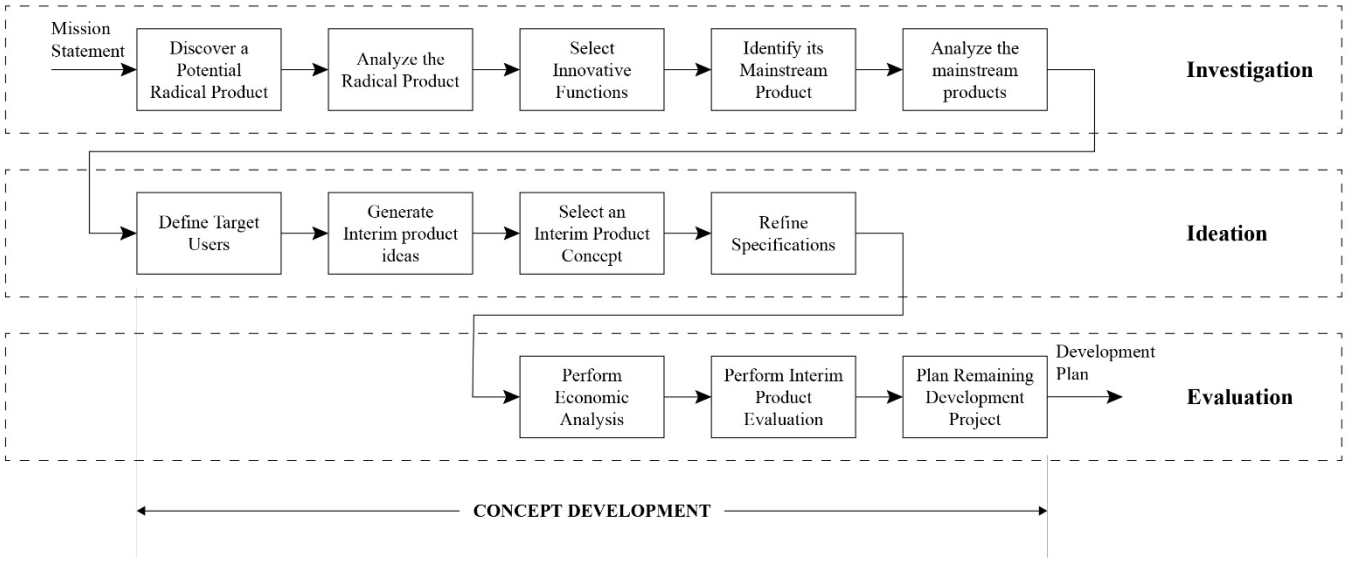


Figure 38. Interim product concept development: the front-end activities

CHAPTER 5

DESIGN APPLICATIONS OF INTERIM PRODUCTS

This chapter will demonstrate how to use interim product design strategies, step by step. This study uses interim design guidelines to examine an interim product designed in this chapter.

5.1 Interim Product Design Strategies Applied to A Detachable Organizer

A target radical product, Unfound Backpack, crowdfunded on Kickstarter, is investigated in the following paragraphs. This study intentionally selects a radical product on Kickstarter to create an interim solution because crowdfunding campaigns that feature more radical innovativeness are generally costly to learn about, less beneficial and riskier for crowd funders (Chan & Parhankangas, 2017). All related resources are authorized by its designer.

5.1.1 Step1. Discover a Potential Radical Product

Unfound is a small team in Taipei, Taiwan. They designed Unfound Backpack, a smart organizer that can accompany everyone to explore the world. In order to get funding, they crowdfund their product on Kickstart, as shown in Figure 39. Its future retail price is $189. Compared to ordinary backpacks, it is costly and unaffordable for consumers in mainstream or low-end markets. Consequently, this study will create an interim solution to allow more consumers to have the capacity to get similar innovative benefits from Unfound Backpack.

Figure 39. The image of Unfound Backpack on Kickstarter (Unfound, 2020)

5.1.2 Step 2. Analyze the Radical Product

Unfound Backpack has a main innovative feature. A magnetically detachable organizer allows users to organize users' small essentials for different occasions. It is magnetically fixed to the inner layer of the backpack (see Figure 38a). Besides, users can easily transform it into a

crossbody bag (see Figure 38b) by simply taking out the adjustable hide-away straps stored in the external pocket.

(a) (b)

Figure 40. The illustration of detachment (a) and transformation (b) (Unfound, 2020)

5.1.3 Step 3. Select one Potential Feature

Unfound Backpack only has one innovative function, a magnetic detachable organizer. As a result, this study selects it to develop an interim solution to benefit consumers in mainstream and low-end markets.

5.1.4 Step 4. Identify its Mainstream Products

Obviously, Unfound Backpack is designed based on conventional backpacks. This study defines conventional backpacks as a pack with two shoulder straps which allows users to carry it on their back and an inside space which can contain stuff, as shown in Figure 41. However,

backpacks have different dimensions, styles, materials, compartments and structures, so this study investigates backpacks in mainstream markets.

Figure 41. A conventional backpack (MUJI, 2014)

5.1.5 Step 5. Investigate Mainstream Products.

The purpose of a backpack mainly depends on its capacity. A backpack in a volume below ten liters is designed to carry the essentials. A backpack capacity between ten and twenty liters is the most common size for commuters and students. It only allows users to travel quickly for no more than a day. The backpack capacity falling between twenty and thirty is ideal for a one-day trip. The most common backpack capacity is below twenty-five liters for daily use to alleviate pressure on a user's back and shoulder. The backpack with a capacity of more than thirty liters is designed for a long-term trip of more than two days.

Backpacks have at least one pocket for organization. A laptop pocket is designed to cushion a laptop, so it has a thick layer. Some pockets are designed to bring users' essentials or particular items, such as pens, a cellphone, shoes and a camera.

Most backpacks are made from cotton canvas, polyester nylon, polyester or leather. Leather backpacks are thicker than others and heavier. Backpacks are equipped with shoulder straps. Some shoulder straps have back panels. Some backpacks might have a hip belt, load lifters and a sternum strap.

5.1.6 Step 6. Define Target User

This study aims at target users who have a backpack with a capacity between 20 and 25 liters. They are curious about Unfound Backpack, but they resist due to its value barrier.

5.1.7 Step 7. Generate Interim Product Ideas

Unfound Backpack adopts powerful magnetic snaps to attach to a magnetically detachable organizer. This magnetically detachable bag can be transformed into a crossbody bag easily. Consequently, this study generated interim solutions to have the mentioned Unfound Backpack innovative functions. Besides, these ideas adopt magnets to combine with an organizer and conventional backpack to avoid harming the latter, as shown in Figure 42.

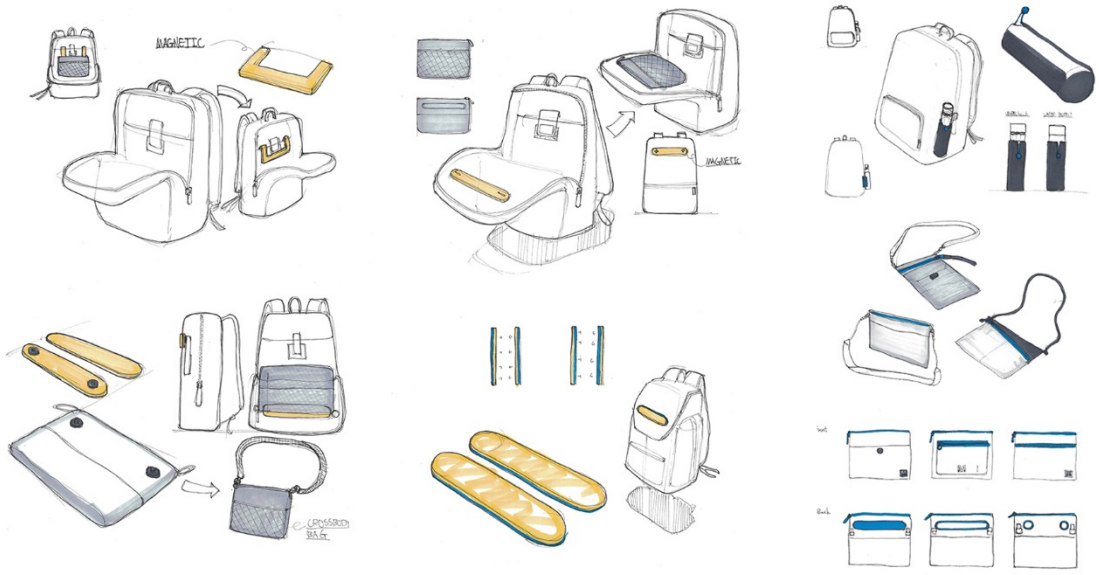


Figure 42. Ideation sketching

5.1.8 Step 8. Select an Interim Product Concept

This study selects an idea that has two separated magnetic clips because they can compatible with more conventional backpacks, as shown in Figure 43 and 44. This interim product is called “Maganizer.” The magnetic clips can be attached to any layer of conventional backpacks, as shown in Figure 45. Afterward, the detachable organizer can be attached to the magnetic clip because there are magnetic male snaps on the clips and magnetic female snaps on the organizer, as shown in Figure 46. As a result, the combination can offer unprecedented consumer benefits similar to Unfound Backpack. When Maganizer is attached to a conventional backpack, it offers an extra compartment for users to organize their small essentials. Moreover, Maganizer can be transformed into a crossbody bag too, like Unfound Backpack, as shown in Figure 47. Another idea with only a single magnetic clip has a limitation. Users’ backpack is required to have a laptop pocket.

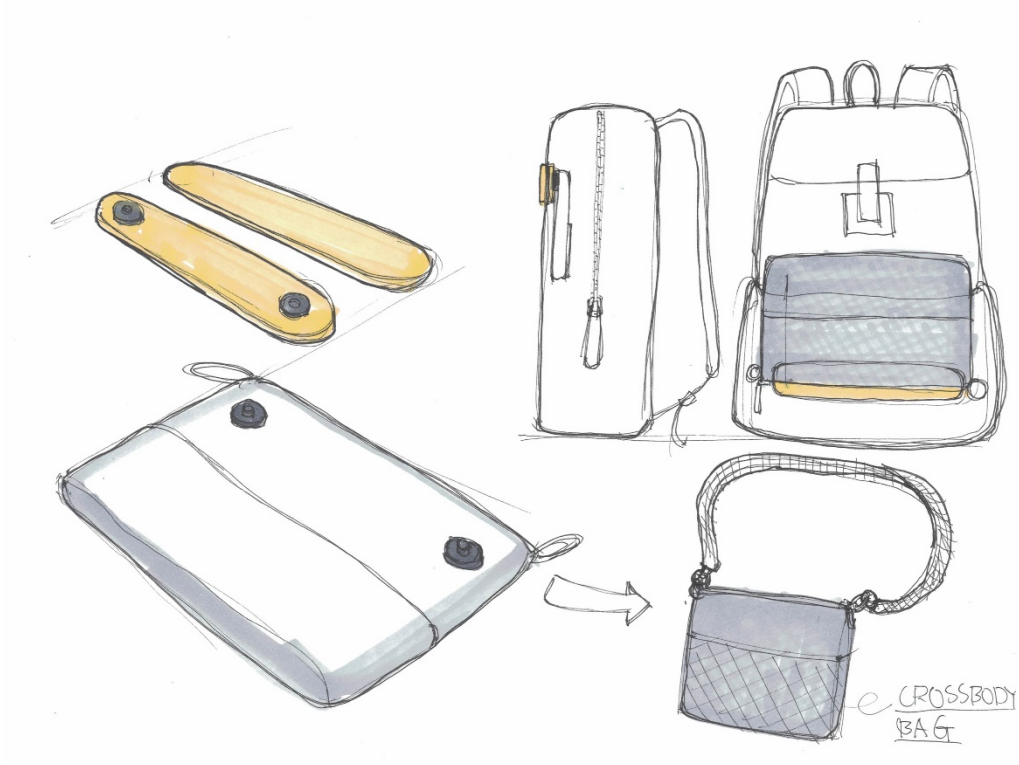


Figure 44. The selected ideation sketching

Figure 43. The prototypes

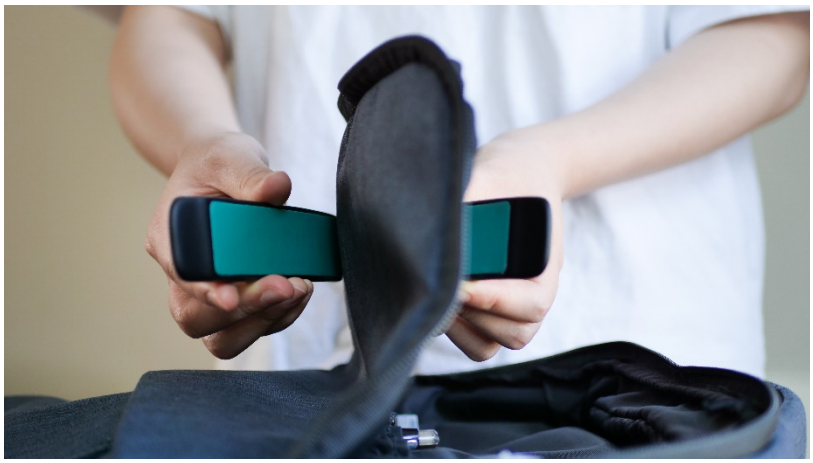


Figure 47. The demonstration how to attach magnetic clips to conventional backpacks

Figure 46. The demonstration how to attach magnetically detachable organizer to a magnetic clip

Figure 45. The transformation of magnetically detachable organizer

5.1.9 Step 9. Refine Specifications

This interim product idea still has some dimensional limitations. The thickness of the layers of conventional backpacks reduces the force between two magnetic clips, so they might fail to attach to a conventional backpack if the weight of the organizer is too heavy to be fixed by the magnetic clips. Therefore, this study should map out the mainstream product's specifications about the thickness of conventional backpacks by validation through prototypes. This study also used more powerful magnets to make the magnetic strips compatible with thicker conventional backpacks. Besides, the fiber materials of conventional backpacks influence magnetic clips negatively. Smoother fiber material can reduce the friction between magnetic clips and a backpack's layers. The solutions are strengthening the magnet in magnetic clips or increasing friction between them and the backpack's layers. This study uses rubber on magnetic clips to solve the problem of friction.

Moreover, the size of a detachable organizer is required to be small enough to be contained by conventional backpacks, so it is crucial to analyze the dimension of conventional backpacks. This detachable organizer can be transformed into a crossbody bag, so it requires to have an external pocket to store an adjustable hide-away strap.

The appearance of this innovative organizer is challenging because there are various conventional backpacks. After investigation, the inner layer of conventional backpacks is mostly black. As a result, this study adopts black fabric to create this detachable organizer because it can fit in the more style of conventional backpacks. Furthermore, this study can offer another brighter style to fit in more conventional backpacks.

5.1.10 Step 10. Perform Economics Analysis

This study does not commercialize this detachable organizer, but its cost is supposed to be cheaper than UNFOUND backpack obviously. Its size smaller than UNFOUND backpack, so it would take less time and use less materials to be manufactured.

5.1.11 Step 11. Perform Interim Product Evaluation

This study uses interim product design guideline scale to evaluate this detachable organizer. The result is shown in Figure 48. This scale is subjective. Its purpose is to make designers evaluate their interim products efficiently through interim product design guidelines. The evaluation result is shown in Figure 48.

Maganizer is much smaller than Unfound Backpack. Although this study does not commercialize it, its cost is supposed to be much cheaper than Unfound Backpack.

Maganizer can offer unprecedented consumer benefits nearly equal to Unfound Backpack, so it does not have a utilitarian advantage.

Maganizer can be combined with most conventional backpacks. The way of the combination successfully avoids harming these backpacks. As a result, Maganizer has high compatibility.

Maganizer has great design communication to prompt users to install it on conventional backpack simply, so it has low complexity.

Maganizer is mainly made from black fiber materials because most inner layers of conventional backpacks are black. Consequently, Maganizer can fit in these conventional backpacks with a black inner layer well. Offering another option for consumers by designing

Maganizer in a brighter style that can fit in more conventional backpacks with a brighter inner layer is a possibility.

Through iterative testing, Maganizer's magnetic clips can have strong force between them when installed on a backpack. Its rubber material solves the problem of friction. As a result, its performance is nearly equal to Unfound Backpack and reduces functional risks considerably.

	Ignore → Strongly follow				
1. Competitive Price Suggest the cost of an interim product is less than half the cost of its counterpart radical product.				✓	
2. Utilitarian Advantage Make the interim product's functions or benefits equal to or better than the referred radical product.			✓		
3. Compatibility Reduce limitations to be compatible with as many mainstream products as possible, including regional, dimensional and material limitations.					✓
4. Low Complexity Make users use or understand the interim product as more easily as possible.					✓
5. Reduce Appearance Risks Make the interim product fit in a kind of mainstream products as many as possible.				✓	
6. Reduce Functional Risks Better the functions of the combination of an interim product and a mainstream product , including product longevity, stability and performance.				✓	

Figure 48. The evaluation result of interim product design guideline scale

5.1.12 Step 12. Plan Remaining Development Project

Ulrich (2003) showed designers formulate a detailed development schedule, plan a strategy to minimize development time, and identify the resources required to finish the project in this final activity of concept development. When designers proceed with an interim products concept in this final stage, they are required to do the same things.

5.2 Strategy Application Summary

The application of strategies demonstrated here is specific to an innovative organizer for backpacks. The innovative organizer designed by this study successfully offer an unprecedented benefit similar to Unfound Backpack. Although this study does not successfully commercialize this idea, it is likely that the cost of the detachable organizer will be less than an Unfound Backpack.

Through this application, this study has two discoveries. Firstly, for interim products, this innovative organizer is a special case because most interim products can work only when they are combined with a mainstream product. The combination can offer unprecedented benefits similar to their counterpart radical products, such as an electric stand-capable desk converter or an electrical bike converter. However, the innovative function offered by Unfound Backpack is a magnetically detachable organizer. It can be transformed into a crossbody bag. Consequently, the innovative organizer designed by this study can offer innovative function when detached from a backpack similar to Unfound Backpack.

Secondly, interim products are more inclusive then their counterpart radical products, but designers still need to identify clear target users for their interim products. It can reduce difficulties caused by dimension limitation and appearance risk. For example, backpacks

designed for students and office workers are in different styles, so it is hard for designers to create an innovative organizer to fit in both of their styles completely. Designers can create interim products in more than one style, such as using different materials or colors, to overcome aesthetic risk, but limited funding is a challenge for companies. Besides, backpacks for office workers might adopt leather, so they have thicker layers and cause dimensional limitations. Therefore, identifying target users is critical for designers to create an interim product.

CHAPTER 6

SUMMARY AND CONCLUSIONS, LIMITATIONS, AND EXTENTIONS

6.1 Summary and Conclusions

This study provides a link through research between innovation and interim products. Interim products are categorized into a new type of innovation, interim innovation. Its aim is to quickly and temporarily achieve market domination to be an interim solution for consumers who cannot afford radical innovations. It is more inclusive than its counterpart radical innovation, so it can benefit more individuals.

Based on the research, this study supposed that the adopters of interim innovation could be a conservative consumer in high-end or mainstream markets because they are not willing to risk adopting radical innovation. Interim innovations have fewer innovation barriers than their counterpart radical innovations. Some of them could also be in mainstream or low-end markets since they do not have a capacity to gain benefits from radical innovations. Interim innovations have a relatively competitive price than their counterpart radical innovation. Ram and Sheth (1989) proposed that innovations have two types of barriers, including functional and phycological barriers. According to the previous case studies, interim innovations overcome usage barriers and economic risk more easily than their counterpart radical innovations. Rogers (2003) showed there are five attributes of innovations, (1) relative advantage, (2) compatibility, (3) complexity, (4)

trialability, and (5) observability. Compared to other innovations, interim innovations have the advantage of high compatibility because they are designed to be compatible with mainstream products and people's current life. During product concept development, designers can design interim products by referring to an existing radical product. It makes designers have clear design goals. Moreover, this study finds that the timing of launching an interim product heighten its familiarity (Gefen et al., 2003), so interim innovations can diffuse more quickly than their counterpart radical innovations.

This study uses case study methodology to investigate existing interim products and discover their pattern. The interim product design guidelines and strategies are proposed. An innovative organizer's design provides a demonstration for how interim product design strategies could be applied to the product category; this interim product is examined with the guidelines. This study hopes that by demonstrating the use of the guidelines and strategies, designers can use them as a toolkit for designing an interim product.

6.2 Identified Limitations

The major limitation of the study of interim products is the lack of related research because this study is a pioneer study related to interim products. This study makes definitions through building a link between innovation and interim products and using multiple case study method to analyze existing interim products.

Another problem is the lack of quantitative research. Existing interim products are simply investigated through multiple case study method. There are still many ambiguous definitions and conclusions. In addition, the characteristics and personalities of the adopters of interim products require further quantitative research.

The interim product design guidelines and strategies can be only applied for design products with a physical presence because this study discovers patterns among existing interim products with a physical presence.

6.3 Extension

Based on this study, the concept of interim products has been demonstrated as a viable method for making radical innovations more inclusive. The interim product design guidelines and strategies are demonstrated, too. The next step is to begin to analyze existing interim products with quantitative research methods. It is considerably helpful to compare interim products with their counterpart radical products in markets to analyze the adopters of interim products. According to further research, the guideline and strategies would still be possibly modified. Also, though there has been some success in bringing interim product design guidelines into the actionable realm for designers, there is still work to be done to solidify its limitations within the field.

The fields of interim innovations and products are not comprehensively researched, and thus there is a lot of opportunities for development. Many investigations have not explored interim products, but that is to beginning to change. A general continuation of design research on interim products will be instrumental in moving our understanding of the construct forward.

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