An Approach For Designing Tech-Driven Innovative Products with a Focus On Improving Early Adoption

by

Xin An

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Approved by

Christopher Arnold, Chair, Associate Professor of Industrial Design
Shu-Wen Tzeng, Associate Professor of Industrial Design
Shea Tillman, Associate Professor of Industrial Design

Abstract

A variety of emerging technologies have become an essential feature of our time. Today's designers not only need to design products but also should serve as a **bridge** between these technologies and human life. Part of the designer's responsibility is to bring these technological developments and innovations to actual products that practically serve people's needs.

To achieve this goal, designers need to understand these technologies and identify their strengths, limitations, and constraints. At the same time, it is the designer's job to **understand the position of the potential customers in the market** and **discover their actual needs**. The ultimate goal is to make the design features match the users' needs. Focusing on the early stage of product and service development, this thesis aims to provide designers with an approach to identifying potential needs from the user's perspective, improving innovation adoption performance when designing products and services utilizing emerging technologies. Several research methods for designers to better understand the potential customers will be introduced, and multiple guidelines and assessment tools helping the designers accelerate the early-stage product and server adoption will be included.

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Table of content

List of Figures

Chapter 1 Introduction

1.1 Problem statement

Most modern designers are mostly educated with User-Centered Design Thinking. Design Thinking, Service Design, UX, CX, etc., which are all usually classified under the broad spectrum of user-centered design and are advertised to effectively create user-focused concepts for products and services by seeing them from the user's perspective. As a result, practitioners of those processes often position themselves on the opposite side of technology-driven innovation, the typical 20th-century product design approach. More recently, there are many technologically innovative companies appearing in our view and affecting people's lives. Some of these organizations put most of their resources into developing and improving new technologies without clearly understanding whether those technologies are being used, are helpful, or may be meaningful. The assumption was that better technology would always generate a market. Therefore, there are many 'new' products and services that are introduced to the customers constantly. Based on Lead Innovation research in 2018, among the innovative product cases investigated, 60% to 80% of new products fail. Therefore, designers usually play a more critical role in the innovation of the entire process of new products entering the market. A large number of failed new product development will lead to economic losses and wasted time. The problem is designers often fail to clearly understand the entire process of new products entering the market, and there are difficulties in perceiving a new technology for designers. As a result, the designed outcomes do not meet the user's needs. At the same time, getting a new technology to be adopted by the mainstream is a long and complicated process. It is necessary to have a comprehensive guide that can help designers decide on the innovation process to improve the final adoption.

1.2 Need for study

According to PwC's 2017 Global Innovation 1000 ranking, tech companies made up nine of the 20 most innovative companies in the world. Technology has transformed the way people live, from small daily ways to ways that change the people who serve the country. As new technologies continue to emerge, the designer's responsibility is to bring those technologies into a real-life product that can fulfill people's needs and succeed in the market.

The gap between science and business is the tech-driven innovation process, which is complicated and long-term. A clear, outcome-driven design process will help the tech-driven product or service be accepted by the potential customers more smoothly and make the design meaningful.

1.3 Objective of study

The main objective of this study is to understand the process of product and service adoption of tech-driven innovation and find out the factors that affect the new product marketing adoption. Then, from these main factors, after studying and classifying, the objective is to find the main factors that can be controlled in the actual design process and summarize them. Finally, the main ideas of the modern user-center design theory and technological innovation characteristics will be systematically combined to develop a comprehensive approach that helps designers find out users' actual needs and match them with the technology innovation to improve the early adoption of technology-driven innovation. The objectives of this study are listed as follows:

a. Identify the main factors that affect tech-driven innovation adoption.
b. Classify and summarized the factors that designers could control.
c. Study and develop an outcome-driven innovation process.

1.4 Definition of Terms

Innovation Adoption Lifecycle (iAL)

Notes: Innovation Adoption Lifecycle is a process that describes how a new tech-driven innovation is being adopted by the market. (Rogers, 2010)

Outcome-Driven Innovation (ODI)

"Outcome-Driven Innovation's customer-centric approach to innovation and product design helps define and address truly important client challenges. That additional clarity further enables us to develop and deliver solutions that provide real customer value, as well as deep, ongoing benefits to my organization and me. Our understanding of client needs and how to gain insights into those needs has been greatly improved." Alex Johnson, System Architect from JTBD

Notes: Outcome-Driven Strategy, a comprehensive strategy that determines the desired outcomes first, then the design process follows.

1.5 Scope of limitations

This research focuses on emerging and disruptive technology-driven innovation design processes. This article is only applicable to a situation when a designer or a related organization tries to bring specific or multiple innovative technologies or unfamiliar technologies into a product and plans to send it to the market.

TDi is a marketing-related process, which means this article's outcomes only apply to a healthy economic environment.

Although multiple factors can potentially influence the adoption, and this research will briefly introduce them, it will only focus on design factors to further develop.

The adoption mentioned above is a long and complicated process, having too many uncontrollable factors in the changes and development of products after entering the market. Therefore, this research will only focus on the early stage of the life cycle of a product or service adoption to provide insights that can potentially help designers during the innovation process.

The approach will mainly focus on the early stage of the designing process, which is to identify the potential needs and opportunities, which is the most challenging but essential part.

1.6 Procedure and methodology

Plan of procedures and methodologies as follows:

a. Study tech-driven innovation models
b. Summarize tech-driven innovation conclusions
c. Identify the factors that influence the iAL performance by literature and case studies
d. Development of an Outcome-Driven design approach
e. Develop an assessment tool to evaluate and predict tech-driven innovation in early market adoption

1.7 Anticipated Outcomes

The outcome of this study would be a systematic design approach focusing on the early innovation stage that helps a designer or an organization bring an unfamiliar technology to an actual product or service and achieve early market adoption. There will be tools to help identify the desired outcomes from the user's perspective and target opportunities. There will be an assessment tool to help designers to self-evaluate their tech-driven innovation in terms of early adoption.

Chapter 2 Literature Review

2.1 Technology Innovation

According to PwC's 2017 Global Innovation 1000 ranking, tech companies made up nine of the 20 most innovative companies in the world.

2.1.1 Sustaining vs. Disruptive Technology Innovation

Disruptive innovation can be defined as "an innovation with radical functionality, discontinuous technical standards, and/or new forms of ownership that redefine marketplace expectations", as proposed by Dubinsky et al.(cited in Nagy et al., 2016). In addition to this definition, Behrens et al. (cited in Dahlin & Behrens, 2005) stated that innovation is considered to be extremely radical when it is a unique novelty with a probable impact on technology. For some consumers, Airpods can be perceived as a disruptive innovation in the audio segment since it revolutionizes an already existing product, the earphones; but for others, it can be seen as merely a new option for wireless phones entitled as a sustaining innovation. Gill, Ying, and Zhenfeng (2015) investigated the consumer approval of new products and concluded that there is a higher intention to adopt a formerly new innovation as an independent accessory (peripheral component) instead of an innovation integrated with the product (core). For instance, it is expected to be a higher intention to adopt independent disruptive innovation products, like Airpods, instead of innovations that come integrated with a product, such as earphones with a Lightning port that come with the iPhone 7.

2.1.2 Emerging technology

Definition of Emerging Technology

"Emerging technologies are technologies whose development, practical applications, or both are still largely unrealized, such that they are figuratively emerging into prominence from a background of nonexistence or obscurity. These technologies are generally new but also include older technologies that are still controversial and relatively undeveloped in potential. Emerging technologies are often perceived as capable of changing the status quo." ("Emerging Technologies, 2019b).

Halaweh (2013) cited the Business Dictionary as defining emerging technologies as "new technologies that are currently developing or will be developed over next five or ten years, and which will substantially alter the social and business environment."

The Wikipedia and Business Dictionary reach a consensus that the emerging technologies will change the future of society and human lives. In other words, the emergence and development of various emerging technologies have become a fact, and they will play important roles in the future of our lives. The road to bringing them into our lives from "nonexistence" is a task for everyone.

Emerging technology is a relative term because someone may see a technology as emerging, and others may not see it the same way. Another factor that determines whether it is an emerging technology is that the majority views its usefulness as dubious, and it may not be embraced by most.

2.2 Technology Adoption

2.2.1 The Adoption of Emerging Technology

Diffusion of Innovation

The studies of the diffusion of innovations, including the part played by mass communication, promise to provide an empirical and quantitative basis for developing more rigorous approaches to theories of social chance (De Fleur, 1987).

In an early study, Kuhn (1966) introduced a Classical Model of the diffusion of new ideas that emerged. The main elements of the classic model are (1) the innovation, defined as an idea, practice, or object perceived as new by an individual or other relevant unit of adoption, (2) which is communicated through certain channels, (3) over time (4) among the members of a social system.

The diffusion of innovation is a graphical chart based on research data and analysis that intend to explain how, why, and at what rate new ideas and technology innovation spread among society.

Rogers (2010) studied found the following:

> "Getting a new idea adopted, even when it has obvious advantages, is often very difficult. Many innovations require a lengthy period, often of many years, from the time they become available to the time they are widely adopted. Therefore, a common problem for many individuals and organizations is how to speed up the rate of diffusion of an innovation." (Rogers, 2010, p.22)

Rogers first introduced the diffusion of innovation model to us in 1962. He defines 'Diffusion' as the process by which an innovation is communicated through certain channels over time among the member of a social system which is a special type of communication.

Figure 1 is a diffusion of innovation with successive groups of consumers adopting the new technology (shown in blue) so that its market share (yellow) will eventually reach the saturation level. The blue curve is broken into sections of adopters.

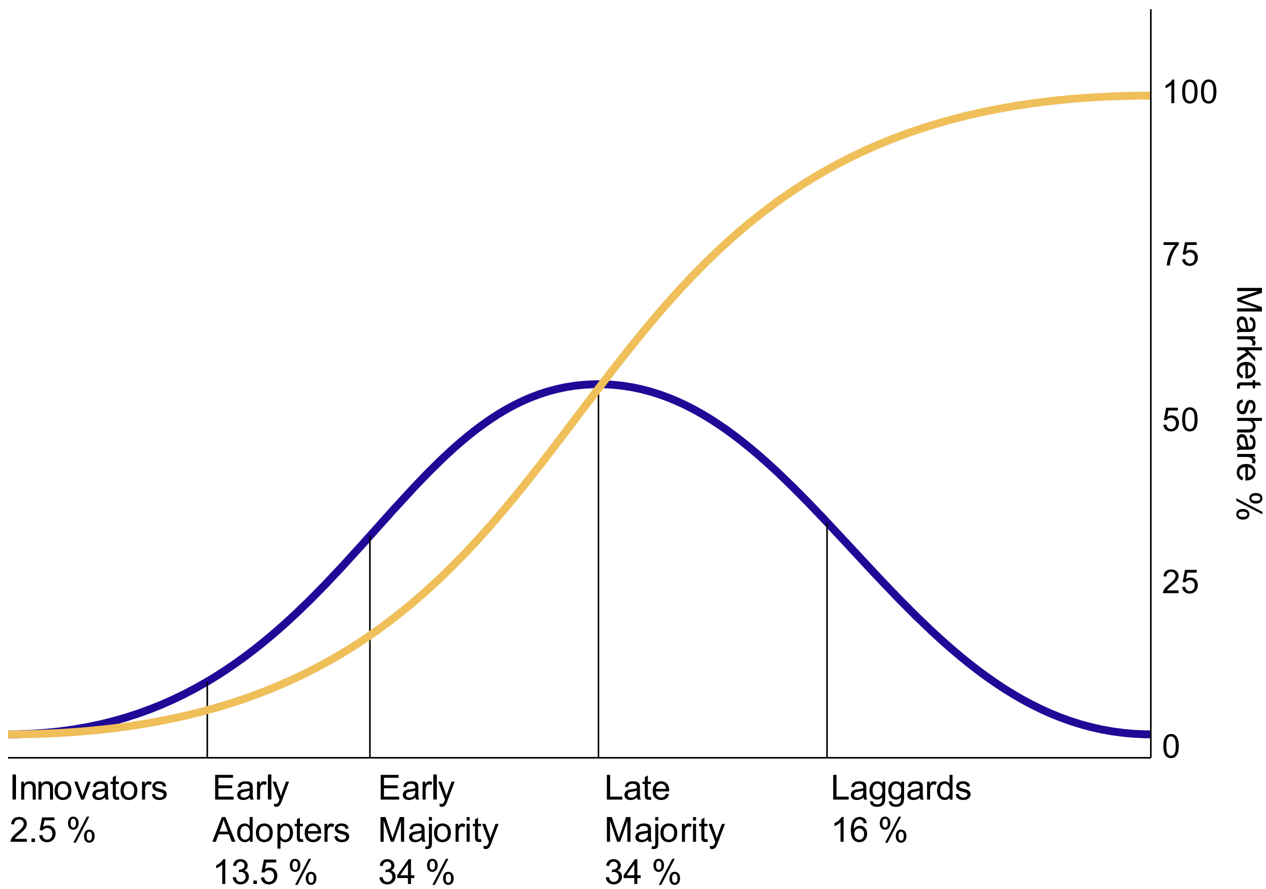


Figure 2.2.1.1 The diffusion model of technology innovation (Rogers,2010)

Rogers(1962) divides adopters into five categories: innovators, early adopters, early majority, late majority, and laggards. Diffusion manifests itself in different ways and is highly subject to the type of adopters and innovation-decision process. To explain the diffusion curve, Rogers proposes that four main elements influence the spread of a new idea: the innovation itself, communication channels, time, and a social system. This process relies heavily on human capital. The innovation must be widely adopted in order to self-sustain. Within the rate of adoption, there is a point at which an innovation reaches critical mass.("Diffusion of Inovations", 2019a)

Roger's diffusion model shows that it is a long and phased process for an innovation to be adopted. It allows designers and marketers to examine why it is that some inferior products are successful when some superior products are not. It was the earliest theory and model trying to present and analyze how an emerging technology goes into our lives. To this day, it still provides a formal understanding on which modern research into the diffusion of innovation is based.

Technology Adoption Life Cycle

Later in the 1960s, **Geoffrey Moore (1999) renamed the *Diffusion of Innovation*** chart into *Technology Adoption Life Cycle* and revised it in his book *Crossing the Chasm(1999)*. As we can see in Figure 2.2.1.2, the components of the life cycle remain the same, but there are gaps introduced between any two psychographic groups. These gaps show the dissociation and discontinuities between every gap properly, which is the difficulty any group has in accepting a new technology or idea if it is presented in the same way as it was to the group to its immediate left. He calls first adopters or innovators venturesome, early adopters are respectful, the early majority deliberate, the late majority skeptical, and the laggards traditional.

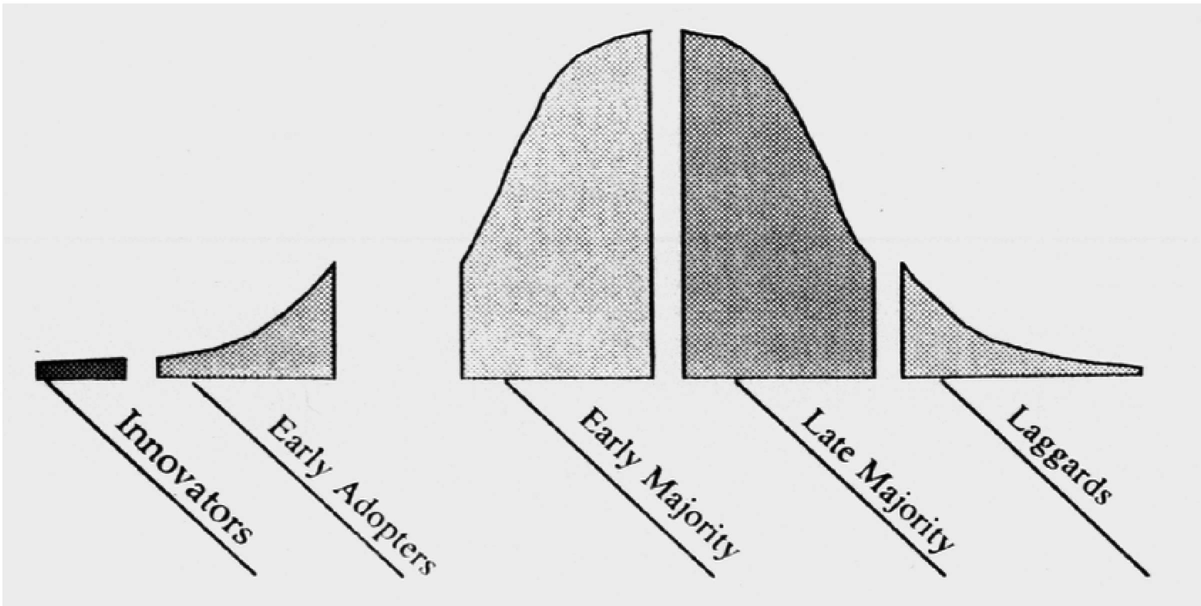


Figure 2.2.1.2 Revision of technology adoption life cycle (Moore,1969)

Moore also made an addition to the diffusion model, which is the famous idea of the "chasm," meaning the biggest obstacle for a technology to move into the mainstream. (Figure 4)

To develop the chasm, **Moore first discovered the two main cracks in a technology adoption cycle**. The first crack is the **one between the group of innovators and the group of early adopters.** The first gap occurs here when a new technology or idea cannot be readily translated into a major new benefit. In other words, how the emerging technology to be adopted is a different language that cannot be translated into some statements that adopters can understand in this early stage. Moore assumed that the key to winning over this segment is to "show that the new technology enables some strategic leap forward, something never before possible, which has an intrinsic value and appeal to the non-technologist" (p.123). This benefit is typically symbolized by a single, compelling application, a product that best captures the power and value of the new innovation. Moore also believes that the development will stall with the innovators, and the future of the innovation falls through the crack if the marketing effort is unable to find that compelling application.

Another crack is the gap falling between the early majority and the late majority, where the market is already well developed, and the mainstream has absorbed the new technology innovation. The gap that occurs that here is the problem of how to transition the technology from early to the late majority, "to be technologically competent" (p.156), Moore says. The product must be made increasingly easier to adopt in order to continue being successful. Otherwise, the transition to the late majority will stop or never happen.

2.2.2 The Chasm

The two main gaps are significant contributors to help people understand the technology adoption cycle. But in the Chasm (see Figure 3), the most important discovery that Moore made is not these two cracks. The real news is the **deep and dividing chasm that separates the early adopters from the early majority**. "This is by far the most formidable and unforgiving transition in the technology adoption life cycle, and it is all the more dangerous because it typically goes unrecognized" (p.126). He summarized the chasm as follows:

> when promoters of high-tech products try to make the transition from a market base made up of visionary early adopters to penetrate the next adoption segment, the pragmatist early majority, they are effectively operating without a reference base and without a support base within a market that is highly reference oriented and highly support oriented (p.126).

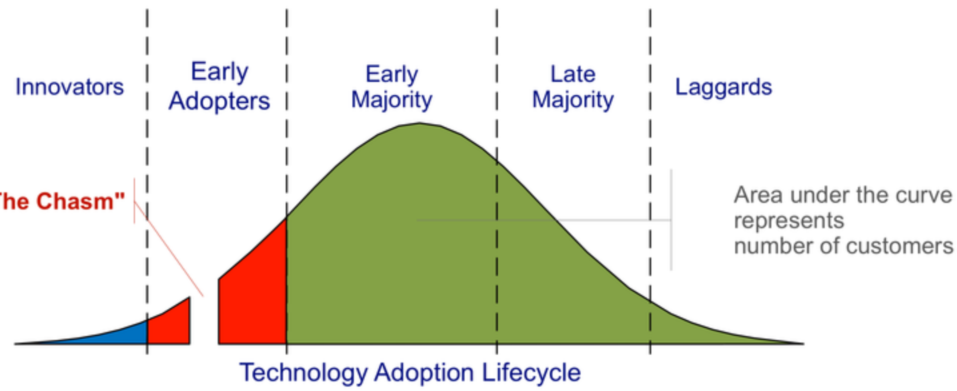


Figure 2.2.2.1 Chasm in technology adoption life cycle (Moore,1969)

There are too many obstacles during the early-adopting process, such as the inability to integrate it easily into existing systems, no established design methodology, and lack of people trained in how to implement it. To cross the chasm Moore discovered is a systematic design process, which requires a related methodology that frames out the whole strategy that can help a technology adopted by the early majority of innovators.

Moore's Chasm Model has become the dominant framework to discuss the development of the markets for high technology products and services.

2.2.3 Hype Cycle of Technology Innovation

2.2.3.1 Introduction to the Gartner's Hype Cycle

In Linden and Fenn's study (2003) on Gartner's hype cycle:

Gartner's Hype Cycle, introduced in 1995, characterizes **the typical progression of emerging technology from overenthusiasm through a period of disillusionment to an eventual understanding of the technology's relevance and role in a market or domain** (see Figure 4). The first part of the hype curve is driven by vacuous hype — mainly by the media, which speculates on the technology's prospects. The second part of the hype curve primarily is driven by performance gains and adoption growth. (p.29)

In summary, **the hype cycle is a graphical representation of the life cycle stages a technology goes through from emergence to maturity and widespread adoption**. It is designed for entrepreneurs and decision-makers to predict future trends, understand the cycles of emerging technologies and make decisions about the adoption of up or coming technologies. But, the period of the earliest stage of technology innovation or conception process is not included in this cycle, and neither is the following development or vanishing of a mature technology or product.

Figure 2.2.3.1 Gartner's Hype Curve (cited in Linden & Fenn, 2003)

2.2.3.2 Understanding the Hype Cycle

There are studies that help people learn the Hype Cycle by breaking it into several sections. Overall, we could divide the whole 's' curve into five phases to understand the characteristics in each phase as well as the transactions between every phase, and most important, their relationship with designers (Figure 2.2.3.2.1).

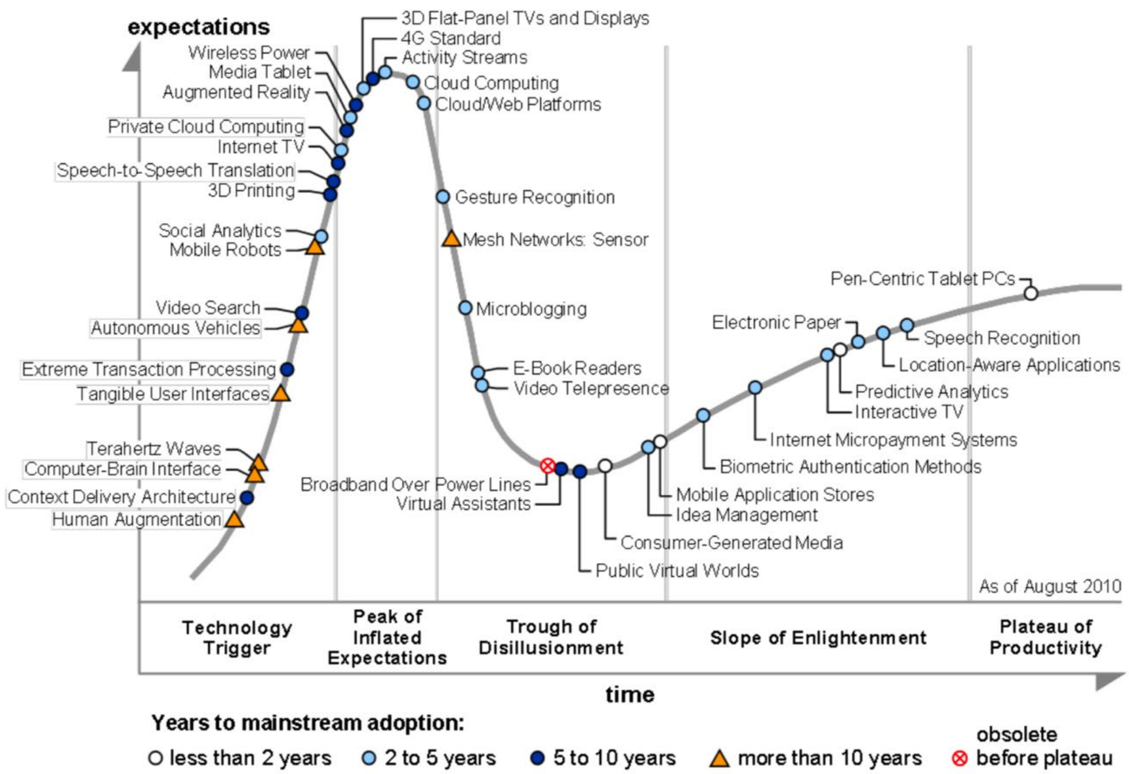


Figure 2.2.3.2.1 Hype Cycle for emerging technologies in 2010

1. Phase 1 Technology Trigger

The first phase, Technology Trigger, begins when the general public becomes aware of the initial hype of an innovation. This could be a new product on the market, a scientific breakthrough, or a similar event that causes great excitement and hope. Here, people begin talking about innovation, and the word spreads quickly (Lajoie & Bridge., 2014). Apparently, the first phase of the hype cycle is close to the end of the pure science in technology industrialization map. It is a transformation from pure science knowledge, experiments, and hypothesis to some information that people can understand and discuss easily. That means this is the starting point for designers to step in as the information begins to become understandable when it represents the possibility and needs to be brought to life. From the perspective of a designer, in this stage, there are typically no usable products existing, only research and laboratory work that shows its existence or feasibility. Here is also where venture capitalists and investors get involved in evaluating or funding as early adopters.

2. Phase 2 Peak of Inflated Expectations

Before the peak, the rise to the Peak of Inflated Expectations is mostly driven by media who are trying to explain the technology and predict their potentiality on human life or economy. "First-generation products emerge, but they usually are highly specialized products or extremely difficult to use" (Linden & Fenn, 2003, p.34). There are barely any designer's activities in this period because the products are mostly engineering-driven prototypes showing the technology application.

During the second phase, the Peak of Inflated Expectations, press, and media coverage is highly optimistic while innovators and early adopters begin using and trialing the new innovation while others worry about being left behind (Lajoie & Bridge, 2014).

At the Peak of Inflated Expectations, never will there be more buzz about this technology than at this stage in the cycle. The technology itself becomes a trend among investors and early enterprises. Different types of products appear here but always come along with visible problems, and most of them fail eventually.

It may be because of the lack of a systematic design process that aims to break the fence between science and business. The designer's responsibility here is to work as a bridge between the technology and real product to apply the technology properly in well-designed products that fulfill a business goal.

3. Phase 3 Trough of Disillusionment

> After the excitement peaks, the *Trough of Disillusionment* begins. This phase of the Hype Cycle sees waning interest in the innovation as consumers look beyond the initial excitement and hype. This is the time period when many adopters, including companies and entire industries, abandon a new technology, believing that negative public opinion indicates the life of the technology has come to an end. In fact, it is possible the innovation simply has not yet hit the next stage in the Hype Cycle, the *Slope of Enlightenment* (Lajoie & Bridges., 2014, p.40)

The technology drops out of the mainstream discussion in this phase. The abandonments are the results of the failure of the first-generation products. Society couldn't find the right position or role for the emerging technologies, as they might have a bad performance, or they were pushed too hard to the limitations.

> The Trough of Disillusionment coincides with the "chasm" in Geoffrey Moore's classic book, "*Crossing the Chasm*." During this stage, vendors need to launch their products from a few early adopters to adoption by a majority of enterprises to begin the climb up the Slope of Enlightenment. (Linden & Fenn, 2003, p. 42).

4. Phase 4 Slope of Enlightenment

"During the slope of enlightenment, early adopters experience benefits of adoption and more fully understand where the innovation can be used effectively" (Lajoie & Bridge, 2014, p.3). This is the point when the innovation goes into the late stage of adoption cycle.

5. Phase 5 Plateau of Productivity

The final phase, the Plateau of Productivity, happens when the long-term benefits of an innovation take hold and are integrated into regular activities and work flows, making adoption a significantly less risky proposition.

Gartner's Hype Cycles offers an overview of relative maturity of technologies in a certain domain. They provide not only a scorecard to separate hype from reality, but also models that help enterprises decide when they should adopt a new technology.

Several technology life cycle models attempt to gauge the evolution of a technology. The two most popular are the performance S-curve, which shows the increase in a technology's performance over time, and the adoption curve, which shows market adoption over time (see Figure *2.2.3.2.2*).

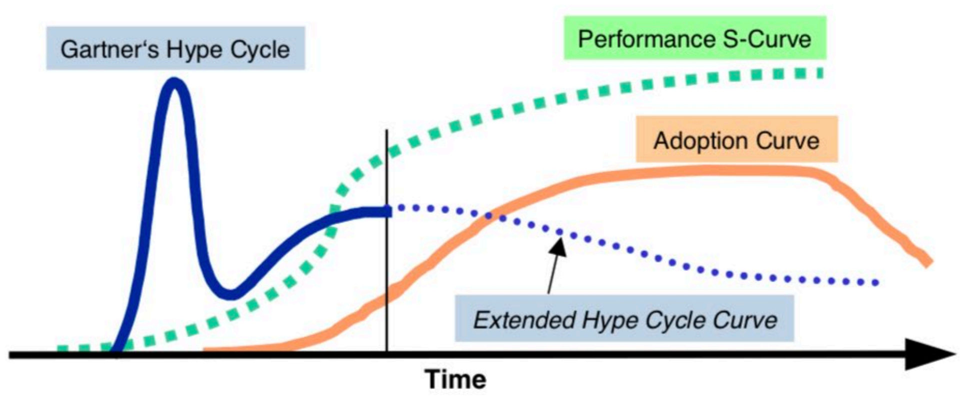


Figure 2.2.3.2.2 Technology Life Cycles (Linden & Fenn, 2003)

The Hype Cycle adds another dimension to these models. In addition to charting technology maturity, Hype Cycles also reflect human attitudes to technology. Most technologies conform to the Hype Cycle because the invariant in the equation is people, not the technology. (The observation that hype precedes maturity has been noted by Howard Fosdick and others.) (Linden & Fenn, 2003)

2.2.4 The Innovation Fence

Since Moore's Diffusion Model and Gartner's Hype Cycle are both trying to objectively describe the process of entering the market after the emergence of a technology innovation, we could find several interesting points when putting them together, seen in Figure 2.2.4.1.

The first obvious gap, which is described as breakthrough one, here occurs when the early adopter starts to adopt right after the stage of innovation process in the Hype Cycle, where the peak of expectations is located. The breakthrough point two happens between the group of early adopters and early major adopters as we can see in the Moore's Adoption Life Cycle, coincidental, but understandable, as here is the lowest point in the whole Hype Cycle after the emergence of technology. The Chasm Moore mentioned occurs between two breakthrough points, which is the period where people start to lose confidence and abandon the product, which we call the Trough of Disillusionment in the Hype Cycle.

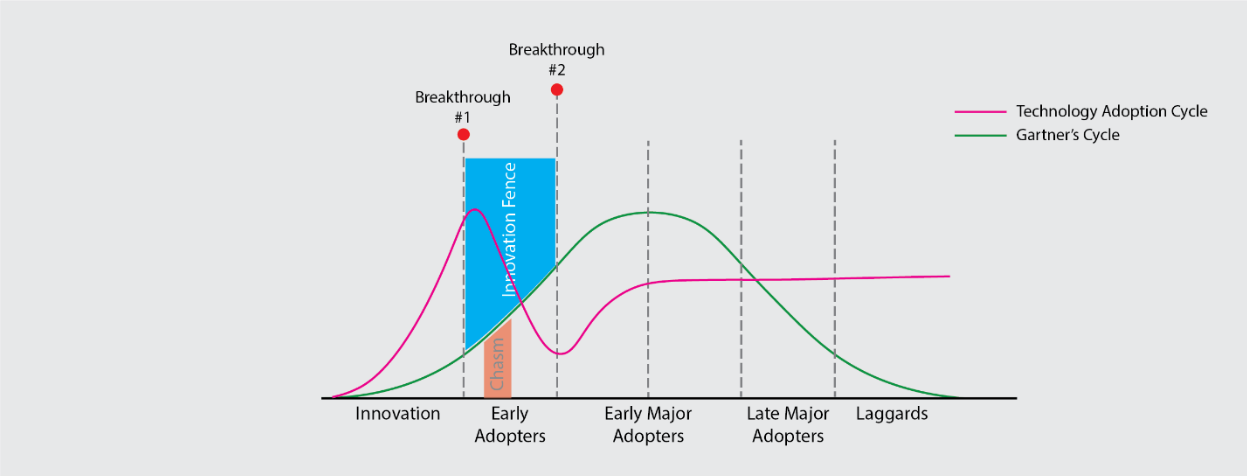


Figure 2.2.4.1 Mixed model of Technology life cycle and Hype Cycle

In summary, the two models from the different theories are describing the same thing, the adoption after a technology emerging, and they coincidentally support each other. From these studies, two breakthrough points and a chasm could be put together to be described as the Innovation Fence on the road to bring emerging technology to life. The Innovation Fence includes the most significant obstacles that should be noticed by every group and program engaged in this process, such as scientists, entrepreneurs, managers, politicians, engineers, and most importantly, the designers.

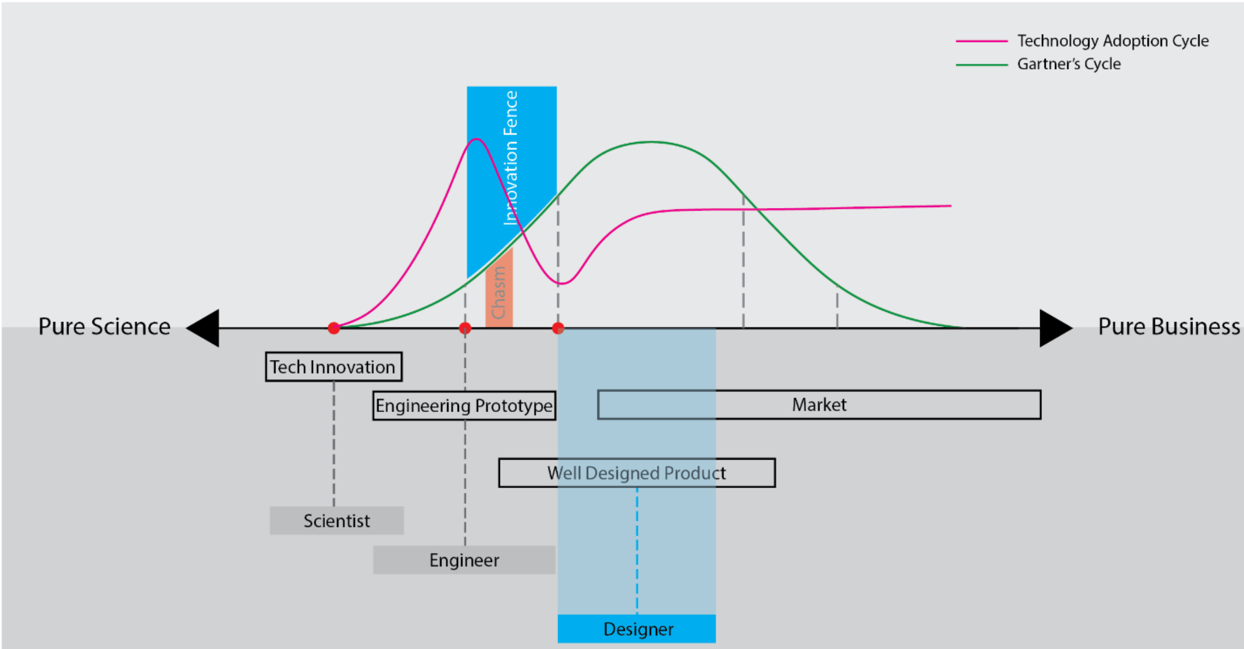


Figure 2.2.4.2 Mixed model with product development map

Figure 2.2.4.2 illustrates the position of different groups of specialists in the technology industrialization process in the new mixed model. The adoption always starts from the technology innovation, which is a process that is highly driven by scientists, who are a group of people who have expert knowledge in one or more particular areas. Apparently, technology invention is infinitely close to pure science due to most of the emerging technologies coming from scientific experiments or developed from research step by step. The earliest adopters show up at this point; simultaneously, people start discovering the emerging technology and showing interest. When concerns and expectations from all walks of life reach the highest peak, technology begins to be brought into human life. Some engineering prototypes are entering our vision, which could be called the first generation of products produced by related engineers. In the absence of designer involvement and effort, most engineering products are not accepted by the mass market. Perhaps these products were created by turning knowledge and science into concrete objects. At the same time, at this stage, we believe that engineers and scientists will have some intersections in the content and nature of their work.

In most cases, **designers are not involved in the design of the first generation of the product. Instead, they are employed more to design products for the mass market.** Usually, this fence was left there for no one to deal with, becoming the cause of the failure of most technological innovation entrepreneurs and various other business failures. It could also lead to the suspension or abolition of technological innovation.

The right people to deal with the innovation fence are designers. As Figure 2.2.4.3 illustrate here, if designers could get involved earlier to bridge the gap between science and product, it is possible to shorten the adoption period and make the design outcomes more meaningful.

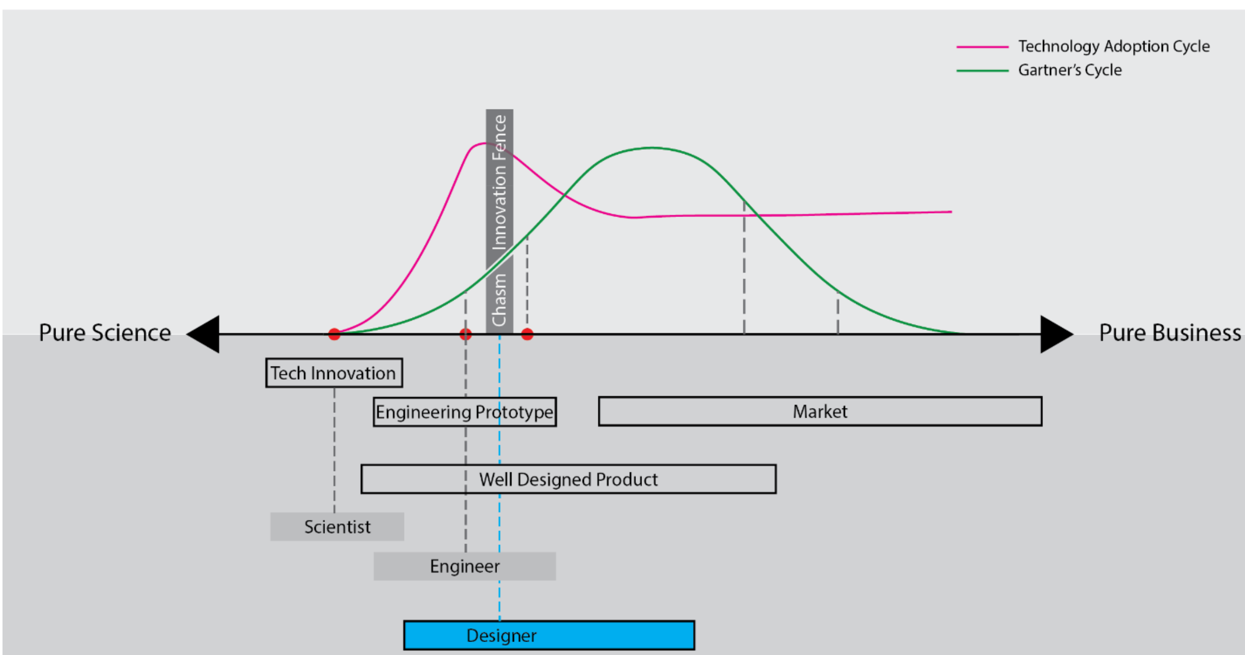


Figure 2.2.4.3 New Mixed Model of Innovation Adoption

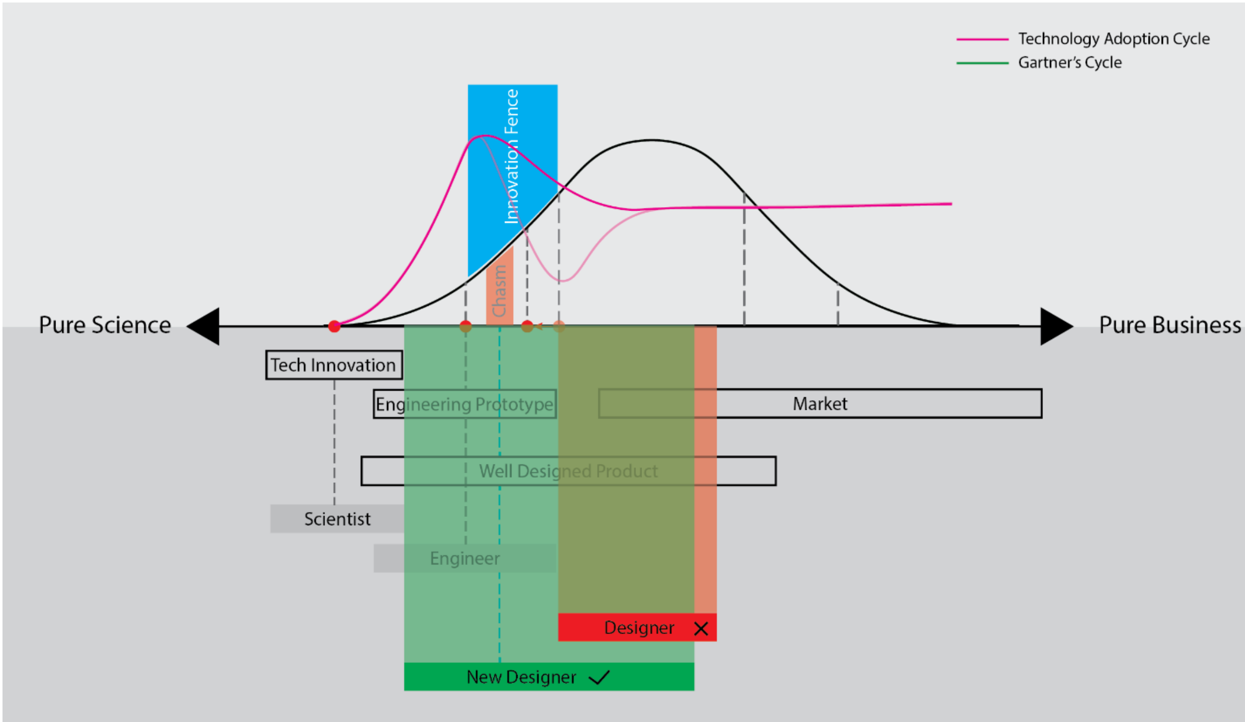


Figure 2.2.4.4 New Mixed Model of Innovation Adoption (Designer Impart)

Marketers and product developers focus too much on customer profiles and on correlations unearthed in data and not enough on what customers are trying to achieve in a particular circumstance (Christensen et al., 2016).

Successful innovators identify poorly performed "jobs" in customers' lives—and then design products, experiences, and processes around those jobs (Christensen et al., 2016).

2.3 Technological Innovation Commercialization

Commercialization is known to be a critical stage of the technological innovation process, mainly because of the high risks and costs that it entails. Based on research made by Cierpicki, Wright, and Sharp (2000), the fully commercialized new products have a remarkable failure rate of 40 to 50%, and this performance has not changed much over the past 20 years. The commercial performance of a new product can be heavily influenced by the approaches used to commercialize it and bring it to market (Schilling, 2016). This is clearly evinced by the host of innovations that, despite being technically and functionally superior to competing ones, proved far less successful mainly because of a poor launch strategy (Hartley, 2005).

Dimensions of Commercialization of Innovation

According to existing literature, Commercialization of Innovation (CoI) could be understood as a set of the decision-making process which defines how the new product is positioned and ultimately introduced into the market.

Launch strategy research suggests that this construct should comprise two classes of variables: strategic and tactical (Cierpicki et al., 2000). Strategic decisions are taken prior to the launch of the innovation and even before starting its development. They essentially define the context in which the launch of the new product occurs. Tactical decisions instead encompass the key elements of the marketing mix and are thus concerned with the operational aspects of the innovation's launch.

Variable	Description	Type of variable
Timing	– Timing of the innovation's launch on the market – Timing of the innovation's preannouncement – Timing for establishing partnerships and alliances	STRATEGIC VARIABLES
Targeting and positioning	– Target market for the innovation – Market positioning of the innovation	
Inter-firm relationships	– External organizations with which to establish relationships – Terms of the agreements underlying the relationships	
Product	– Configuration of the "whole product"	TACTICAL VARIABLES
Distribution	– Type of distribution channel for the innovation – Critical functions the distribution channels is expected to perform	
Advertising and promotion	– Types of advertising channels – Type of message conveyed	
Pricing	– Pricing strategy – Pricing of complementary goods and services	

Figure 2.3.1 Different Decision Making Models(Cierpicki et al., 2000)

As we can see in the Dimensions of CoI, some of the decision-making processes might require designers' related activities, such as defining the configuration of the "Whole Product," critical functions, even the consideration of market targeting and positioning.

2.4 Comprehensive Factors Influencing Technology Adoption

Concerning some research studies on new product adoption of recent consumer electronic products, it was found that age and income are the main drivers as personal characteristics, more relevant than consumers being innovative by nature (Im, Bayus, & Mason, 2003). In specific, the main findings from this research suggested that consumers who have higher incomes and younger ages, as well as predisposition to innovations, are more likely to be the segments of consumers to adopt more new products, namely "innovators" and "late adopters."

Word-of-mouth (WOM) is a type of promotion of a product or service in which customers expose to others their satisfaction or dissatisfaction about their consumption experience. Electronic word-of-mouth, also known as Virtual word-of-mouth, consists of another form of WOM present in digital platforms such as online websites; during the digital era we are present in, it is beginning to gain more relevance. Recent studies about the impact of virtual word-of-mouth on purchase intentions (or willingness to pay) of consumer electronic innovations stated that virtual word-of-mouth is perceived as credible information about the innovation, and customers' willingness to pay "is also positively correlated with an innovation's perceived utilitarian and perceived hedonic value" (Parry & Kawakami, 2015, p.23). According to Kawakami and Parry’s studies (2015), also in this field, both personal and virtual word-of-mouth influence use innovation in a different way. The findings from the research established that personal word-of-mouth positively strongly impacts the intensity of use (perceptions of the number of local adopters) and the variety of use (perceptions of the complementary products available). In practice, these findings may suggest that personal WOM has a stronger influence over virtual WOM on making people adopt innovative products. Some studies on technology acceptance indicate that both personal and virtual word-of-mouth positively influence the perceived ease of use (Parry & Kawakami, 2015). In more detail, in the smartphone industry, Parry (2015) found that virtual word-of-mouth is more related to perceived usefulness and has a greater influence on perceptions of Innovation via 17 attributes, such as ease of use.

The communication of innovations also has an impact on new product adoption, and a study on the willingness to try an innovation stated that consumers are more influenced to try innovations through a mixture of visual and verbal communication elements (Chaudhuri, 2014). More precisely, these studies found that a consumer's willingness to try an innovation increases significantly when is a picture is added to a hedonic verbal description of that specific innovation, and vice-versa for utilitarian verbal descriptions.

According to Wildman and Griffith's (2016) studies on cross-cultural new product strategies, design innovations are preferred over technological innovations aiming to establish a social status differentiating from others. Adding to these findings, the results from the same study suggested that the positive relationship between technological innovations and market share declines in countries with higher uncertainty avoidance (meaning, in other words, less tolerance to ambiguity).

The commercial performance of a new product can be heavily influenced by the approaches used to commercialize it and bring it to market (Schilling, 2016). Poor launch and marketing strategies have doomed a large number of innovations, even when they are technically and functionally superior to other products.

2.5 Business Factors Influencing Purchase Intentions

Consumers can be influenced in their intention to purchase a product by many strategies applied by brands. It can be through the brand image, which is considered attractive for one and creates awareness in the customer's mind, and hence influences the consumer for a repeated purchase creating brand loyalty in this process. The related brand building plays an important role in the product adoption, which could be classified into four categories as following: (Khurram, Qadeer, & Sheeraz et al., 2018)

Awareness

Brand awareness, including brand recognition and brand recall. Recognition is defined as a capability by consumers to easily identify the brand when exposed to some sort of product, whereas recall is designed as a capacity of consumers to remember the brand when presented with some categories of products.

Loyalty

A series of definitions of brand loyalty explains that loyal consumers are the ones who develop a strong relationship with a brand of their preference, whether by purchasing repeatedly or making recommendations of products and services experienced by them to other potential customers. Chaudhuri's (2001) study on the role of brand loyalty found the effects that trust in the brand and affection for the brand have on the overall performance of the brand itself. They stated that focusing on purchase loyalty leads to more sales outcomes. Consequently, increasing market share while focusing on attitudinal loyalty leads to premium outcomes, meaning higher relative prices from the brand. According to a study on consumer electronics products (Dawar, 1994), some aspects highlighted in marketing strategies can become signals for consumers as quality, such as the brand name, the price, and the physical appearance, perceived as the design.

Lock-In

Brands want to retain their consumers through the concept of Lock-in, making them to be less likely to search and switch sellers after having an initial investment. Lock-in is mainly caused by choice of immediate costs minimization and by a non-anticipation of future switching costs that may occur, as concluded by Zauberman (2003). Therefore, consumer electronics companies are interested in keeping their customers loyal to them by using this strategy, for instance, through software incompatibilities between brands.

Network Externalities

Network externalities are considered an effect caused to increase the value of a product when there are many users. Kawakami's (2009) study on technology acceptance revealed that consumer perceptions of these network externalities 19 variables influence their own perceptions of innovation attributes and directly impact their purchase intentions.

2.6 Existing Design Principles for more humanistic technology.

Technology should empower human capacities. "The problems that we face with technology are fundamental. They cannot be overcome by following old pathways. We need a calmer, more reliable more, human approach. We need augmentation, not automation" (Norman, 2013, p.64).

Design should balance business value with user needs. Designers have a responsibility to warm their business peers when their decisions can make the user experience harder and therefore negative for product development.

Technology should be calm and non-intrusive. "The challenge is to add intelligent devices to our lives in a way that supports our activities, complements our skills, and adds to our pleasure, convenience, and accomplishments, but not to our stress" (Norman, 2013, p.62).

Design technology that requires the least possible amount of attention. Technology doesn't always need to speak.

Design for inclusion. Technology doesn't fit everyone's needs and habits. Inclusive design in tech means designing different versions of service tailored to different personas.

Design meaning drove innovation. Innovation is not self-serving. Creation is good when it solves a problem. **To avoid building meaningless things**. It would be necessary for designers to do user research, build empathy with affected people and understand real industry problems that are worth solving.

In Follett's (2014) book *Design for Emerging Technologies*, based on several studies, eight design tenets for emerging technology were introduced with his viewpoint. "Design should provide the connective tissue between people and technology. The seamless integration of a technology into our lives is almost always an act of great design" (Follett, 2014, p.6). Follet describes the designer **as the bridge between human beings and technologies**, which is consistent with previous research in this study. In his studies, he thinks design provides the frame for how technology works and how it's used. It can also situate it within a broader context: incorporating system thinking, planning for a complete technological life cycle, and evaluating the possibility of its unintended consequences.

The first tenet is to **identify the problem correctly,** "Designers should be problem identifiers, not just problem solvers searching for a solution to a pre-established set of parameters. We must seek to guide our technology, rather than just allow it to guide us"(Follett, 2014, p.49).

The second tenet is to **learn constantly**. Designers will need to understand the implications of science and technology for people. To do this effectively, designers must immerse themselves in the new technical domains and learn them quickly. Just as the understanding of and empathy for people allows us to successfully design with a user's viewpoint in mind, understanding the materials, whether they be pixels or proteins, sensors or servos, enables designers to bring a design into the world. To achieve this, designers need to be early adopters of technology, learning constantly. **The study shows that designers are being encouraged to be the earliest adopter of the technology and keep learning and understanding as far as they can to have better innovation processes and succeed in decision makings.**

The other suggestion is to **think systemically**. "But the magic of the consumer experience of these products is only possible through the design of a complete, and hopefully seamless, ecosystem" (Follett, 2014, p.54).

Follet also suggests **designers should work at various scales, from the aforementioned overall system view to the nitty-gritty details**. Moving between these levels will be necessary, too, as each one informs the other—the macro view informs the micro, and vice versa. On top of regular design work, designers should understand, analyze, and design every detail and connection.

2.7 Designers and Engineers

In this section, the role designers and engineers play in the product development process are studied.

Under most circumstances, it will be a complicated process, a multi-party cooperation task to bring technology into a real-life product. Follett (2014) stated in his book:

> The challenges inherent in much of emerging technology are far too great for an individual to encompass the requisite cross-domain knowledge. For this kind of work, then, the team becomes paramount. It is a multidisciplinary mix of scientists, engineers, and designers who are best positioned to understand and take advantage of these technologies.(p. 5)

2.8 Design Factors

Other than business factors, adopter factors, market factors, design factors are the key to the success of early market adoption. In a study conducted by the National Programme on Technology Enhanced Learning (NPTEL) named *Module 8 Diffusion of Innovations* in 2011, five main design factors affect innovation adoption.

Relative Advantages

The relative advantage of the innovative product/service offering over already existing products/services accelerates its adoption rate by the target market. The degree to which customers perceive a new product/service superior to similar existing products determines the relative advantage("MODULE 8: DIFFUSION OF INNOVATION," 2011).

The Relative Advantages take the most priority. For example, Palm Pilot handwriting recognition systems provide a better solution over traditional input methods on the mobile device; it is also relatively better known than Apple Newtons. The user experience, workflow, and physical shapes mentioned above in the case study are all concluded here in relative advantages.

A product/service that provides an advantage over other existing products indicates being superior to existing alternatives and thus higher in terms of "value." The more radical a change and the higher the relative advantage, the faster would be the diffusion. The relative advantage may lie in terms of it being a modified product (with better features, attributes, benefits, form etc.), or at a lower price (better deals, discounts, terms of payment, warranty and exchange), or more accessible in terms of availability (physical store format, or virtual electronic format), or better communication. **Thus, the relative advantages shall be considered from the user's perspective**, not the innovators. So it is essential to identify users' needs and expectations to achieve this goal.

Compatibility

The compatibility of the innovative product and service offered with the existing backgrounds, behavior, and lifestyle patterns of consumers also affects its adoption by the consuming public. The compatibility of a product/service measures how closely it relates to needs, value systems, and norms, lifestyles, culture, etc. ("MODULE 8: DIFFUSION OF INNOVATION," 2011). The higher the level of compatibility of the innovative product, the quicker the diffusion; lack of compatibility slows the diffusion. A product will diffuse more quickly if it does not require consumers to change their values, norms, lifestyles, cultures, and day-to-day behaviors. Continuous and dynamically continuous innovations are higher on compatibility than discontinuous innovations. ("MODULE 8: DIFFUSION OF INNOVATION," 2011)

Complexity

The level of complexity in product purchase and usage also affects the diffusion process. An innovative offering would be quickly diffused when there is ease of understanding, purchase, and use. The easier it is to understand and use a product, the more likely it is to be accepted quickly, and vice versa. Tech-Driven designs should not create confusion, difficulties. It is suggested the design outcome be clear, understandable. Technology language shall be transformed to the user's language, which means the design feature will serve the user's expectations instead of causing any confusion. ("MODULE 8: DIFFUSION OF INNOVATION," 2011)

Observability

Observability refers to the ease with which the product can be observed. Observability in an innovative product refers to the degree to which a product/service's benefits can be observed, imagined, and perceived by a potential consumer. In other words, the feature or advantages that the innovative design brings should be discovered easily.

The higher the degree of observability, the greater the chances of the innovative offering being accepted by the prospects. It is a more comprehensive term of discoverability. The advantages that the technology brings should be easily discovered and observed. ("MODULE 8: DIFFUSION OF INNOVATION," 2011)

Trialability

The ease with which the product or service can be tested and tried also determines the rate of acceptance. The higher the degree of trialability, the greater would be the rate of diffusion. This is because the prospects get an opportunity to try the product/service, assess it, and decide to accept/reject it. Based on previous research and studies, the ability of an innovation that could be tested or tried by users is also an essential factor that could affect the adoption. ("MODULE 8: DIFFUSION OF INNOVATION," 2011)

2.9 Introduction to Case Study

To further find out the design factors that influence tech-driven adoption and test the five abilities theory, four case studies were conducted—first, a comparison between Apple Newton and Palm Pilot. Second, a successful case of Airpods with wireless technology.

Third, the failure of iPhone 3D touch Technology innovation.

During the case evaluation, an assessment guide is developed based on the five abilities theory, as we can see from Figure 2.9.1

Design Features	Relative Advantages	Compatibility	Complexity	Observability	Trialability
Default Example	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Guide	**Relative advantage measures how improved an innovation is over a competing option or the previous generation of a product. Potential users need to see how an innovation improves their current situation. Improvements can be in one or many of these areas but not limited to these areas:** better service, consolidation of multiple functions into one tool, decreased need for supplies and equipment, empowerment of users, improved interface, increased customizability, increased longevity, increased productivity, reduced user effort, reduced environmental impact, saving of money, saving of space or storage, saving of time.	**Compatibility refers to the level of compatibility that an innovation has with individuals as they assimilate it into their lives. Potential adopters need to know that your innovation will be compatible with their life and lifestyle.** How will your innovation fit into users' lives? What shifts in behavior will need to occur for your innovation to be adopted? What additional products will be required for your innovation to succeed (for example, a high-speed Internet connection, a mobile phone plan with data, gasoline)? What existing products does your innovation replace? How does your innovation fit with potential adopters' mental model, beliefs and attitudes regarding the issue your innovation will address?	**Complexity or simplicity refers to how difficult it is for adopters to learn to use an innovation. Complexity slows down the gears of progress. The more complex an innovation, the more difficult it will be for potential adopters to incorporate it into their lives. Potential adopters do not usually budget much time for learning to use an innovation. The more intuitive an innovation, the more likely it will be adopted.**	**Trialability describes how easily potential adopters can explore the innovation. Trialability is critical to facilitating the adoption of an innovation. Potential users want to see what the innovation can do and give it a test run before committing. This is the underlying concept of trial sizes for tangible goods, and demo or beta releases for digital goods. Potential adopters can see for themselves what life might be like once they adopt the product.**	**Observability is the extent to which the results or benefit of using an innovation are visible to potential adopters.** Side-by-side comparison. Potential adopters are able to observe the benefits of some innovations more than others. A side-by-side comparison is good when your innovation has easily noticeable improvements over what people are currently using. What will an adopter's life look like once they start using your innovation? Will there be a noticeable increase or decrease in some aspect that will result from use of your product?

Figure 2.9.1 Assessment Guide

Also, in Figure 2.9.2, a default assessment template is introduced.

Innovation	**Relative Advantages**	**Compatibility**	**Complexity**	**Observability**	**Trialability**
Design Feature #**1**	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○
Design Feature #**2**	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○
Design Feature #**3**	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○
…	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○
Example	● ● ○ ○ ○	● ● ● ○ ○	● ◐ ○ ○ ○	◐ ○ ○ ○ ○	○ ○ ○ ○ ○

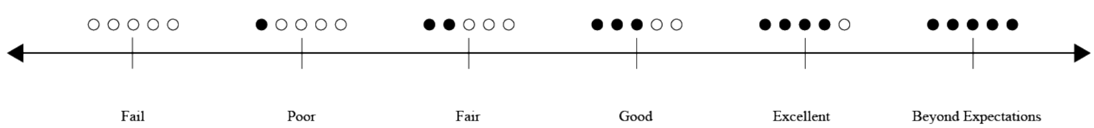


Figure 2.9.2 Assessment Template

The core participants of the evaluation should be the design team itself. Relevant user research and data analysis should also be carried out in the evaluation stage to obtain more accurate information

2.10 Case Study Apple Newton and Palm Pilot

To further find out the design factors that influence the tech-driven adoption, we first pick a comparison between Apple Newton and Palm Pilot since both companies were bringing the same technology to a similar product at almost the same time.

The Apple Newton was created by a multi-billion-dollar corporation as a promise to be a successful PDA (Personal Digital Assistant) but turned out as one of the major failures.

Figure 2.10.1 Apple Newton 1994

The Palm, created by a founder that was desperately in need of money, on the other hand, found its place as the successful case for a PDA, while not the first PDA on the market

Figure 2.10.2 Palm Pilot 1996

Innovation	Brief Description	Target Market	Date of Launch	Sales Target	Actual Sales
Apple Newton	Apple Newton was the first Personal Digital Assistant (PDA). Based on a RISC processor, it featured handwriting recognition and an operating system based on an advanced object-oriented programming language.	- Mass consumer market, and in particular adults who often travel and are accustomed to using a PC	August 1993	- After 1 year: 50,000–100,000 - In 5 years: tens of millions	- After 1 year: 80,000-100,000 - In 5 years: 350,000 (withdrawal due to poor sales: February 1998)
Palm Pilot	First palm-held device allowing instant connectivity with all personal computers. It featured a functioning handwriting recognition system and a user-friendly graphic interface.	- Mass consumer market, and in particular adults who travel frequently and are accustomed to using a PC	April 1996	- After 1 year: 200,000 - In 5 years: 2 million	- After 1 year: 1 million - In 5 years: 7 million

Figure 2.10.3 Palm Pilot vs Apple Newton

	APPLE NEWTON (1993)	PALM PILOT (1995)
Innovators	**The APPLE Inc.** multi-billion-dollar corporation as a promise to be a successful PDA	**The Palm Inc(Startup)** created by a founder that was desperately in need of money
Core Technology A	mobile computing philosophy / tablet computing	
Core Technology B	Touching Screen / Handwriting Recognition	
Outcome	Personal Digital Assistant	
Price	$700	$400
Discontinuation	After Steve Jobs return to Apple in 1997 the Newton was cancelled in 1998	Palm PDA lines shifted exclusively to smartphones in 2011
Market Share	By 1997, Newton only had a 5 percent share of the personal digital assistant market (DATAQUEST,1997)	Palm had a 66 percent share of the personal digital assistant market (DATAQUEST,1997)

Figure 2.10.4 Palm Pilot vs. Apple Newton Comparison

As we can see from the comparison, both companies aimed to bring mobile computing philosophy and touch screen technology to a new class of Personal Digital Assistant devices. However, while Apple held huge advantages on branding and marketing, Newton still failed hard. Next, my study focused on the design features to find out the reasons behind them.

1st obvious problem is the size.

Apple Newton was designed to be seven by four point five inches, while the Palm Pilot was only four and seven by three-point one inches, two-fifths smaller than the Apple Newton. Big or small was not a factor affecting adoption. But how it serves users' needs is the factor, the portability. As a personal digital assistant, Apple Newton can't even fit into a pocket, while the Palm Pilot could easily fit into the pockets of a formal shirt. Compare to any mobile device at that time, and Apple Newton was considered to fail on portability. Portability was sacrificed to exchange a larger screen and more comprehensive interface.

“It just didn't quite fit in your pocket, A friend had one (second hand a few years old), and it seemed to do most things he wanted, and he was happy with it, but it lived in his briefcase,” according to a review written by Tom Seven in *The Register* in 2013.

On the other hand, the Palm Pilot did a better job on portability. It remains the standard size that could be carried around or fit in any pockets or handbags.

"The goals were to design a new category of handheld device and to build a platform to support it," explained Steve Capps, Newton's head of user interface and software development, who both helped dream it up and make it real. "The restrictions imposed by battery life necessitated a new architecture." That is, with Newton, Apple didn't just set out to create a new device. It wanted to invent an entirely new class of computers that could slip into pockets and go out into the world. In fact, the pocket was a core design requirement.

"You need to be able to reach around with your fingertips on one side and the fleshy part of your thumb on the other to feel like you're not going to drop it," *Newton Reviews* said.

The importance of portability was identified. But the design failed to achieve the goal.

2nd problem. The interface.

Figure 2.10.5 Palm Pilot vs. Apple Newton Comparison

The open-up interface of Newton can be broken down into four sections. A small note area, an involved menu area, a navigation bar, and a silkscreen button navigation bar are relatively complicated. At the same time, Palm Pilot has two main sections, a systematic menu with a writing area and the main navigation bar with physical buttons that is clearer and easily understood. The most helpful action buttons are designed in a traditional way to keep the performance.

3rd main problem is the touch screen.

Apple implemented its touch screen handwriting technology with a “Stylus Pen” system. They intended to bring a new interactive solution to mobile devices. However, later this system became well known for its instability, inaccuracy, and high latency, even compared to traditional 9-keys pad input.

“A colleague of mine won a Newton at the Apple launch event at Olympia. The following day at work, we all (naturally) had a play with it, writing our names (and various rude phrases). Most names and phrases were interpreted quite well (apart from some of the rude bits, but one chap (I'll have to use his real name) called Nick O'Brian had his name interpreted as ‘Slick O Berlin’” Iven Headache wrote in his review in 2013.

When Steve Jobs returned to the company in 1997, he killed the product line. He was critical of the device's weak performance, the management of the development team, and the stylus, which he disliked as it prevented the use of the fingers.

As blog writer Honan (2003) noted:

> "There was just one problem: handwriting. "We were just way ahead of the technology," laments Capps. "We barely got it functioning by '93 when we started shipping it." Handwriting recognition was supposed to be Newton's killer feature, and yet it was the feature that probably ultimately killed the product."

Many reports defined the technology as not ready to enter the market. But looking back to the Palm Pilot, it was not the technology being unready. It was Apple that failed to bridge the gap between the technology and the users’ actual needs and expectations. When Palm introduced their Pilot, it came with an integrated Graffiti recognition system, as shown in Figure 2.10.6.

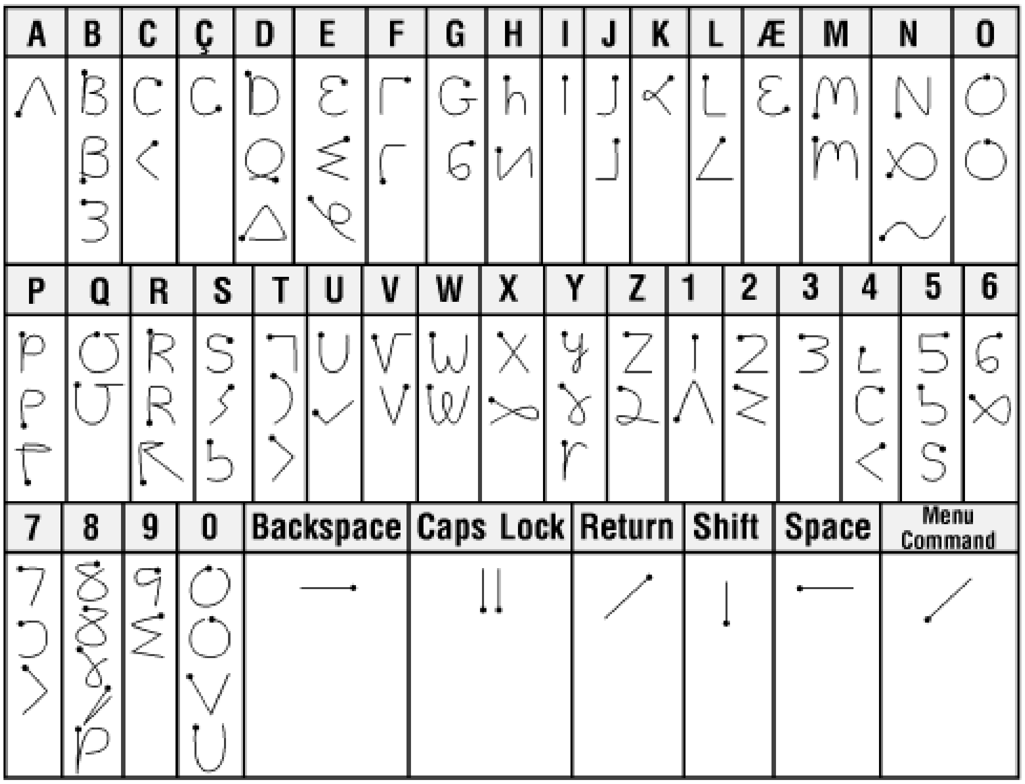


Figure 2.10.6 Palm Pilot vs. Apple Newton Comparison

The touch screen with the Graffiti recognition system provided a better input experience on the mobile device. It could identify ambiguous handwriting more precisely and efficiently. The technology was not what the users were asking for. The solution and experience are.

Overall, in this case, under the same economic background, compared to the Palm Pilot project, Newton failed to enter the early market due to the following reasons:

a. The technology itself was not being transformed into the user's language.

b. The core needs and expectations of the potential users were not being identified clearly

c. The technology was pushed too hard without a clear target on what needed to be accomplished.

Every design feature of the two cases was assessed by the five abilities as follows:

Apple Newton	**Relative Advantages**	**Compatibility**	**Complexity**	**Observability**	**Trialability**
Default	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○

Figure 2.10.7 Default Assessment Chart of PDA

Apple Newton	Relative Advantages	Compatibility	Complexity	Observability	Trialability
Portability	◐ ○ ○ ○ ○	◐ ○ ○ ○ ○	● ◐ ○ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Computing Performance	● ◐ ○ ○ ○	● ◐ ○ ○ ○	● ◐ ○ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Input Performance	◐ ○ ○ ○ ○	◐ ○ ○ ○ ○	● ◐ ○ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Interaction Performance	● ◐ ○ ○ ○	● ◐ ○ ○ ○	● ◐ ○ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Assistant Ability	● ● ● ○ ○	● ● ● ○ ○	● ● ● ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○

Figure 2.10.8 Five Ability Evaluation of Apple Newton

Palm Pilot	Relative Advantages	Compatibility	Complexity	Observability	Trialability
Portability	● ● ● ● ○	● ● ● ● ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Computing Performance	● ● ● ○ ○	● ◐ ○ ○ ○	● ◐ ○ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Input Performance	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Interaction Performance	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Assistant Ability	● ● ● ○ ○	● ● ● ○ ○	● ● ● ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○

Figure 2.10.9 Five Ability Evaluation of Palm Pilot

As we can see from the comparison, Apple Newton gets zero points on relative advantages while Palm Pilot did a better job with sixteen points. Apple failed to provide comparative advantages in terms of portability input performance and interaction performance. It does give a better experience on mobile computing and assistant. Still, overall, it's a failure on relative advantages, which was the main reason driving Apple Newton to fail in the market. At the same time, Apple Newton was not compatible with users' expectations on portability, input, and interacting performance. It was too complicated compared with Palm Pilot. All design features for both devices are easily discovered, and they are trialable.

Overall, Apple Newton gets a score of eight while Palm Pilot gets forty-three. In Palm Pilot's case, it successfully achieved the five goals, making the innovation succeed in the market and last longer.

The reason that Palm succeeds in the market: Palm Pilot did a better job of providing better solutions and experiences than Apple Newton, and Palm also made their design features more compatible with user's behaviors and expectations. However, these are not the only factors affecting the market adoption, but it is proved that Relative Advantages and Compatibility are the design factors affecting the early market adoption.

2.11 Case Study Airpods with Wireless Connection Technology

The first generation of Airpods was a wireless earbud designed by Apple, released in December 2016, built with a highly integrated W1 chip, utilizing Bluetooth technology, optical sensors, and a motion accelerometer. The Airpods not only succeeded in the market but also promoted the acceptance of wireless headphone technology.

The wearables market goes back to the first Bluetooth headsets launched in 2001, followed by wireless stereo headphones, which arrived a few years later. Neither made significant waves in the market, and Bluetooth stereo headphones took almost a decade to attain significant market share (Hunn, 2016).

In this case study, the factors helping the acceptance of Airpods by the mainstream market will be identified.

Airpods were first mentioned in 2011, which was five years earlier than its official launch in 2016. Apple filed for a patent for Ear Pod-like headphones that could work with or without wires called a detachable wireless listening device. In the patent description, the technology that Airpods would utilize was described as "when the listening device is detached from the corded portion, a wireless signal that includes the audio signal is transmitted from the second part of the corded portion for the reception at the first part of the listening device." In other words, “the embodiments described herein relate to a media apparatus that can be used in conjunction with a host device to provide an end-user a pleasurable listening experience, especially during periods of physical activity" (The surprisingly long history of the Apple AirPods, 2018).

Figure 2.11.1 Airpods Patent illustration.

In the illustration (Figure 2.11.1), notice the break in the wire just below the figures' chin. It's a connector showing a wired headphone cable that can been disconnected. **At this point, the focus seems clear on creating a listening device that doesn't get interrupted by problems with the connection.** It doesn't seem to be aimed at making a wireless-only solution.

The core technology work within Airpods was Bluetooth. Bluetooth technology utilized on headphones was first introduced in 2000. "There are quality issues – the bandwidth isn't high enough, and even if it does get there someday, people don't want to recharge their headphones." Steve Jobs once said in Paris in 2005. In other words, the technology does not bring relative advantages on sounds quality, and it complicated the user interaction with an earphone. Apple filled its patent in 2011, and it took them 16 years from the technology emerging to launch the Airpods officially.

In this study, the technology application of earbuds couldn't provide relative advantages in terms of sounds quality which is the reason Steve Jobs defined the technology as not ready. Actually, with the development of Bluetooth technology, the quality issue was believed solved later in 2011, and that was the time Apple initiated the Airpods project. Another concern was how to recharge the headphones. Still, the potential users are now all so trained to recharge everything every day, even when the Airpods low-power sounds is heard, that this is no longer a major issue.

Figure 2.11.2 Airpods Gen 1st.

In the book Airpods *The Next Step of Headphones* written by Gack Davidson in 2018, Davidson concludes fifty good design features that made Airpods the next generation of headphones.

Comfortable Wear	Seamless Device Switching	Voice Control	Control Switching	Time Taken for Full Charge
Tight Grips	Paring Previous IOS	Increased Response Frequency	Sounds Quality	Charge Case Storage
Shape and Looks	Paring Non-Apple	Hands Free Calling	Voice Accelerometer	Quick Charge
Carrying Box Shape and Looks	Connection Range	Tap to Call	External Voice Filtering	Case Charging
Charging your Air-Pods	Connection Strength	Hands Free Control	Motion Accelerometer	Battery Check
Charging the Carrying Box	Built in Speaker	Hands Free Tracks Selection	Optical Sensors	Misplaced Solution
Power Hub for Air-Pods	Duo Mic	Auto Pause	W1 Chip	Storage of Air-Pods
Bluetooth Connection	Beam Forming Microphones	Revert To iPhone Speaker	Wireless Connection	A way forward Solution
Instant Setup	Incorporation with Siri	Hands Free Directions	Energy Efficiency	
Pair Multiple Device	Double Tap Active	Control Device via Siri	5-hour Listening time	

Figure 2.11.3 Airpods Design Features

The design features that make Airpods successful as a tech-driven innovation could be grouped into the following areas:

Success on basic physical needs

The first important factor that made Airpods successful is that it fulfills every basic need working as earbuds. The physical conditions could be size, weight, ergonomics, and any other factors that could define earbuds. All technology parts were developed after the fundamental physical limitations have been identified.

Comfortable wear. Airpods were designed to transform digital signals into sounds and play on ears. Unlike other wired ear pods or Bluetooth earbuds that start to make your ears ache in a little while, Airpods are remarkably comfortable. The design makes them sit cozily in your ears without putting any strain on your ear cartilage. This is one of the main features that let you use Airpods for extended periods (Davidson, 2017).

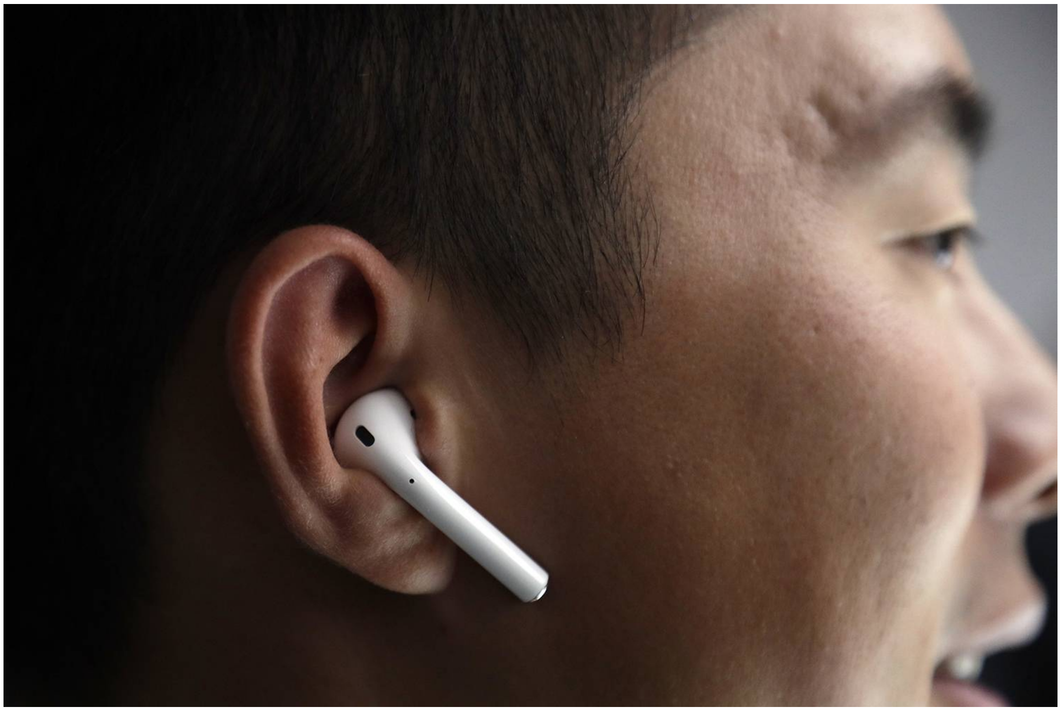


Figure 2.11.4 Airpods fit in the ear.

Tight Grips. Although comfortable to wear, Airpods have a tight grip. They sit in users' ears without falling off, even if banging the head or tossing hair or even running. The angle of the stick and pod give a secure feeling and lets them stay put.

Great solutions for undesired outcomes of the technology application.

The concept of Airpods is a new generation of earphones. Unfortunately, problems come along with the huge updates Apple made.

Since Apple proposed to design fully wireless earbuds without a physical connection to the devices, the Airpods are very likely to fall or be lost. Apple developed software called Find

My Airpods on the OS platform, just like Find My iPhone. It allows users to locate their paired Airpods as long as it had been set to connect to one of their Apple devices.

Wireless connectivity consumes energy. An integrated battery is placed inside the body of Airpods to provide adequate power that supports five hours normal use of them.

Another price that needs to be paid to apply wireless technology is that Airpods need to be recharged. The solution for recharging is the carrying box, which is the house of Airpods and doubles up as the charging device for them. The charging case stores power for additional 24 hours of playback time so that users can charge their Airpods on the go, which means five times charge before plugging the charging case into a power source.

When connected by Bluetooth, it takes a reset and reconnect process for the user to switch between devices. The traditional cabled earbuds can be simply unplugged and re-plugged on the new device to get the connection, which is a more straightforward solution than a Bluetooth connection. The innovation team developed related software to solve the problem that allows the connected Airpods to be switched between devices seamlessly.

The user experience of technology application

Instant Setup. When users take Airpods out of their case for the first time, the pairing is instant. As if by magic, the iPhone prompts the user to connect it to Airpods. The user can hold down the button to set up the connection with any of their iOS devices.

Airpods can pair with multiple Apple devices. Users can pair Airpods with multiple Apple devices at one time. Any Apple device such as iPad, iPhone, iMac, and iWatch could be connected with Airpods.

Figure 2.11.5 Airpods pairing-up.

Seamless device switching. Airpods switch between devices seamlessly. All devices logged with the same Apple ID could be connected with Airpods instantly.

Paring connection range. The Airpods provide an outstanding range for wireless headphones using Bluetooth. Leaving the connected device inside the home, the user can walk around the house and away from it for a considerable distance without any interruption in the connection.

Connection Strength. Airpods provide an extraordinary connection strength at all places. Airpods relay excellent sound quality without any loss of connection or interruptions even when they are far away from the connected device.

Success on Technology user interaction

Double tap to activate SIRI. Airpods have put the personal voice assistant, SIRI, a touch away from the user. This gives all the control to SIRI.

Voice control. The voice is the ultimate control of the Airpods.

Handsfree calling, apart from listening to music, SIRI can be used to make calls right through itself.

Tap to receive calls. When receiving phone calls while wearing Airpods, the user simply taps Airpods to pause the music and gets the call.

Figure 2.11.5 Airpods pairing-up.

In conclusion**, every technology being integrated into the design aims to solve problems or fulfill needs on the user ends, which could be classified into physical needs, functional needs, and emotional needs—**the following chart illustrates how the integrated technologies in Airpods are transformed at the user's end.

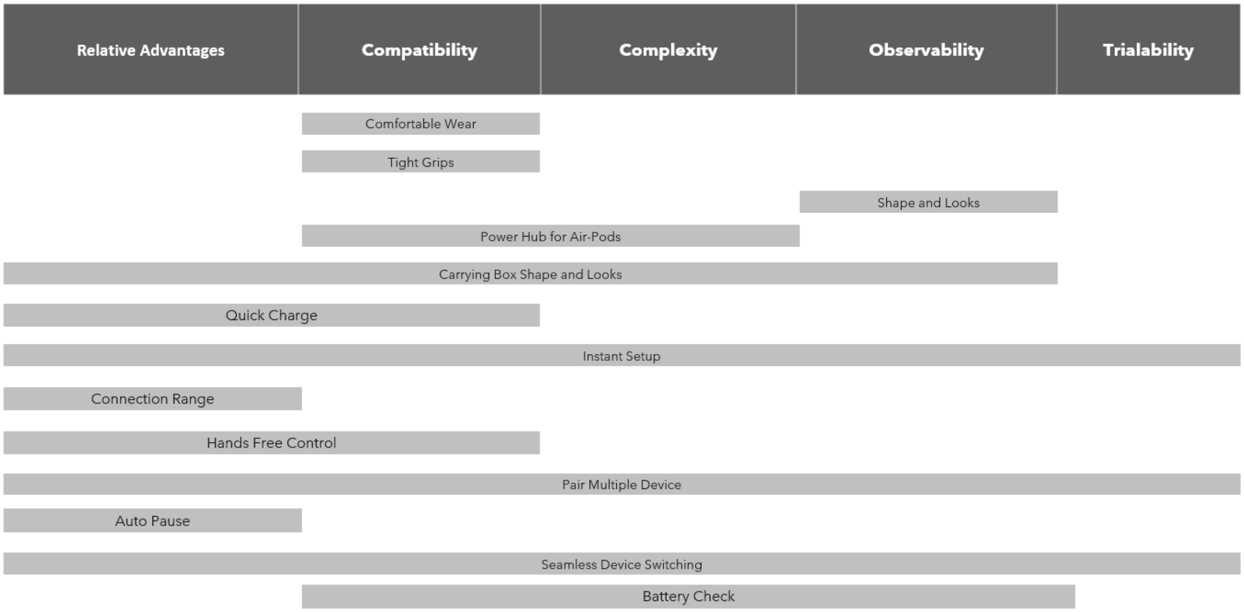


Figure 2.11.6 Airpods Design Features Mapping

Also, the design features of Airpods are assessed within the five abilities theory as follows:

Wireless EarPhone	**Relative Advantages**	**Compatibility**	**Complexity**	**Observability**	**Trialability**
Default	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○

Airpods	Relative Advantages	Compatibility	Complexity	Observability	Trialability
Physical Needs	● ● ● ● ◐	● ● ● ● ○	● ● ◐ ○ ○	● ● ● ● ○	● ● ● ● ○
Sounds Quality	● ◐ ○ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Interaction	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○
Assist	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○

Figure 2.11.7 Airpods Assessment

Each of the design features brings relative advantages over traditional earphones. Apple did a great job with regard to compatibility by making all design features align with the user's expectations. The high level of refinement of Airpods makes it easy to use and interact with, which succeed in complexity and trialability. In the Airpods success case, the five abilities are tested to be core factors that drive innovations to be adopted in the early market. Apples' brand background cannot be ignored, but the 3D touch introduced in the same year failed the market.

2.12 Case Study iPhone and Force-Touch Technology

Apple introduced 3D Touch / Force Touch in 2014. The technology came as a companion to the Haptic Engine technology, of which the primary goal was to recreate the haptic feeling of mechanically pressed or actuated buttons. However, instead of an actual button that gets clicked, there's a set of electromagnets that move enough to feel like there's a click happening, which Apple calls the "Taptic Engine." This was a significant evolution in Apple's industrial design strategy, which has always favored reducing mechanical parts that are prone to break with use. Another feature of the technology is it enables trackpads and touchscreens to distinguish between various levels of force being applied to their surfaces, which successfully adds another dimension for user interaction.

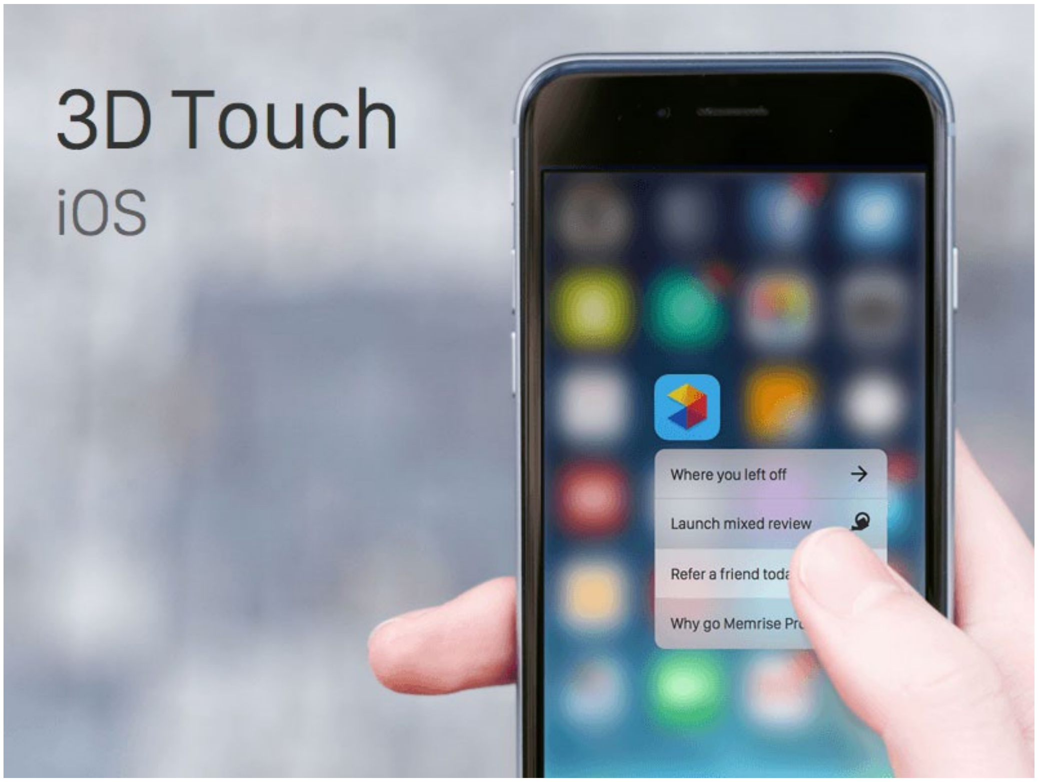


Figure 2.12.1 3D Touch.

The technology of Force-Touch, operating with MacOS, was embedded on MacBook (Retina) and MacBook Pro from early 2015 onwards and related accessories like Apple Trackpads, which could be called the MacBook product line. The other version of Force-Touch, named 3D-Touch, is designed for IOS, which is the same technology, is integrated into the product line of iPhone, including iPhone 6s, iPhone 6 Plus, iPhone 7, iPhone 7 Plus, iPhone 8, iPhone 8 Plus, and iPhone X. But iPhone XR, released in 2018, does not have 3D Touch.

The Force-Touch on MacBook got broadly accepted and became a great feature on the MacBook product line. The size of the trackpad integrated with Force-Touch was enlarged twice from 2015-2018. On the other hand, 3D-Touch on the iPhone has not been adopted successfully. It has become a rarely used feature on iPhone. There are few if any App developers embracing it.

The iPhone XR, released in 2018, does not have 3D-Touch. Apple most likely is giving up on this feature, and it decided to drop it from a new iPhone, which signals the company means to re-adjust their product strategy for the coming years.

The iPhone and MacBook are both successful product lines in the empire of Apple. These lines the result of a parallel development of brand awareness, loyalty, value, and market strategy during these years, this case study attempt to analyze and find those key factors that lead to the failure of 3D-Touch technology application on the iPhone product line.

The extremely poor developer adoption could be the cause or a result of the failure of 3D-Touch. Based on Ramirez's (2018) study on 200 popular apps on iPhone, only 40% of the apps had a 3D-Touch shortcut menu. Digging into details, Google is one of the developers who try to include a 3D-Touch shortcut menu in every app they design, but there was a lack of consistency in their implementations. The Google Sheets app did not offer a shortcut menu, while the Google Docs app did. Other popular apps like Lyft and Bumble didn't provide a Force Touch shortcut, and Uber has it only for the ride but not for within UberEats app. A number of other apps have shortcuts that don't work. Some apps attempt to deep-link into the described view of functionality and then get stuck in white screens. Most of the apps that provide a 3D touch-enabled shortcut menu are not offering a lot of value in their menu either. Taking Hertz app, Counter app, and Headphone app as examples, the only option they provide in the shortcut menu is "Share this app."

Duplicated or overlapping user paths. 3D-Touch was designed to be a feature of productivity and a time-saving feature on user interaction. Any workflow or operation on iPhone was expected to be speeded up and easier. For instance, to open the camera on Instagram, normally, it takes three steps to do so: locate the Instagram icon, tap it, swipe from left to right, or tap the camera icon on the top left. It also takes three steps to utilize 3D-Touch shortcuts: locate the Instagram icon, force touch on it, choose the camera. But the Force-touch takes a small amount of time to respond; the sensor system needs to measure the pressure to identify the operation of force touch. The 3D-Touch does not provide a better or easier option to achieve goals. This failed the relative advantages, adding another step to the workflow which fails the complexity.

Relative Advantages	Compatibility	Complexity	Observability	Trialability
-1	0	-1	0	0

Figure 2.12.2 Five Ability of 3D Touch one

Lack of ergonomic considerations.

Soft material provides intuitive feedback of being pressable, while hard material provides a feeling of being un-pressable. One of the problems is the difficulty of determining the right amount of pressure to trigger the interaction. There are no official pressure force requirements to trigger the interaction. Users would have to try several times to get the feeling of force touch. Sometimes it could be triggered unintentionally, or sometimes it just failed to respond. Most of the users might apply a quarter pound of pressure to trigger the 3D-Touch, which makes this feature utterly impractical for daily use. The failure of operation also leads to negative emotions, which fail the compatibility and complexity.

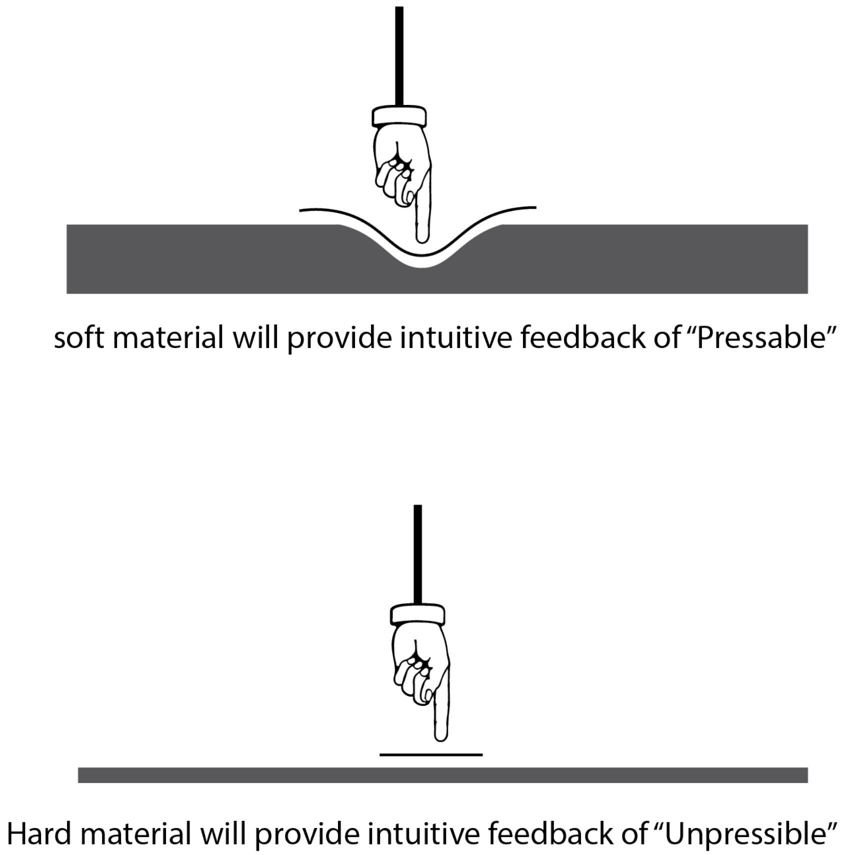


Figure 2.12.3 3D Touch Ergonomic

Relative Advantages	Compatibility	Complexity	Observability	Trialability
-2	-1	-2	0	0

Figure 2.12.4 Five Ability of 3D Touch two

Lack of discoverability.

The feature of 3D touch is hard for users to discover if the user wants to understand the actions that this interaction can do, as they will have to press every place on the screen and expect to get some feedback. And even if they get feedback sometimes, it's hard to understand which enhancements or which features are brought about by this interaction. This is a significant failure of observability.

Relative Advantages	Compatibility	Complexity	Observability	Trialability
-2	-1	-2	-1	0

Figure 2.12.5 Five Ability of 3D Touch three

The learning cost of 3D-Touch.

The interaction of 3D-Touch is not an 'instinctive design.' Instinctively, the user will not perceive a hard board could be used to detect pressure until they are told so. It is easier for the user to understand pressing on soft material. Apple's solution is to give users different vibration feedback based on different pressures to inform users that the forced touch is effective. It also does not intuitively give users a hint that it could be pressed. On the contrary, touch is a "dominant design," which is easier to understand and more in line with "natural design." The user learning cost greatly increased.

Relative Advantages	Compatibility	Complexity	Observability	Trialability
-2	-1	-3	-1	0

Figure 2.12.6 Five Ability of 3D Touch four

Behind current solutions.

Apple did it quite successfully with the introduction of multi-touch capacitive screens and the range of motions and interactions that came from that technology. 3D touch doesn't provide a practical advantage over a typical capacitive touch. In fact, it does the opposite. Physical pressure is required to trigger the response while it is creating physical fiction between fingers and screen, just like the old technology of touch screen does, the resistive screen. As a feature that relies on physical pressure, 3D touch sits in a place in the interaction spectrum that clashes and negates the continuous success of the light touch interactions enabled by capacitive screens. This fact makes the tech feature fail the relative advantages, compatibility, and complexity.

Relative Advantages	Compatibility	Complexity	Observability	Trialability
-3	-2	-3	-1	0

Figure 2.12.7 Five Ability of 3D Touch five

Overall 3D touch could be rated failure on relative advantages and poor on compatibility, complexity, and observability. These are the main reasons that drive the tech-innovation failure in the market within two years.

Relative Advantages	Compatibility	Complexity	Observability	Trialability
◐○○○○	●◐○○○	●○○○○	●○○○○	●●◐○○
FAIL	POOR	POOR	POOR	FAIR

Figure 2.12.8 3D-Touch Final Evaluation

2.14.1 Case Study Conclusion

Summarizing the case study results, Palm Pilot and Apple AirPods succeeded in achieving all five goals, and they made their way to the market. In contrast, Newton and Apple did a poor job on relative advantages compatibility and complexity; even though they were acceptable on observability and trialability, they still failed in the early market. 3D touch was a hard fail on almost all of the five abilities, and it was discontinued by Apple in only two years.

Case studies show the five attributes are core design factors that affect the early adoption of tech-driven innovation. Although there might be other factors, these five are considered necessary based on current studies.

CASE	Relative Advantages	Compatibility	Complexity	Observability	Trialability	MARKET
APPLE NEWTON	POOR	POOR	POOR	FAIR	GOOD	FAIL
PALM PILOT	GOOD	GOOD	GOOD	GOOD	GOOD	SUCCESS
APPLE AIRPODS	GOOD	GOOD	GOOD	GOOD	GOOD	SUCCESS
APPLE 3D TOUCH	FAIL	POOR	POOR	POOR	FAIR	FAIL

Figure 2.14.1 Case Study Result

2.15 Factors affecting Tech-Driven Innovation Adoption

From previous research and studies, there are four main categories of factors that have been summarized as follows:

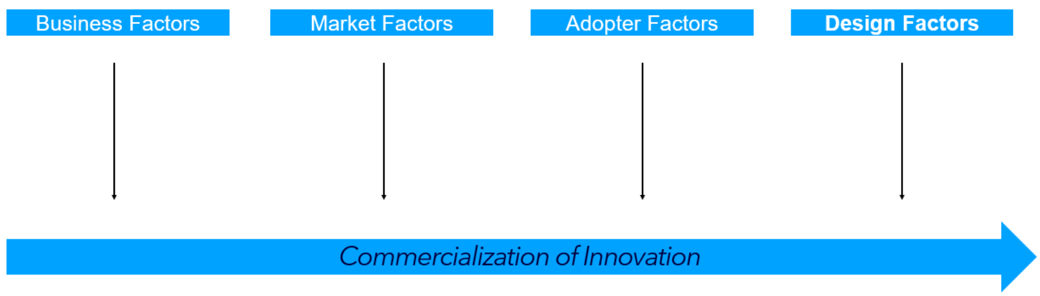


Figure 2.15.1 Factors influence commercialization of innovation

Business Factors are the Timings, Target, Positionings, Relationships, Pricings, Budgets, and related Decision Makings along the tech-driven innovation process. For instance, Apple Newtons' Price decisions, Airpods Targeting Customer establishments, BigBelly Innovation Directions, etc.

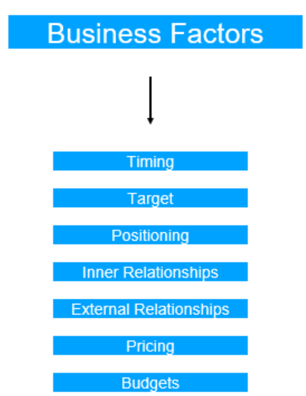


Figure 2.15.2 Business Factors

They are under-controlled by the business owners or top-level decision-makers. It is suggested the designers be involved in this series of the decision-making process.

Marketing Factors are the factors related to Economy, Brand, Industry, Dominations, Competitors, and Advertisings, etc. Great Branding background makes it easier for the innovators to bring a new idea to the market. Stronger competitors tend to add more difficulties to the adoption. There are more factors that will potentially affect the market adoption of a tech-driven innovation. These factors are usually the long-term status of an organization or uncontrollable facts like the economic background environment, as well as the decisions made by marketing professionals like advertising strategy or ideas. Designers should be aware of these factors and provide insights and thoughts from a designing perspective during the tech-driven innovation process.

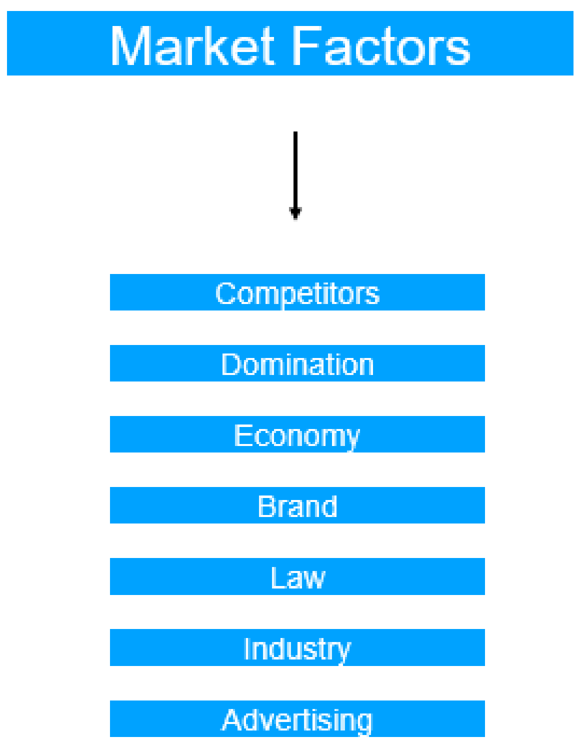


Figure 2.15.3 Market Factors

Adopter Factors are the comprehensive situation related to the society like Culture and Politics, and detailed information about the potential customers like Age, Income, Personalities, and Education. For example, customers at a younger age with higher income tend to be more active in adopting innovations. These are the factors that cannot be easily controlled due to them lying on the customers' side. But it is suggested to study customers as much as possible to get the related information before the innovation process starts. The better the designers understand the customers, the better chance the innovations get adopted.

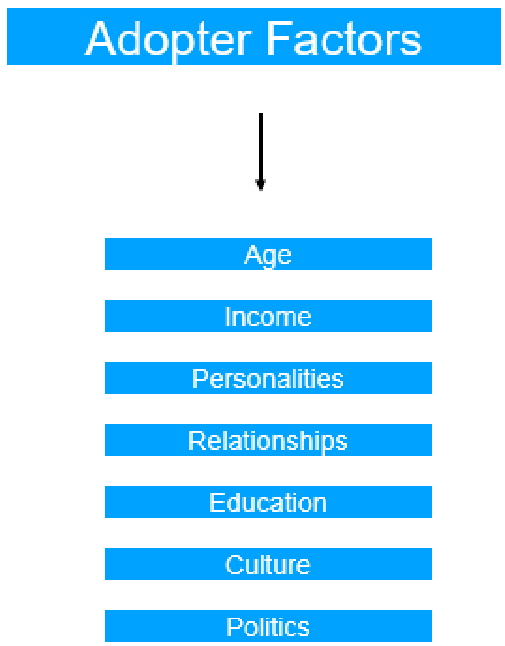


Figure 2.15.4 Adopter Factors

Design Factors are where a designer or organization defines the customer's expectation correctly. Failing to identify the user's desired outcomes would lead the innovation in the totally wrong direction. Other than that, the relative advantages, compatibility, complexity, observability, and trialability of innovation are the key design factors that drive an innovation getting adopted.

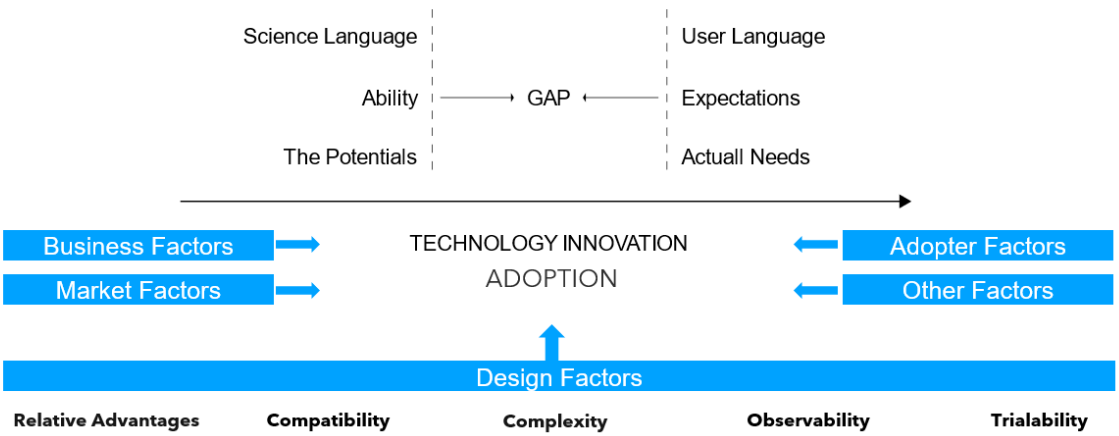


Figure 2.15.4 Adopter Factors

Chapter 3 Approach

3.1 Bridge the Gap

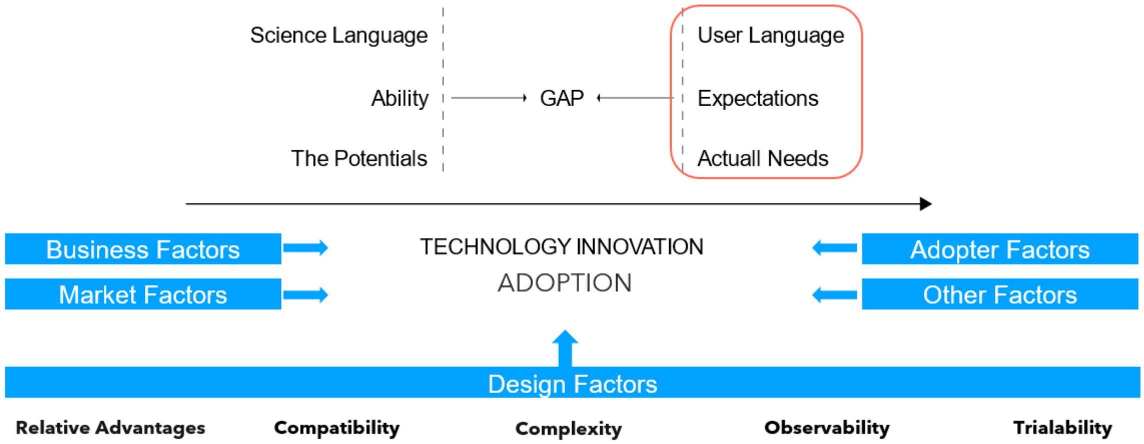


Figure 3.1.1 Illustration of the Gap

The factors, including business factors, market factors, and adopter factors, have been identified from the previous study. The design factors that could affect the early adoptions have been summarized in five abilities. Now the problem is how to bridge the gap between science language and user language, the gap between the tech-innovation ability and users' expectations, and the gap between the potentials and actual needs.

The following study will focus on bridging the gap in an early stage of an innovation process, which is how to clearly identify users' needs and expectations of a tech-driven innovation. Failing to identify the users' needs would lead the tech-driven design in a wrong direction that will be meaningless in the end. More importantly, designers need to bridge the gap after the needs and expectations are identified.

3.2 Approach

3.2.1 DEFINE THE CUSTOMERS

Who we design for is the first question designers will engage in a tech-driven innovation process. What kind of customers are we developing for? Who will be our early adopters?

The first step is to define the potential customers from an adoption perspective. A customer matrix created by Ulwick (2018) suggested to be used here to classify the customers. Successfully positioning the customer in the matrix will help the upcoming innovating be more directional and concentrated. What needs to be mentioned here is that the definition of your customers will not change the adopter factors. The core duty of this section is to know who you are designing for.

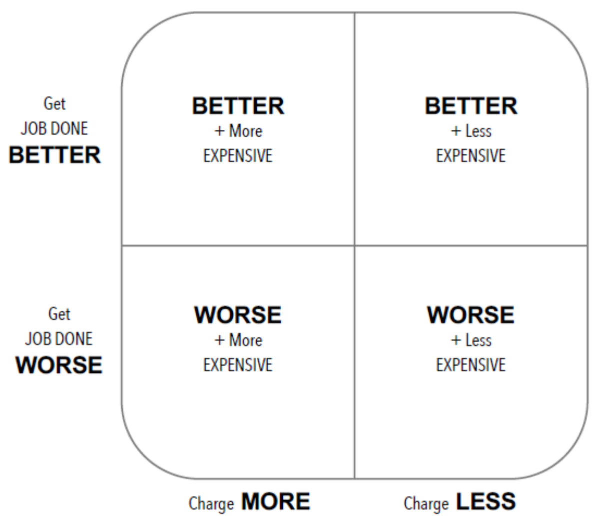


Figure 3.2.1.1 Customer definition one

The matrix suggests that companies can create products and services that are **(1) better and more expensive, (2) better and less expensive, (3) worse and less expensive, and (4)**

worse and more expensive. The matrix prompted us to ask what types of customers might be targeted with a product or service offering in each quadrant.

Next, the customers need to be placed in their respective quadrants, highlighting the differences in target customer type: **(1) Win underserved customers only (2) Win all types of customers (3) Win customers with limited options (4) Win overserved customers and non-consumers.**

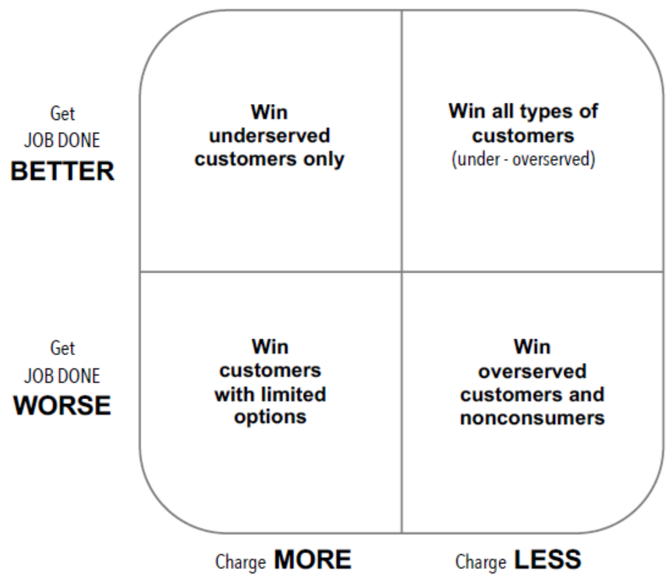


Figure 3.2.1.2 Customer Definition two

Then there will be five strategies that should be followed along the innovation process, discussed below:

Differentiated strategy: A company pursues a differentiated strategy when it discovers and targets a population of underserved consumers with a new product or service offering that gets a job (or multiple jobs) done significantly better but at a considerably higher price. Examples of offerings that successfully employed a differentiated strategy include Nest's thermostat, Nespresso's coffee and espresso machines, Apple's iPhone 2G, the Herman Miller Aeron chair, Whole Foods' organic food products, Emirates airlines' international flights, Bang & Olufsen's audio products, BMW sports cars, Sony's PlayStation (original model), and Dyson's vacuum cleaner and Air-blade hand dryer.

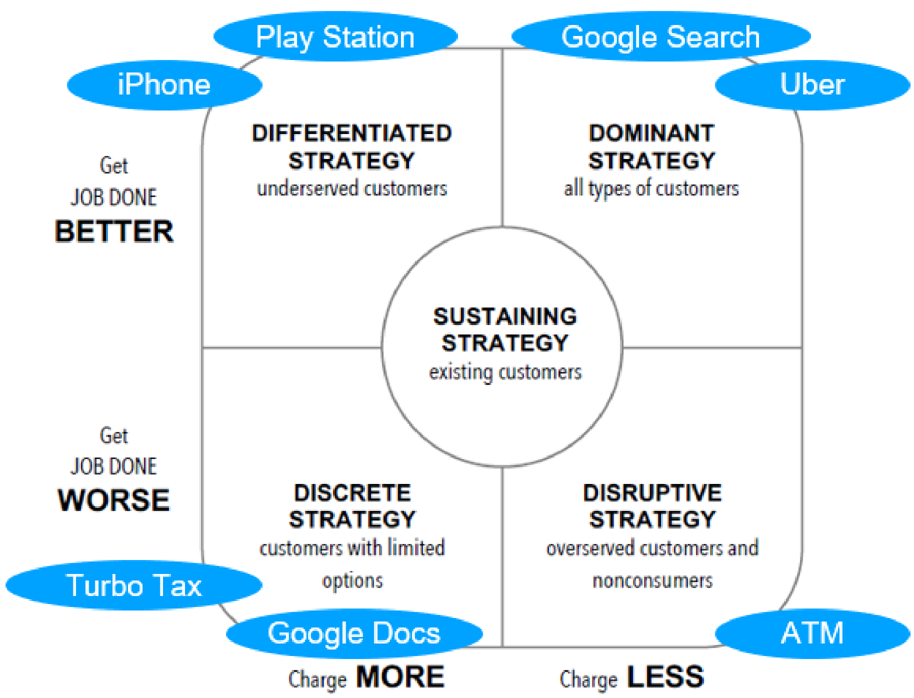


Figure 3.2.1.3 Customer Definition three

Dominant strategy: A company pursues a dominant strategy when targeting all consumers in a market with a new product or service offering that gets a job done significantly better and for substantially less money. Examples of offerings that successfully employed a dominant strategy include Google Search, Google AdWords, UberX, Netflix's streaming video, Progressive Insurance's nonstandard automobile insurance, and Vanguard Group's personal. investment services (Ulwick, 2018).

Disruptive strategy: A company pursues a disruptive strategy when it discovers and targets a population of overserved customers or non-consumers with a new product or service offering that enables them to get a job done more cheaply, but not as well as competing solutions. Examples of offerings that successfully employed a disruptive strategy include Google Docs (relative to Microsoft Office), TurboTax (relative to traditional tax services), Dollar Shave Club's razor offering (relative to Gillette), eTrade's online trading platform (relative to traditional financial brokerages), and Coursera's online educational services (relative to traditional universities) (Ulwick, 2018).

Discrete strategy: A company pursues a discrete strategy when it targets a population of "restricted" customers with a product that gets the job done worse yet costs more. This strategy can work in situations where customers are legally, physically, emotionally, or otherwise restricted in how they can get a job done. Examples of offerings that successfully employ a discrete strategy include drinks sold in airports past security checkpoints, stadium concessions at sporting events, check-cashing and payday-lending services and ATMs in remote locations. (Ulwick, 2018)

3.2.2 UNCOVER DESIRED OUTCOMES

3.2.2.1 Define the Functional Needs

According to previous research, the main problem that leads to failure is the innovators failing to identify the users' actual needs and expectations.

The functional need is called desired outcome or a 'Job' that needs to be done from a perspective of a user.

People buy products and services to get a job done. The job the end-user is trying to get done is the core functional job. A deep understanding of the core functional job enables a company to create product or service offerings that get the job done significantly better than competing solutions. The core functional job is the anchor around which all other needs are defined. It is defined first, then the emotional, related, and consumption chain jobs are defined relative to the core functional job. For example, if the core functional job were defined as *pass on life lessons to children*, then we would seek to discover the customer's emotional and related jobs as they are trying to pass on life lessons to children. All other jobs are in the context of executing the core job. When defined correctly, a functional job-to-be-done has three unique and extremely valuable characteristics -("MODULE 8: DIFFUSION OF INNOVATION," 2011).

First, a job is stable; it doesn't change over time**.** It's the delivery vehicle or the technology that changes. Take the music industry, for example. Over the years, people have used many products to help them *listen to music* (the job-to-be-done). This has included record players, tape and cassette players, compact disc players, MP3s, and streaming services. Through this decades-long evolution of drastically changing technology platforms, the job-to-be-done has remained the same. The job is a stable focal point around which to create customer value.

Second, a job has no geographical boundaries. People who live in the USA, France, UK, Germany, South Korea, China, Russia, Brazil, and Australia have many jobs in common that they are trying to get done. The solutions they use to get those jobs done may vary dramatically from geography to geography, but the jobs are the same. The degree to which the customer's desired outcomes are underserved may also vary by geography, depending on the solutions they use, but their collective set of desired outcomes are the same. Consequently, knowledge of the job-to-be-done in one geography can be leveraged globally.

Third, a job is solution-agnostic**.** The job-to-be-done does not care if your company provides product, software, or service offerings. The job has no solution boundaries. This means that a deep understanding of the job will inform the creation of a solution that combines hardware, software, and service components. It also informs a digitalization strategy—ways to use technology to get a job done better.

Define the job statement in the correct format**.** A job statement always begins with a verb and is followed by the object of the verb (a noun). The statement should also include a contextual clarifier. In the job statement, listen to music while on the go. The contextual clarification is made by adding "while on the go" to the job statement. Commuters who stop at quick-service restaurants on the way to work are trying to get breakfast while commuting to work*,* where "while commuting to work" brings needed context to the statement (Summarized from the JTBD theory). A core desired outcome statement shall follow this format:

Core Outcome statement = verb + object of the verb (noun) + contextual clarifier

3.2.2.2 Define Related Needs

After the core functional job is defined, the next step is to uncover other related needs. The related needs including related functional needs, emotional needs, and financial needs from the users' perspective. And the statements shall follow this format:

Related Needs Statement = direction of improvement + performance metric + object of control + contextual clarifier

3.2.3 MAP DESIRED OUTCOMES

After the core 'jobs to be done' and related desired outcomes are identified, the next step is to map those needs to find opportunities. The tool that will be introduced here is called Importance and Satisfaction Map, as shown in the following:

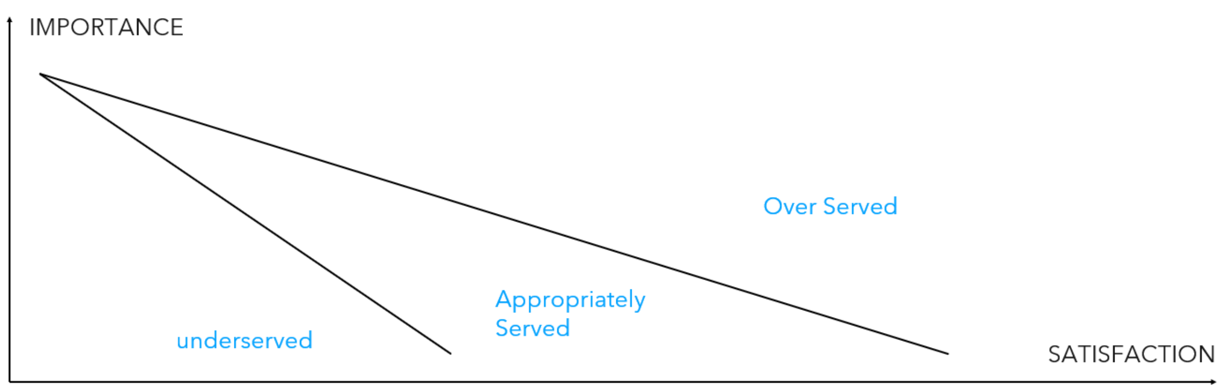


Figure 3.2.3.1 Importance and Satisfaction Map

The Map is designed to map the desired outcomes in a two-dimensional map to find better opportunities for the innovation to get into the early market.

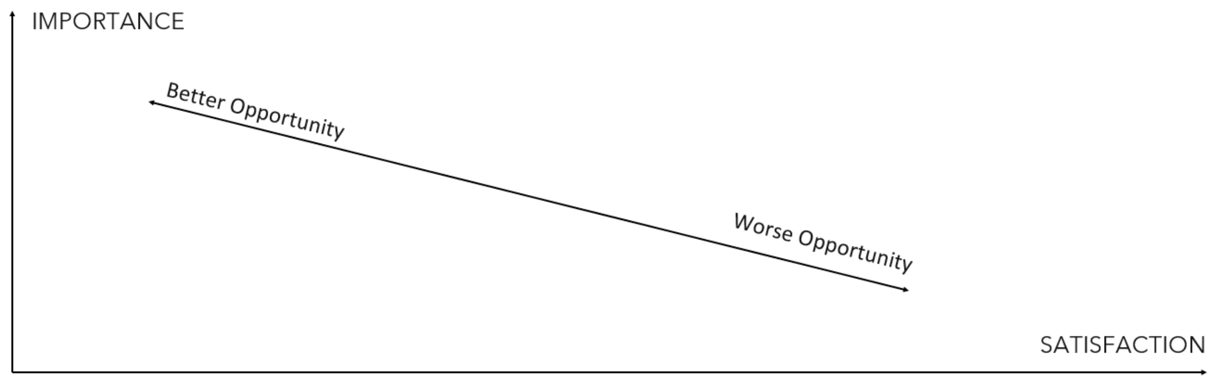


Figure 3.2.3.2 Importance and Satisfaction Map (Opportunities)

The upper left section is the target area. In tech-driven innovation, the desired outcomes that are more important for users with less satisfaction are the opportunities that should be focused on. Here is presented an ISM of Apple Newton.

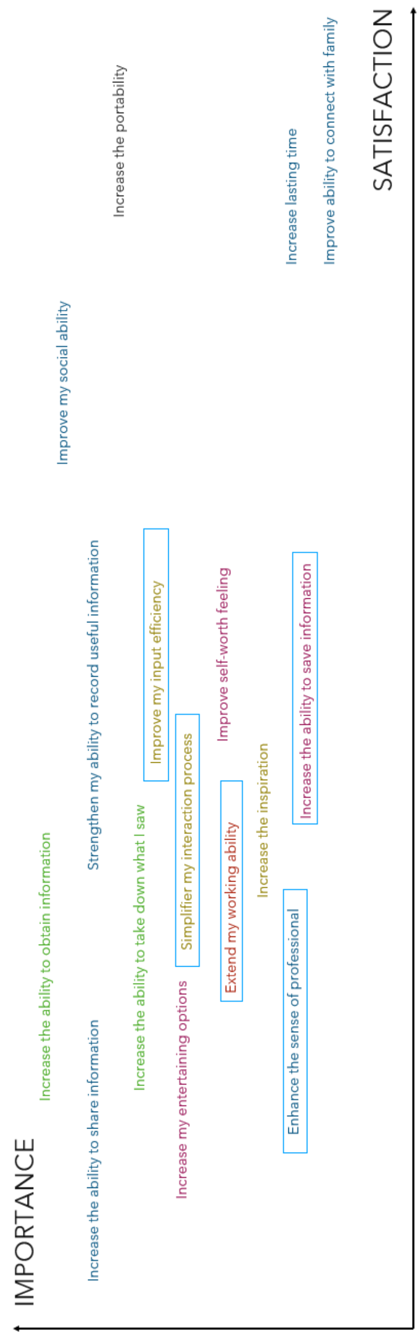


Figure 3.2.3.3 Importance and Satisfaction Map (PDA)

3.2.4 OUTCOME-DRIVEN DESIGN PROCESS

In an outcome-driven design process, the very first step before everything started is to understand the technology as much as possible. Designers should conduct research on the development of the technology, and performance, potentials, and constraints, etc. In order to achieve the five abilities mentioned in previous research, it is suggested to gather as much information as possible. Communications with professionals and developers are suggested, as well as pre-design tests.

After the learning of technology, the design process started follows the established desired outcomes and opportunities. From this point, designers are suggested to take their most practical and professional methodologies. Design features shall aim to build relative advantages based on desired outcome statements. Design features of the innovation shall offer advantages to existing products or services. Designing for compatibility, complexity, observability, and trialability of innovation are the key design factors that drive an innovation getting adopted.

What's more, several things are suggested to be followed.

Understand the technology as much as possible.

Even though designers are not technology inventors, it's the designers' job to be the first group of people that adopt the new technology.

Cooperate with related professionals.

Technology innovation usually starts with scientists or engineers. Better communication with a related professional helps to identify the technology potentials, constraints, and performance, etc.

Follow Core Outcome Statement

Core Design Outcome drives the designing process. Remember what the core job is trying to accomplish, and keep it in mind.

3.2.5 ASSESS THE DESIGN FEATURES

The Design Factors can be used as guidelines and an assessment tool to evaluate the design features of a tech-driven innovation.

CORE TECHNOLOGY	Mobile computing philosophy/Tablet Computing		Touching Screen/Handwriting Recognition		
PALM PILOT					
DESIRED OUTCOMES	**Relative Advantages**	**Compatibility**	**Complexity**	**Observability**	**Trialability**
Improve my input efficiency	✓	✓	✓	✓	✓
Simplifier my interaction process	✓	✓	✓	✓	✓
Extend my working ability	✓	✓	✓	✓	✓
Enhance the sense of professional	✓	✓	✓	✓	✓
Increase the ability to save information	✓	✓	✓	✓	✓
APPLE NEWTON					
Improve my input efficiency	✗	✗	✗	✓	✓
Simplifier my interaction process	✗	✗	✗	✓	✓
Extend my working ability	✓	✓	✗	✓	✓
Enhance the sense of professional	✓	✓	✓	✓	✓
Increase the ability to save information	✗	✗	✗	✓	✓

Figure 3.2.5.1 Assessment of Palm Pilot and Apple Newton

Take the comparison case of Palm Pilot and Apple Newton. The desired outcomes of mobile computing devices that both Apple and Palm were trying to accomplish are: Improve Input Efficiency; Simplifier Interaction Process; Extend Working Ability; Enhance Sense of Professionalism, and Increase the Ability to Save Information.

The five abilities could be used as an assessment tool to evaluate the design features.

The objective of the assessment is to evaluate the five abilities of every design feature that developed from the outcome-driven innovation process under the guide of established outcome statements.

The primary executor of the assessment is the design team itself. However, it is encouraged that related potential users be involved in this process if it is possible.

The method of the assessment includes but is not limited to:

Design team self-evaluation A (comparing with existing similar product or service)

Design team self-evaluation B (comparing between concepts)

User survey (User direct assessment based on personal experience)

User survey (User assessment comparing with existing similar product or service)

The result is to provide an iconic scoring sheet showing the assessment result of every design feature on Relative Advantages, Compatibility, Complexity, Observability, and Trialability. Blow template offers more information on how to assess a design feature during the evaluation.

Design Features	**Relative Advantages**	**Compatibility**	**Complexity**	**Observability**	**Trialability**
Default Example	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○
Guide	**Relative advantage measures how improved an innovation is over a competing option or the previous generation of a product. Potential users need to see how an innovation improves their current situation. Improvements can be in one or many of these areas but not limited to these areas:** better service, consolidation of multiple functions into one tool, decreased need for supplies and equipment, empowerment of users, improved interface, increased customizability, increased longevity, increased productivity, reduced user effort, reduced environmental impact, saving of money, saving of space or storage, saving of time.	**Compatibility refers to the level of compatibility that an innovation has with individuals as they assimilate it into their lives. Potential adopters need to know that your innovation will be compatible with their life and lifestyle.** How will your innovation fit into users' lives? What shifts in behavior will need to occur for your innovation to be adopted? What additional products will be required for your innovation to succeed (for example, a high-speed Internet connection, a mobile phone plan with data, gasoline)? What existing products does your innovation replace? How does your innovation fit with potential adopters' mental model, beliefs and attitudes regarding the issue your innovation will address?	**Complexity or simplicity refers to how difficult it is for adopters to learn to use an innovation. Complexity slows down the gears of progress. The more complex an innovation, the more difficult it will be for potential adopters to incorporate it into their lives. Potential adopters do not usually budget much time for learning to use an innovation. The more intuitive an innovation, the more likely it will be adopted.**	**Trialability describes how easily potential adopters can explore the innovation. Trialability is critical to facilitating the adoption of an innovation. Potential users want to see what the innovation can do and give it a test run before committing. This is the underlying concept of trial sizes for tangible goods, and demo or beta releases for digital goods. Potential adopters can see for themselves what life might be like once they adopt the product.**	**Observability is the extent to which the results or benefit of using an innovation are visible to potential adopters.** Side-by-side comparison. Potential adopters are able to observe the benefits of some innovations more than others. A side-by-side comparison is good when your innovation has easily noticeable improvements over what people are currently using. What will an adopter's life look like once they start using your innovation? Will there be a noticeable increase or decrease in some aspect that will result from use of your product?

Chapter 4 Application

4.1 Solar-Driven Smart Parasol Innovation

A group of engineers from Light and View Inc initiated the Solar-Driven Smart Parasol project in 2019. The core technology is based on Solar Panels. As solar power prices decreased, the engineers built a parasol with solar panels on the top surface.

Figure 4.1.1 Solar-Parasol Prototype

With an integrated power station, the parasol prototype could be self-lifting, and have a multi-media platform, and an internet connection. The prototype was built by engineers. There were no dimensions or forms, or any design considerations, but simply showing what could be done under the solar technology.

The request is to design an easy adopting smart parasol utilizing Solar Technology for private home use and public area use.

4.2 Define the Customers

In the customer definition section, the goal is set to win underserved customers only. A Smart Parasol will not be competing with traditional parasols. It was defined to go in the early market as a new type of parasol innovation that provides a better experience that will cost more.

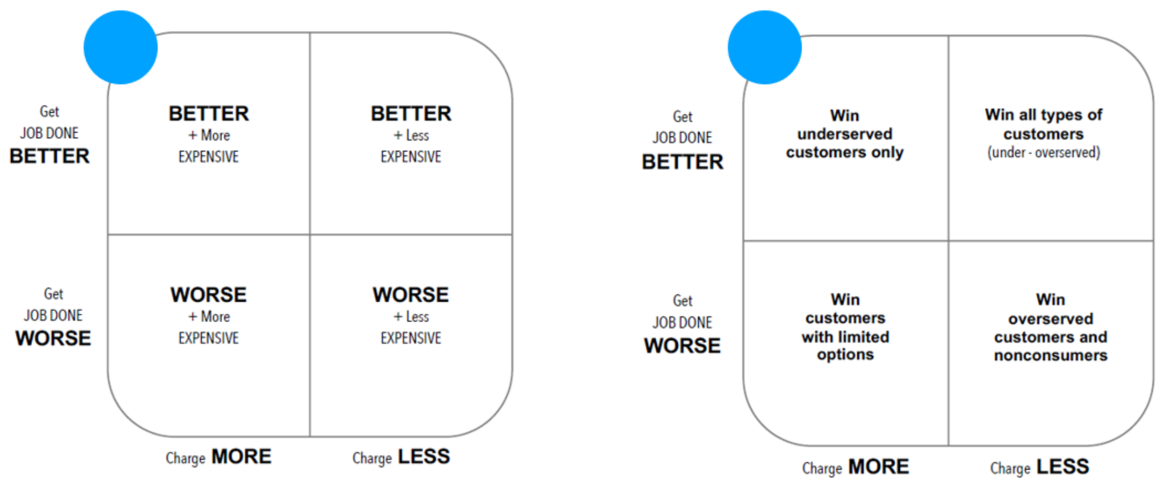


Figure 4.2.1 Define the Customer (Solar Parasol)

The statement was established to: design a Solar-Parasol for house owners with backyards who are under-served and looking for better backyard shading solutions and willing to pay a higher price. Based on that, we conduct deeper market research before the designing process begins.

		Sampling Address Book	Solar Pannels	%	Patio Umbrella	%	Pool	%	Respondent Population
		7708 Top O The MorningSan Diego, CA 92127	12	23.53%	9	17.65%	46	90.20%	51
		15822 Monte Alto TerSan Diego, CA 92127	11	15.28%	8	11.11%	0	0.00%	72
		7559 Northen Lights San Diego, CA 92127	11	22.00%	12	24.00%	44	88.00%	50
		17891 Old Winery WayPoway, CA 92064	10	16.67%	6	10.00%	49	81.67%	60
		4526 Shorepointe WaySan Diego, CA 92130	8	9.20%	25	28.74%	10	11.49%	87
		13069 Via LatinaDel Mar, CA 92014	8	10.53%	15	19.74%	5	6.58%	76
		444 Pine NeedlesDel Mar, CA 92014	13	11.93%	27	24.77%	14	12.84%	109
		3724 Newcrest PtSan Diego, CA 92130	14	12.39%	37	32.74%	32	28.32%	113
		13760 Rosecroft WaySan Diego, CA 92130	4	9.52%	10	23.81%	5	11.90%	42
		4650 Rancho Del Mar TrlSan Diego, CA 92130	14	10.45%	54	40.30%	131	97.76%	134
		6395 Clubhouse DrRancho Santa Fe, CA 92067	3	4.11%	40	54.79%	50	68.49%	73
		6896 Farms View CtRancho Santa Fe, CA 92067	14	24.56%	29	50.88%	45	78.95%	57
		7952 Entrada LazanjaSan Diego, CA 92127	1	1.19%	15	17.86%	23	27.38%	84
		7775 Sendero AngelicaSan Diego, CA 92127	11	15.49%	34	47.89%	22	30.99%	71
COAST		7712 Hillside DrLa Jolla, CA 92037	2	3.45%	20	34.48%	22	37.93%	58
		1257 Silverado StLa Jolla, CA 92037	1	1.27%	24	30.38%	7	8.86%	79
		6653 Neptune PlLa Jolla, CA 92037	1	1.18%	22	25.88%	0	0.00%	85
		7076 NeptuneLa Jolla, CA 92037	7	9.21%	28	36.84%	16	21.05%	76
		6665 VIA ESTRADA, La Jolla, CA 92037	36	26.47%	52	38.24%	69	50.74%	136
		1208 Virginia WayLa Jolla, CA 92037	24	30.77%	24	30.77%	10	12.82%	78
		7345 Draper AveLa Jolla, CA 92037	8	10.53%	46	60.53%	8	10.53%	76
Average List Cost $2.6M		5959 Via ZuritaLa Jolla, CA 92037	24	31.58%	25	32.89%	54	71.05%	76
Data source: REDFIN		355 Via Del NorteLa Jolla, CA 92037	23	26.44%	27	31.03%	28	32.18%	87
		5776 WaverlyLa Jolla, CA 92037	9	11.39%	22	27.85%	13	16.46%	79
		1191 Avenida AmanteaLa Jolla, CA 92037	22	30.14%	24	32.88%	30	41.10%	73
		5961 La Jolla Scenic Dr SLa Jolla, CA 92037	22	31.43%	42	60.00%	42	60.00%	70
		6092 Avenida ChamnezLa Jolla, CA 92037	16	18.60%	31	36.05%	26	30.23%	86
		1055 Muirlands Vista WayLa Jolla, CA 92037	16	19.51%	32	39.02%	52	63.41%	82
		7228 EadsLa Jolla, CA 92037	8	11.11%	11	15.28%	7	9.72%	72
		6545 El Camino Del TeatroLa Jolla, CA 92037	14	16.67%	40	47.62%	28	33.33%	84
		6741 Avenida MananaLa Jolla, CA 92037	24	26.09%	60	65.22%	46	50.00%	92
		6484 Caminito NorthlandLa Jolla, CA 92037	9	10.47%	17	19.77%	16	18.60%	86
		2270 Juan StSan Diego, CA 92103	11	11.00%	11	11.00%	16	16.00%	100
		1929 Titus StSan Diego, CA 92110	16	14.41%	13	11.71%	14	12.61%	111
		4334 Arcadia DrSan Diego, CA 92103	9	9.68%	23	24.73%	10	10.75%	93
		1729 W Montecito WaySan Diego, CA 92103	2	5.41%	9	24.32%	5	13.51%	37
		3605-13 Wilshire TerSan Diego, CA 92104	7	7.22%	22	22.68%	55	56.70%	97
DOWNTOWN		435 W Thorn StSan Diego, CA 92103	5	10.00%	12	24.00%	13	26.00%	50
		3234 Webster AveSan Diego, CA 92113	1	1.69%	1	1.69%	3	5.08%	59
		6626 Norman Ln, San Diego, CA 92120	20	21.05%	37	38.95%	19	20.00%	95
		4615 Yerba Santa DrSan Diego, CA 92115	10	16.95%	39	66.10%	16	27.12%	59
		4744 PANORAMA DrSAN DIEGO, CA 92116	8	9.76%	7	8.54%	22	26.83%	82
		3605-13 Wilshire TerSan Diego, CA 92104	4	4.00%	2	2.00%	11	11.00%	100
		TOTAL	606	14.33%	1207	28.54%	1291	30.53%	4229

Figure 4.2.1 Define the Customer (Solar Parasol)

The research was conducted in 2019, in the location San Diego California. The target was to find out how much a percentage of house owners are potential customers of the solar parasol by using Google Earth information and real-time images. Among the houses with more than 2500 square feet area and valued over one million dollars, we found 606 of 4229 respondent have private solar panels installed around or in their house, which is 14.33 percent, and 1207 of

4229 houses in San Diego has patio parasols in or around their backyards, which is 28.54 percent. The investors of the project agreed to move further to the next step.

4.3 Uncover Desired Outcomes

To define the desired outcomes, we had an opportunity in California to visit two house owners with parasol or shading areas in their backyard. One was located in San Diego and the other in San Francisco. Also, there was a chance to interview an owner of a restaurant in San Francisco. From theinterview feedback and team discussion, the desired outcomes in the current period are defined as follows:

Core Desired Outcome (Stay Long-Term):

Maximize the enjoyment under the outdoor shading area.

Related Functional Needs (Private House Owners):

Decrease the operating difficulties; maximize the shading ability; Improve the stability; Increase the Portability; Improve the leisure abilities; Maximize the open-close performance; Improve the ability to let the user work under the shade; Improve the ability to let users get connected; Improve the ability to let users listen to music in the backyard; Increase night serving opportunities; Improve the social functions, etc.

Related Emotional Needs (Private House Owners):

Improve the feeling of safety; Increase the sense of luxury; Maximize the feeling of being-served.

Related Financial Needs (Private House Owners):

Improve the financial benefit by having one

4.4 Map the Desired Outcomes

The desired outcomes being identified are now being positioned in the Importance and Satisfaction Map, as we can see from the chart.

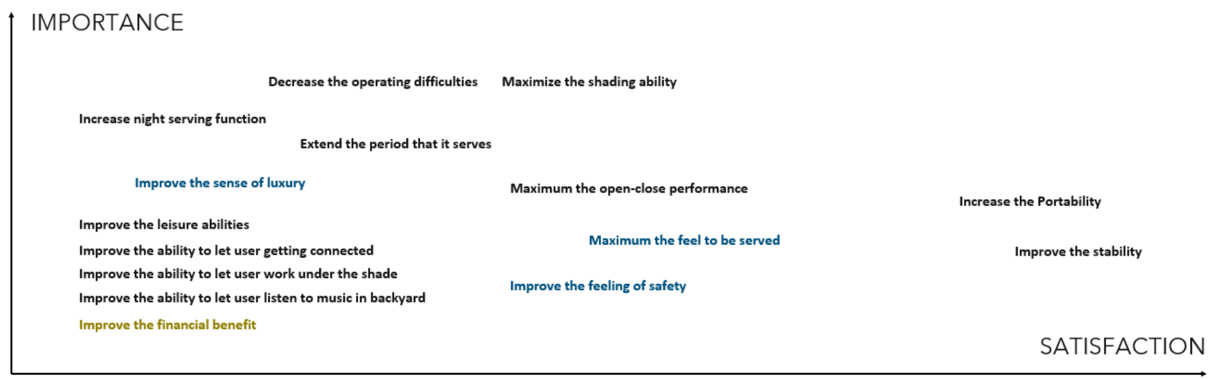


Figure 4.4.1 Mapping Desired Outcomes (Solar Parasol)

The top opportunities in the upper left section are to Decrease the operating difficulties; Maximize the shading ability; Improve the leisure abilities; Maximize the open-close performance; Increase the sense of luxury; While the Tier two opportunities are to Improve the ability to let users get connected; Improve the ability to let users listen to music in the backyard; Improve the social functions; Improve the feeling of safety.

The following design process will be focused on achieving these goals.

4.5 Outcome-Driven Design Process

The first step is to explore the basic forms of a parasol design with solar panels. What has been done in the very first phase was to rebuild a prototype with correct dimensions and proper ergonomic considerations.

According to the resource we had from the engineering team, the international standard of solar cells is 156mm by 156mm square cell. The solar panel could be customized to different shapes, but the minimum cell unit would be 156mm by 156mm square. The first solar panel sample we received was 25 inch by 17 inch standards modules that provide 50w output power, which means it can generate 0.4KW power per day (in comparison, fully charging an iPhone needs 0.014Kw).

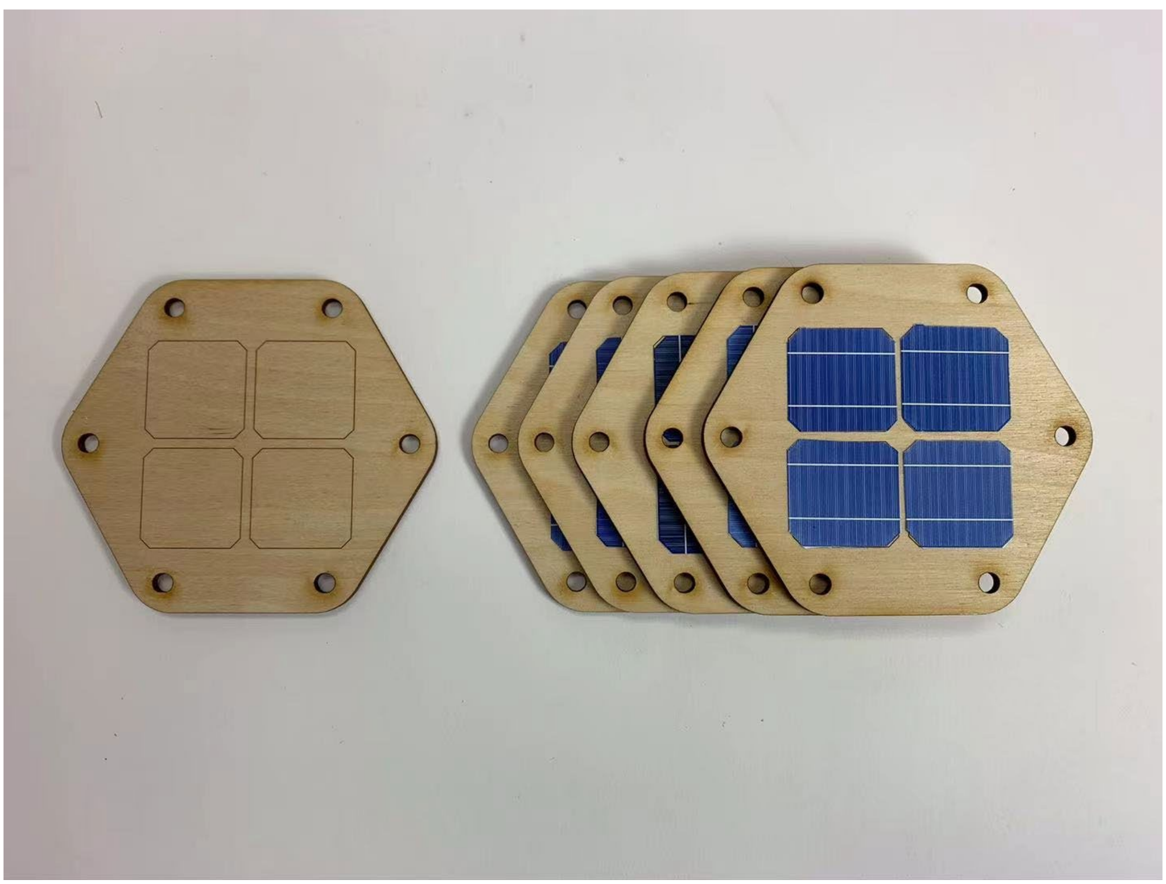


Figure 4.5.1 Re-prototype Solar Module Top Surface

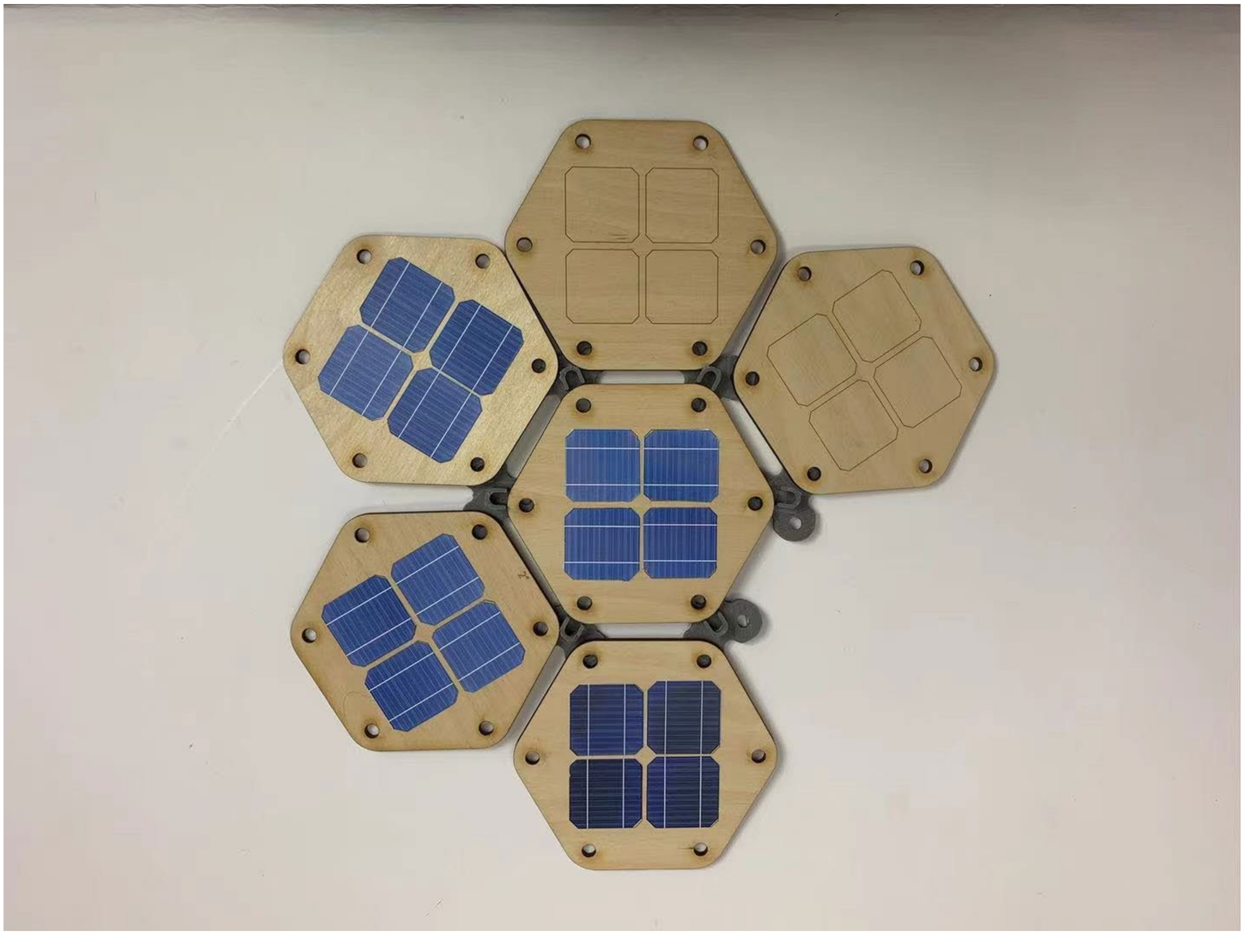


Figure 4.5.1 Re-prototype Solar Module Top Surface Layout

The main purpose of this section is to understand the technology as much as possible by working around solar panels and then explore the basic shape and forms of a parasol design that utilizes solar technology. The results of the testing prototype are listed as follows:

1. One square meter of solar cells can generate enough power to support multiple portable devices like MacBook or cellphones, fully charging four to five times. Incorporated with a proper power station, it can power proper motors and sensors at the same time.
2. Solar cells can be customized into different shapes and sizes, but the smallest solar cell unit would be 156mm by 156mm square.

3. Some solar panel providers provide foldable, flexible solar panels that could be used in the design process.
4. Solar panel weight varies. To support multiple solar panels does not require heavy construction. But it requires solid support to keep them stable during windy weather.

Figure 4.5.3 Re-prototype Solar Module Top Support

5. As the sun moves, the projection position changes greatly, resulting in a significant drop in shading efficiency.

Figure 4.5.4 Re-prototype Solar Module Dimensions

Figure 4.5.5 Re-prototype Slighter Support

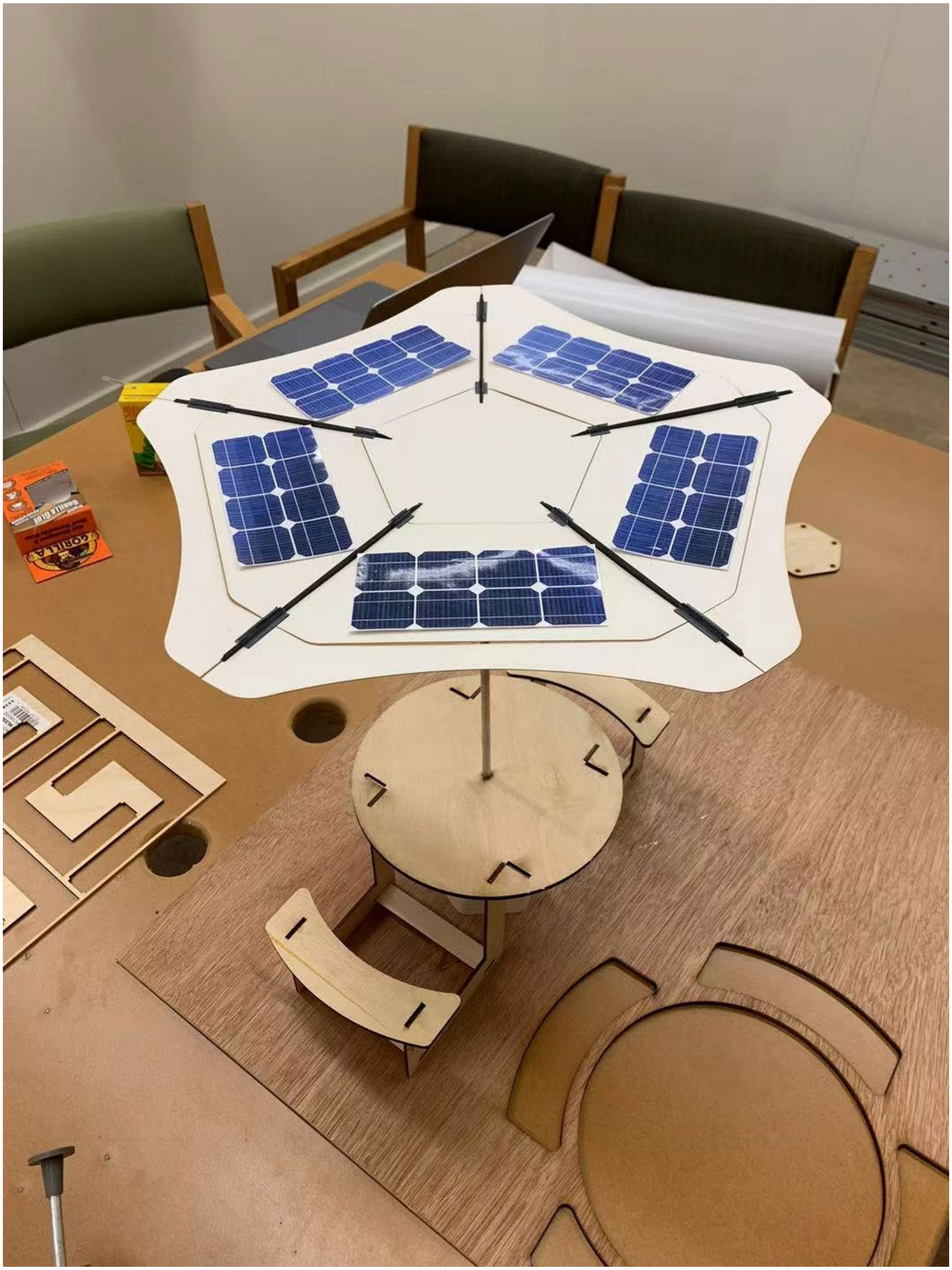


Figure 4.5.6 Re-prototype Different Surface

4.5.1 Home-Use Concept T

The Home-Use concept T chose to focus on Decrease the operating difficulties; Maximize the shading ability; Maximize the open-close performance; Increase the sense of luxury; Extend the night serving ability.

Figure 4.5.1.1 Home use Concept T

The unique folding feature is designed to improve shading ability. While the top surface tilts and slides during the daytime to face directly against the sunlight and provide efficient shades, it also provides auto Open-Close function.

Blinders Top design provides **relative advantages** on open-close performance and shading ability. The solar panels are designed to be hidden on top of the blinders which will be facing sunlight during daytime and close up in the nighttime to make the design more compatible and easier to operate.

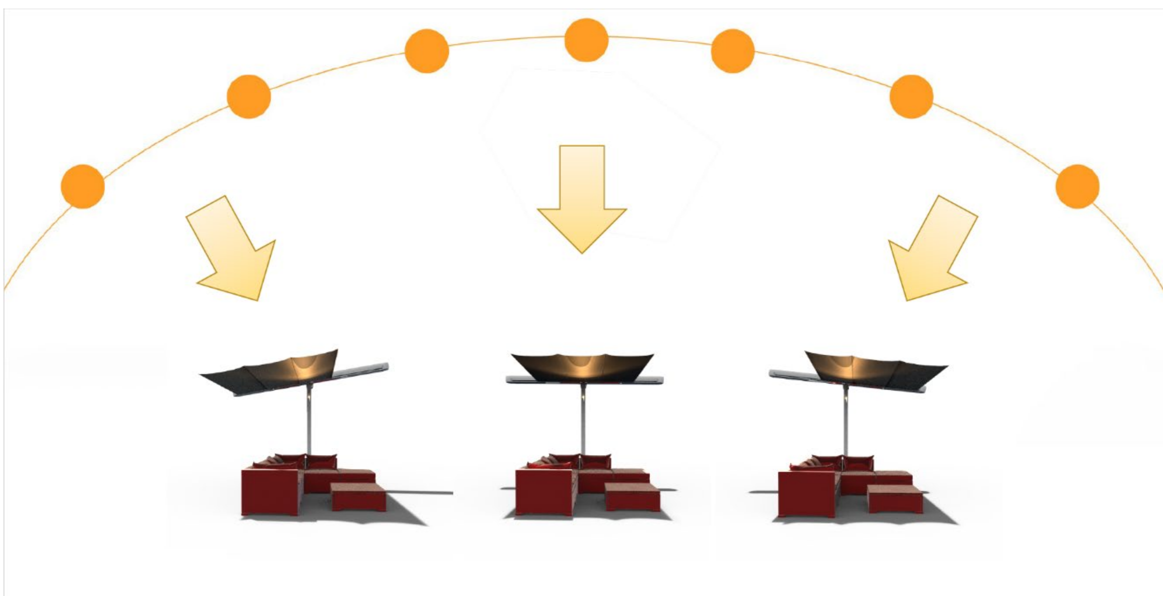


Figure 4.5.1.2 Home use Concept T Sun-Tracking

The slidable tiltable top cover was designed to provide better shading performance by sun-tracking feature during daytime, making it more **compatible** with the user's scenario. The movement will be auto-controlled by the light sensor to **avoid complex** user operations. And the feature is easily **discovered** and it is **trialable**.

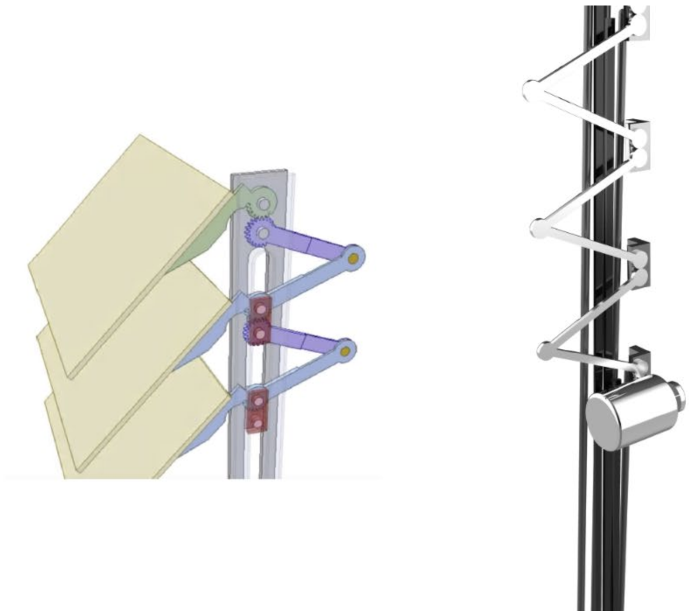


Figure 4.5.1.3 Home use Concept T Folding Structure

It could be fully closed at nighttime to serve as a nightstand, providing a lighting environment for the backyard and make it more stable during severe weather. The overall shape and look were designed to match modern house backyards to offer a luxurious feel for owners to be **compatible** with the user’s expectations.

Figure 4.5.1.4 Home use Concept T Night Use

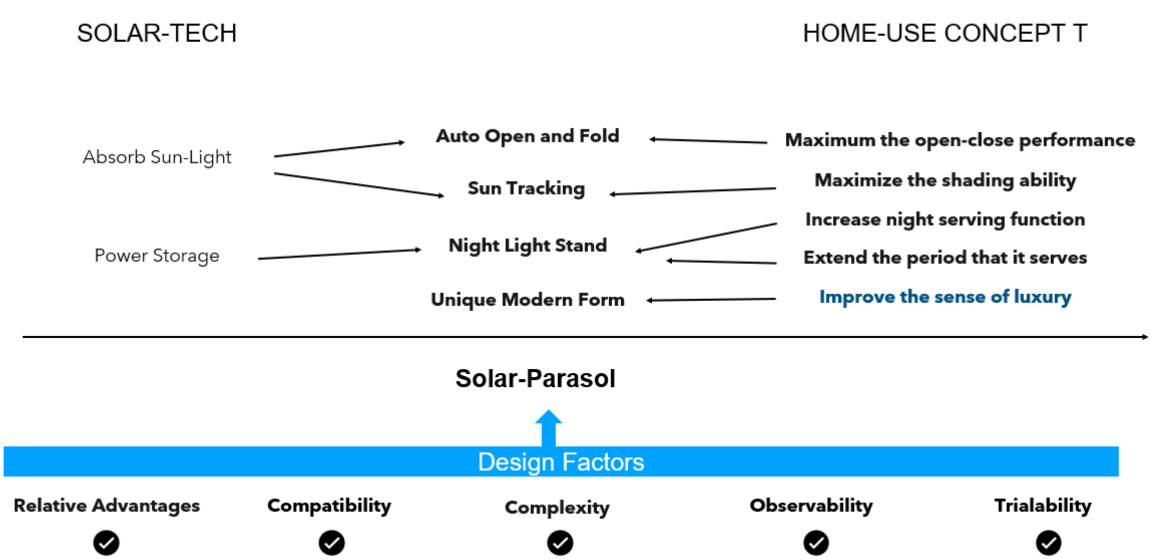


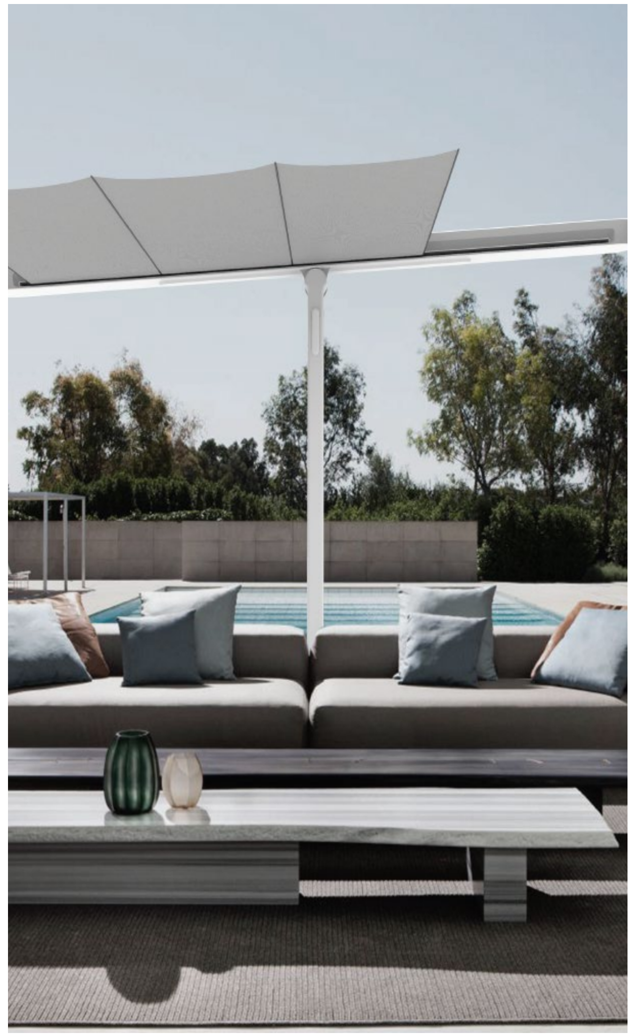
Figure 4.5.1.5 Concept T Bridge the Gap

Parasol	Relative Advantages	Compatibility	Complexity	Observability	Trialability
Default	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○	● ● ◐ ○ ○

Parasol (Original Prototype)	Relative Advantages	Compatibility	Complexity	Observability	Trialability
Default	◐ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	◐ ○ ○ ○ ○	○ ○ ○ ○ ○

Figure 4.5.1.6 Original Prototype Evaluation

As we can see from the original prototype, the features do not provide any advantages over traditional parasols, except the bulb driven by the power station may give it a night-serve ability, but it's not compatible with the user’s scenario is way too complicated.



Design Factors	Relative Advantages	Compatibility	Complexity	Observability	Trialability
Maximize the shading ability	●●●○○	●●●○○	●●●○○	●●●○○	●◐○○○
Maximum the open-close performance	●●●●○	●●●●○	●●●●○	●●●○○	●◐○○○
Improve the sense of Luxury	●●●●○	●●●●○	●●●●○	●●●○○	●◐○○○
Extend the period that it serves	●●◐○○	●●◐○○	●●◐○○	●●●○○	●◐○○○
Increase night serving function	●●◐○○	●●◐○○	●●◐○○	●●●○○	●●●○○

Figure 4.5.1.7

The evaluation is done by the design team based on the comparison of the prototype. It is suggested to reach out the related customers and make them participate in the evaluation. Due to the limited source, the customer evaluation will be done in the future development.

In Concept T, the ability to provide advantages, compatibility, complexity, observability, and trialability are well-considered during the whole innovation process. In further development, trialability should be the priority to be improved over other abilities.

4.5.2 Home-Use Concept TT

Home-Use concept TT is a double pole design that is focused on Improve leisure abilities, Improve the ability to let users get connected; Improve the ability to let the user listen to music in the backyard, and maximize the feeling of being served:

Figure 4.5.2.1 Home-Use Concept TT

The concept TT is designed to be more significant to provide an outdoor living room experience. The solar roof on the top is 75 inches by 98 inches, including 197 pieces of solar cells that generate 385W power per hour to 2 power stations located at the bottom of the stand.

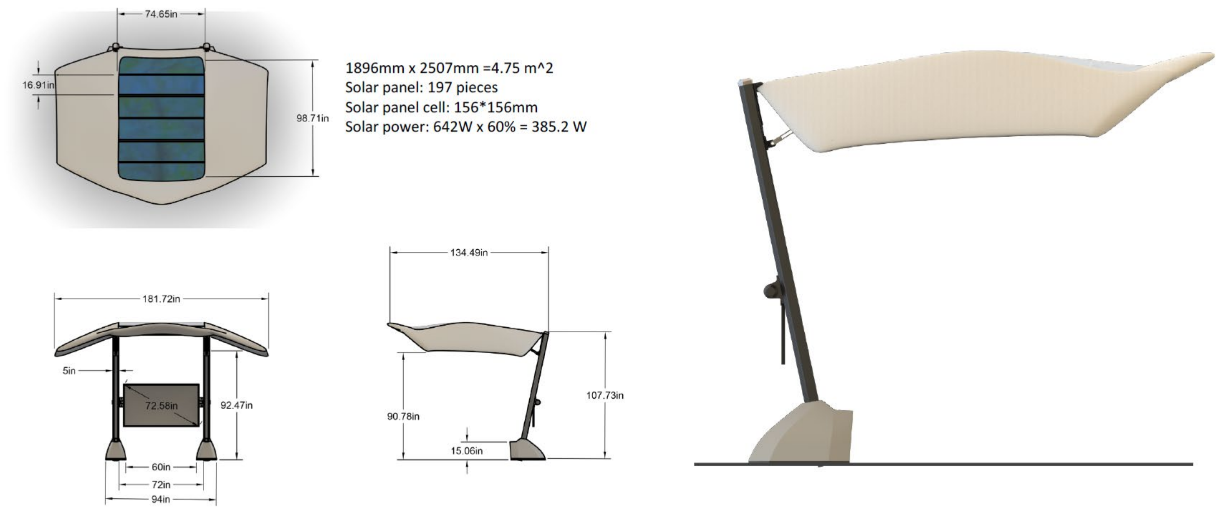


Figure 4.5.2.2 Concept TT dimension and structures

The Solar roof is foldable due to safety considerations. However, the large top surface will need to be folded up during severe weather conditions.

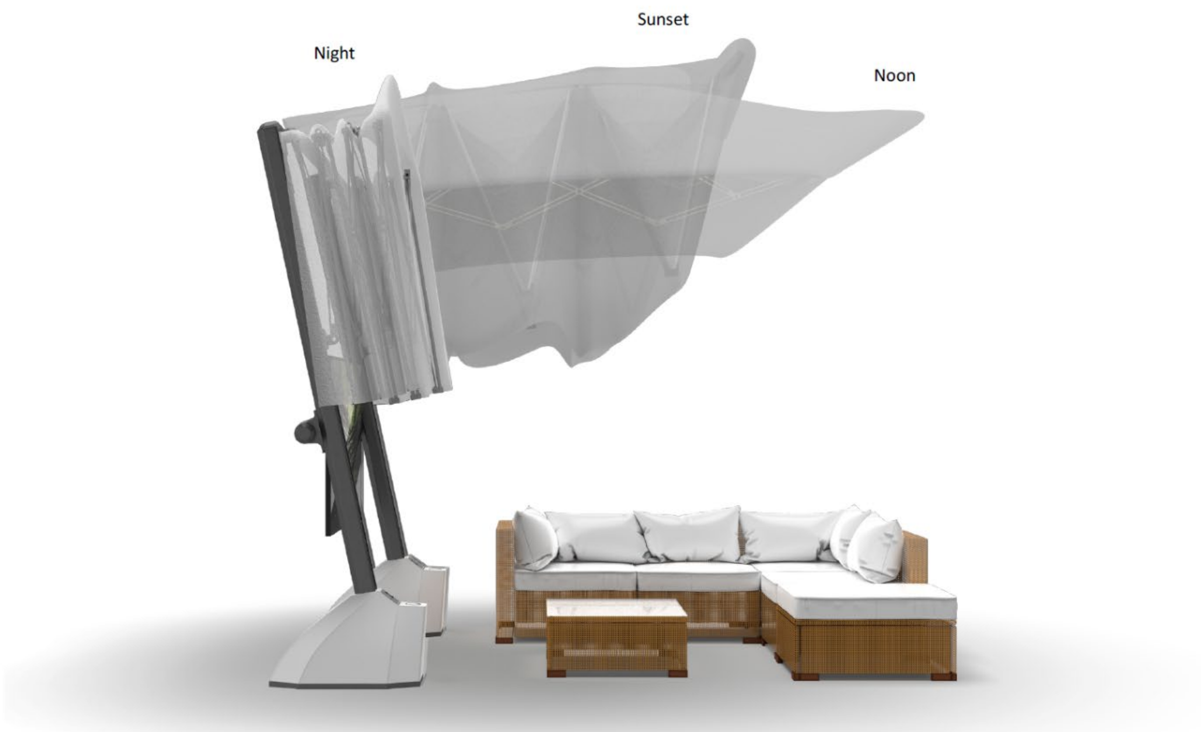


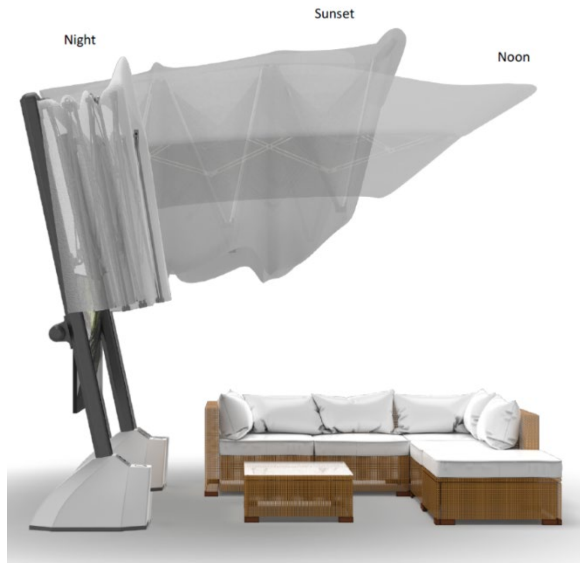
Figure 4.5.2.3 Concept TT Folding and Sun-track

The multi-media platform integrated with this design provides outdoor living space for modern homeowners. It serves as a living room where the speaker and display will be powered and serve as an internet center for the backyard. It is a space where users can read, watch TVs, charge their devices, and sit down with friends or family to have a weekend afternoon. Differentiated from Concept T, it is mainly focused on providing more serving opportunities of outdoor 'furniture,' as shown in the following image.

Figure 4.5.2.4 Concept TT outdoor living space

A multi-media center is installed to fulfill the expectations of luxury and entertainment. See Figure 4.5.2.5 below.

Figure 4.5.2.5 Concept TT media station



Design Factors	Relative Advantages	Compatibility	Complexity	Observability	Trialability
Maximize the shading ability	●●●●◐	●●●●◐	●◐○○○	●●●●○	●◐○○○
Maximum the open-close performance	●●◐○○	●●◐○○	●◐○○○	●●●●○	●◐○○○
Improve the sense of Luxury	●●●●◐	●●●●◐	●◐○○○	●●●●○	●◐○○○
Extend the period that it serves	●●●●◐	●●●●◐	●◐○○○	●●●●○	●◐○○○
Increase night serving function	●●●●◐	●●●●◐	●◐○○○	●●●●○	●●●○○

Figure 4.5.2.6 Concept TT Assessment

Comparing to Concept T, Concept TT provides more advantages on maximizing outdoor leisure ability and maximizing shading area. While the design features are compatible with user's expectations, overall, the Concept TT is designed to be more complicated for the users, which may be an obstacle when introduced to the early market. In the future development, keeping the advantages while making it more simple and easier to use would be the next step to make the design more readily adopted.

Chapter 5 Conclusion

This thesis studies multiple innovation diffusion models and concludes the main reason a tech-driven innovation fails in the early market is the failure to identify the user's expectations and the gap between science language and use language.

The factors affecting an adoption have been summarized, and the main design factors have been found and evaluated using specific case studies.

The thesis develops an approach to identify deeper levels of user needs and provides a tool to bridge the gap between a focus on technology and potential users. The method of using these tools has also been demonstrated as part of a demonstration project.

Having a new innovation adopted is a long-term and comprehensive process. Further research from other perspectives and research focusing on the mid-stage or late stage of the adoption process are encouraged.

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