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Acceptability engineering: the study of user acceptance of innovative technologies

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Abstract

The discipline of human-computer interaction (HCI) has been vital in developing understandings of users, usability, and the design of user-centered computer systems. However, it does not provide a satisfactory explanation of user perspectives on the specialized but important domain of innovative technologies, instead focusing more on mature technologies. In particular, the success of innovative technologies requires attention to be focused on early adopters of the technology and enthusiasts, rather than general end-users. Therefore, user acceptance should be considered more important than usability and convenience. At present, little is known about the ways in which innovative technologies are evaluated from the point of view of user acceptance. In this paper, we propose Acceptability Engineering as an academic discipline through which theories and methods for the design of acceptable innovative technologies can be discussed.

Keywords: Acceptability; Discipline; Early adopter; Human-computer interaction; Innovative technologies; Usability; User acceptance

1. Introduction

Innovative technologies can open up new technological markets, bring about new values and practices, and transform existing technologies. As an innovative technology emerges, however, it can be very difficult to predict how significant it will become. Innovative technologies are usually unpredictable, prone to failure, and often uneconomic. For this reason, industry and governments hesitate to invest in innovative technologies. This issue arises in part from a lack of systematic and scientific methods for assessing future technologies, as well as the intrinsic complexity that new technology often exhibits.

Evaluating the future of innovative technologies has not been considered a scientific endeavor; rather, such speculation is left to the insight and intuition of a few knowledgeable individuals. A similar approach is often seen in the human-computer interaction (HCI) community. While many technology-oriented HCI researchers have shown an interest in innovative technologies, human-oriented HCI researchers have overlooked them to a large extent. For example, wearable healthcare systems and devices have rarely been explored in terms of user perspectives (Kim et al., 2011). Here we argue that a scientific approach to the design of innovative computing technologies would be desirable to assess the design of future innovative technologies in a systematic manner from the perspective of user acceptance, and discuss the potential of a new discipline of Acceptability Engineering (AE), where concepts, theories, and methods can be generated, shared, and validated among researchers.

The remainder of this paper is organized as follows. In section 2, we discuss what are innovative technologies, describing related definitions and examples, and categorizing them into emerging technologies, disruptive technologies, and immature technologies. In section 3, we briefly introduce a technology life cycle model proposed by Moore (1991), which is the model through which AE can be best described, and explain the relationship between the early and mainstream markets, and describe the types of customers (i.e., early adopters and late adopters). In section 4, we describe the differences between AE and HCI with respect to Moore's model. Because HCI is now a well-established discipline for user-centered approaches, a comparison with AE can help readers grasp the significance of AE. In section 5, we characterize early adopters of innovative technologies as influential users, and discuss their importance for AE. In section 6, we compare two key notions of usability and acceptability, which symbolize HCI and AE, respectively. This is also useful for understanding AE and the difference between AE and HCI. We also discuss acceptability as a tradeoff between a variety of factors influencing the acceptance and use of technologies. Section 7 proposes a definition of AE and discusses the characteristics and nature of AE. Section 8 concludes the paper.

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2. Innovative technologies

The word 'innovation' is derived from the Latin word *innovates,* the noun form of *innovare* meaning 'to renew or change,' stemming from *in* ('into') and *novus* ('new'). Thus, innovative technology is technology that is changed or developed to improve products and services. Various notions that relate to such changes in technology are considered innovative technology.

2.1. Emerging technologies

Emerging technologies are technological innovations that create more competitive ideas or products (Soares et al., 1997). An example is the convergence of previously separate technologies to serve similar goals, known as technological convergence.

For example, the field of communications once consisted solely of people delivering and exchanging information using telephony, postal mail, and telegraphs. However, due to technological advances, many of these features have been combined to achieve more convenient and effective transfer of information. For example, video calling and voice telephony can be implemented using a single internet connection. Telepresence technology is widely used for business purposes, wherein two parties located in different places can conduct meetings or conferences remotely, enabling faster and more effective evaluation of information and decision-making. Current emerging technologies include nanotechnology, biotechnology, information technology, and cognitive science (NBIC).

One way to describe emerging technologies is to use Gartner's Hype Cycle (www.gartner.com), which provides a graphical representation of the maturity and adoption of emerging technologies and applications. The Cycle gives insight into how a technology or application may evolve over time, and has five key phases, from technology trigger to the plateau of productivity. Figure 1 shows Gartner's 2013 hype cycle, with a number of emerging technologies illustrated.

2.2. Disruptive technologies

Disruptive technologies are innovations that create a new method, replacing the previous technology and making it redundant. The term was coined by Clayton M. Christensen (Christensen, 1997; Christensen & Overdorf, 2000), although he later replaced the term with 'disruptive innovation' (Christensen et al., 2004). This kind of innovation originally aims to create a new market, but eventually reaches the mass market, mostly by reducing costs, thus disrupting the current market.

Take, for example, the creation of automobiles as an innovative replacement for horse-drawn vehicles. Early automobiles were made as expensive luxury items. These did not affect the market for earlier transportation methods, and it was not until the low-cost Ford Model T was introduced in 1908 that the technology became disruptive. In this respect, the mass production of an affordable automobile can be considered the disruptive innovation, rather than the automobile itself. As such, disruptive technologies are often referred to as innovations in marketing.

2.3. Immature technologies

Immature technologies are new innovations that require further development. They are usually rapid to appear, have diverse applications, and are often limited to experts and professionals in a particular field, with some remaining as theoretical concepts. For instance, wearable computing with biosensors for healthcare is not matured enough (Kim et al., 2011; Rajan & Sukanesh, 2013), but still has its huge potentiality in the future. In general, nanotechnology, quantum computers, and nuclear fusion power are a few examples of this kind of innovative technology.

3. Moore's technology adoption cycle model

3.1. Moore's model

Geoffrey Moore interpreted the technology adoption life cycle in terms of a dichotomy between early adopters and late adopters in his book *Crossing the chasm* (Moore, 1991). Moore was the first to identify a chasm between the early adopters and the early majority customers when dealing with discontinuous or disruptive innovations. Figure 2 shows a distribution of adopters of new technologies; the left part of the chasm refers to the early market, and the right refers to the mainstream market. Therefore, crossing the chasm implies moving from the early

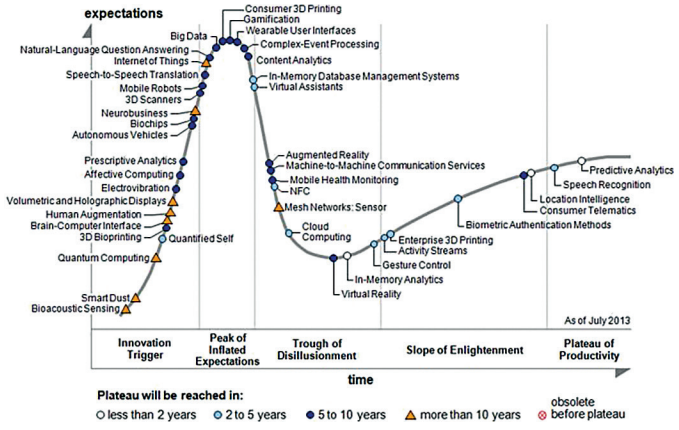

Fig. 1. Gartner's 2013 hype cycle for emerging technologies.

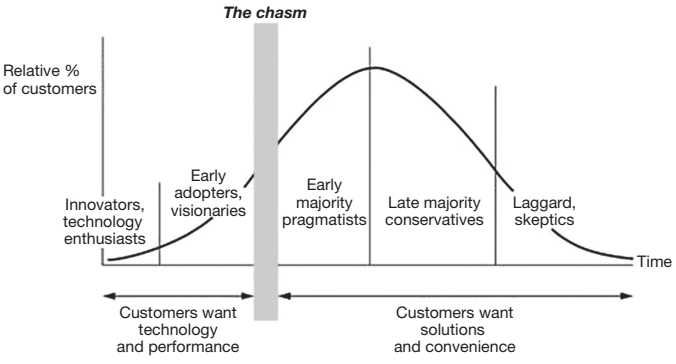

Fig. 2. Moore's model for the technology adoption life cycle.

market, where innovators and early adopters dominate, to the mainstream market, where late adopters dominate.

As an example, consider the first generation of pen computing technologies. Early entrants into the market did not succeed in crossing the chasm in the early 1990s, and these companies went out of business. Early products were expensive, bulky, and suffered from limited battery life and poor handwriting recognition. Many years later, however, products with a pen user interface, such as the Palm Pilot, Palm Treo, and a variety of Microsoft Pocket PC/Windows Mobile powered devices finally succeeded in crossing the chasm. In addition, full-size tablet PCs are now crossing the chasm, with success in vertical markets such as healthcare, insurance, and real estate.

One reason that the chasm exists is that the industry has not yet established the conditions necessary for adoption of the technology by the early majority customers, who remain unconvinced by the merits of the products. Furthermore, while many technology enthusiasts and early adopters purchase innovative products, there are too few such visionaries to sustain market growth.

According to Moore (1991), there are some strategies that can be employed to cross the chasm. The first and most crucial strategy is to identify niche markets. He believes that it is better to focus resources on one target market and achieve an entire product solution, rather than work on a number of target markets simultaneously. A vendor must quickly capture the lead market share, and the developing strategic alliances with providers of content, technology, software, or services are helpful for building a product solution.

3.2. Adopter categories

It is worth discussing the different adopter categories in Moore's model in more detail. When a newly developed innovation is launched commercially, not all target users adopt the technology at the same time. It depends on the degree of innovation and other factors, and each adopter has different characteristics and behavior.

The first people to adopt a new technology with the greatest level of innovation are called the *innovators*. They are typically adventurous and cosmopolitan, which distinguishes them from their local network of peers. *Early adopters* make up the second group. They are more integrated with the local social system and have the highest degree of opinion leadership among a group of adopters. They are respected by their peers for their judicious decisions regarding new innovations. The next group is called the *early majority*. With less opinion leadership, people in this group deliberate for some time before adopting new ideas. The *late majority* group is next and is made up of people who are skeptical toward innovation and thus do not adopt until the uncertainties relating to the product have been largely removed. The *laggards* are the last to adopt a new idea due to limited resources. They want to be sure that a new idea will not fail.

Among these groups of adopters, the most influential are the early adopters; they are the most important in terms of influencing others to adopt an innovation and in expediting the rate of technological diffusion.

4. AE vs. HCI

An innovative technology, or more specifically a disruptive technology, typically exhibits poor performance and thus is generally not convenient (Christensen, 1997). For HCI researchers, it may be too early to consider and study usability and user convenience in such innovative but inconvenient technologies, because the basic functionality is usually premature. In this respect, success, or user acceptance, of innovative technologies cannot be explained by notions of convenience and usability. This is one reason that HCI researchers study user perspectives of mature technologies much more than innovative technologies.

The target technologies of AE are innovative ones. In AE, convenience is not the primary concern, even if it deals with user understanding, as with HCI. There is a belief that the future of innovative technologies is not determined only by solutions and convenience. More complex dimensions are required to predict future trends in the uptake of technologies, including social, cultural, political, and economic aspects. Although these aspects are important for mature technologies, we wish to emphasize that complex angles should be systematically analyzed to evaluate innovative technologies and design acceptable technologies.

AE is concerned with how to cross the chasm. Therefore, AE must provide theories and methods to build innovative computing technologies that are acceptable to users. In terms of types of users, HCI has contributed to the understanding of users in computer science, particularly late adopters who want solutions and convenience. However, such people fall into the right side of the chasm shown in Figure 1. In contrast, AE concerns primarily those users on the left side of the chasm: the innovators and early adopters. Figure 3 illustrates the difference between AE and HCI and user experience, based on Moore's model.

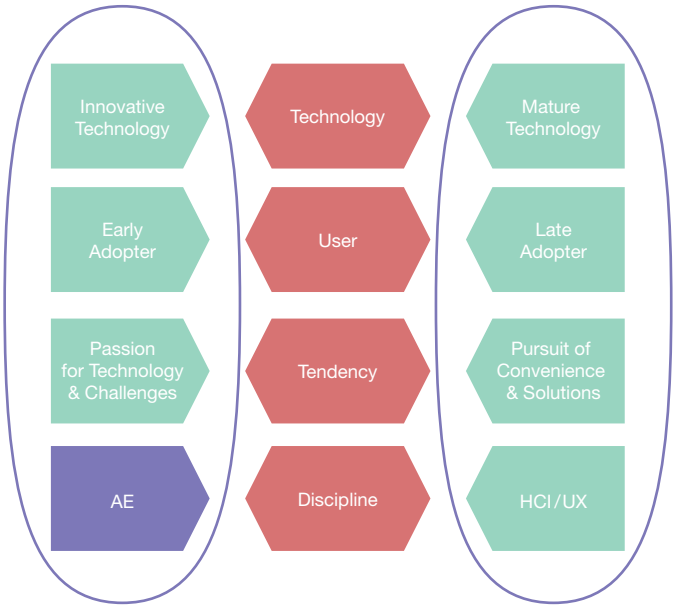

Fig. 3. A comparison between Acceptability Engineering and HCI/UX based on Moore's model.

5. Usability vs. acceptability

Usability is a core notion in HCI. Acceptability is a broader concept than usability; however, it has not been used nearly as frequently by the HCI research community. Acceptability is a key notion of AE. In this section, we discuss the notions of usability and acceptability, which are key to understanding the differences between AE and HCI.

5.1. Usability

As pointed out by Shackel (1986), usability was probably first defined in by Miller (1971) as a notion to measure *ease of use*. There are several criteria, including the duration of the learning process, number of errors, and exasperation responses. However, Bennett (1979) was perhaps the first to use the term *usability* to refer to the quality by which a tool becomes convenient and practical for use. In 1986, Shackel extended his definition (Shackel, 1981) to a "formal operationalized definition of usability" within a framework of four principal components: user, task, system, and environment. He proposed that, for a system to be usable, it must be effective, able to be learned, flexible (Shackel, 1986).

ISO standard 9241 defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11, 1998). However, effectiveness, efficiency, and satisfaction may not cover all of the relevant aspects of usability (Bengts, 2004). Therefore, Bengts defined usability in terms of affective aspects, utility aspects, and cognitive aspects (Bengts, 2004), as shown in Figure 4, combined with the layered model of Van Welie et al. (1999). A notable feature of this definition is that it covers almost all attributes mentioned by other authors; in particular, the affective aspect of usability not only reflects a broader view than satisfaction, but also includes user experience features, although he did not use the term 'user experience.'

Researchers in HCI began to use the term "user experience" more frequently starting in the 2000s. Because of this, one may be confused between the notions of usability and user experience, and some consider them to be synonymous (Saizmaa & Kim, 2006). Because the term of usability was primarily confined to cognitive usability by the turn of the century, many researchers felt that it is was too limited. They introduced a broader term replacing usability and including emotional aspects. The new term for this became user experience.

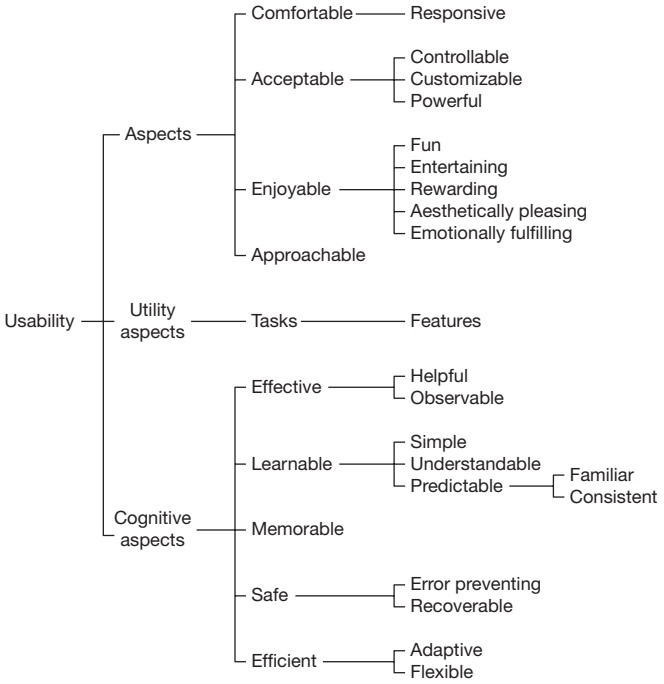

Fig. 4. The tree-like concept hierarchy of usability (adapted from Bengt).

5.2. Acceptability

Some years after he defined the notion of usability, Shackel proposed a new model, in which product *acceptance* is the highest concept (Shackel, 1991). The principal idea of this model is that the user balances the following four factors: utility (the match between user needs and functionality), usability (ability to utilize functionality in practice), likeability (affective evaluation), and cost (both the financial costs and the social and organizational consequences of buying a product).

Nielsen (1993) also regards usability as an aspect affecting product acceptance. He divided *acceptability* into practical and social acceptability, where practical acceptability consists of factors such as usefulness, costs, compatibility, and reliability, as shown in Figure 5.

In summary, the notion of acceptability is a higher-level concept than that of usability, involving more complex social, organizational, and financial aspects. As mentioned earlier, innovative technologies require an explanation that takes into account richer dimensions of appeal, beyond usability and ease of use, to see further development and hence widespread use. AE emphasizes acceptability or user acceptance to help cross the chasm from the early market to the mainstream market.

Therefore, acceptable innovative computing technologies in an AE sense do not correspond to usable or convenient technologies but rather to technologies that users adopt and use (in one word, accept). There are many examples where inconvenient systems are commonly used. There are also many systems that are inconvenient and even inaccurate, but are in popular use.

In particular, because innovative technologies are typically (and perhaps intrinsically) inconvenient, due to limited functionality and immaturity, it may not be helpful to consider usability and ease in the design of such technologies. Rather, designers should consider how to create acceptable systems. For this reason, a new discipline to evaluate and design acceptable innovative technologies is required, one that is distinct from HCI, as illustrated in Figure 6.

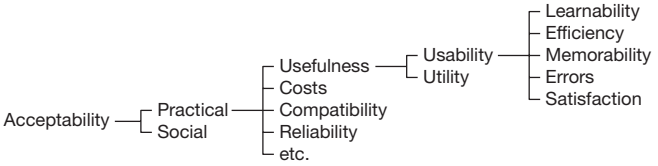

Fig. 5. Nielsen's definition of product acceptability.

5.3. Acceptability as a trade-off

The adoption of technology is affected by a large number of factors. Usability is an important factor, even if it merely refers to ease of use. In addition, accuracy, price, brand, physical appearance, security, function, interoperability, and robustness are all independent factors affecting user acceptance.

When users adopt a technology, they consider many factors. What is important is that it is not generally possible to make users accept the new technology with every factor being fulfilled completely. This is true particularly in the case of innovative technologies, which typically exhibit some technical shortcomings. User acceptance, therefore, is affected by some of these critical factors only, while other factors can be less critical. Furthermore, which factors are most important typically depends on the type of technology. For example, accuracy may be crucial in one technology, whereas security may be crucial in another. Whatever the case, user acceptance is the result of a tradeoff among a variety of factors. Such considerations are illustrated schematically in Figure 7.

One study concerning wearable computers, for example, suggested that six factors (fundamental needs, cognitive aspects, physical aspects, social aspects, demographic characteristics, and users' technical experience) had a significant impact on user acceptance (Buenaflor & Kim, 2013). That study showed that acceptability has a number of aspects, and that there is a tradeoff among the factors (although there is debate over whether the six factors were well-identified, if there are some important missing factors, and if each factor is affected by sub-factors that may also require a tradeoff). When acceptability is a tradeoff, it requires a systematic evaluation, and tools such as an acceptability index or matrix, or strategic tools, e.g. a hybrid SWOT analysis model (Wang, 2014).

6. Early adopters as influential users

The field of information technology (IT) is evolving rapidly, and there have been a number of recent technological developments and innovations. User acceptance of innovative technologies is, therefore, a greater concern that ever before. While IT companies, developers, and researchers make many efforts to evaluate product features and functions to suit user requirements and to increase the rate of acceptance, the structure of the target users' social network may be composed of different types of interconnected individuals with different adoption behaviors, and this should also receive attention. A special group of users may be highly influential in accelerating the adoption and acceptance of innovations: the early adopters.

Early adopters are a crucial user group in AE, and they play an important role in the diffusion of innovative technologies. In this section, we describe the nature of early adopters, highlighting their characteristics, roles, behavior, and how they may contribute to accelerating the adoption and acceptance of innovations (Buenaflor & Kim, 2012).

6.1. Characteristics

Examining the characteristics of early adopters will help us understand their adoption behavior, as well as their influence on the adoption of innovation by other potential users.

- *Social status.* Early adopters typically have more years of formal education, making them more likely to be literate than late adopters (Rogers, 2003). They also have higher incomes and thus more spending power (Kauffman & Techatassanasoontorn, 2009). It is easier for them to adopt an innovation regardless of the cost and the risk of losses from possible failure of an immature technology.
- *Innovativeness.* Being risk-takers, they have a desire to be the first in their social network to acquire new technologies (Foxall, 1994). They have a more favorable attitude towards change, new ideas, and in using IT innovations (Pedersen, 2005).
- *Independent decision makers.* While the decisions of later adopters are influenced by the experiences communicated by others, early adopters make such decisions independently. They are self-reliant and inner-directed, which makes them willing to try new products with less interpersonal influence (Watier, 2003).

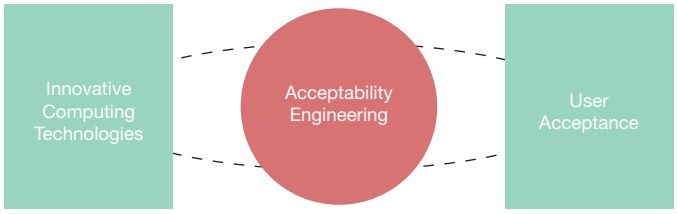

Fig. 6. Acceptability engineering relates innovative technologies to concepts of user acceptance.

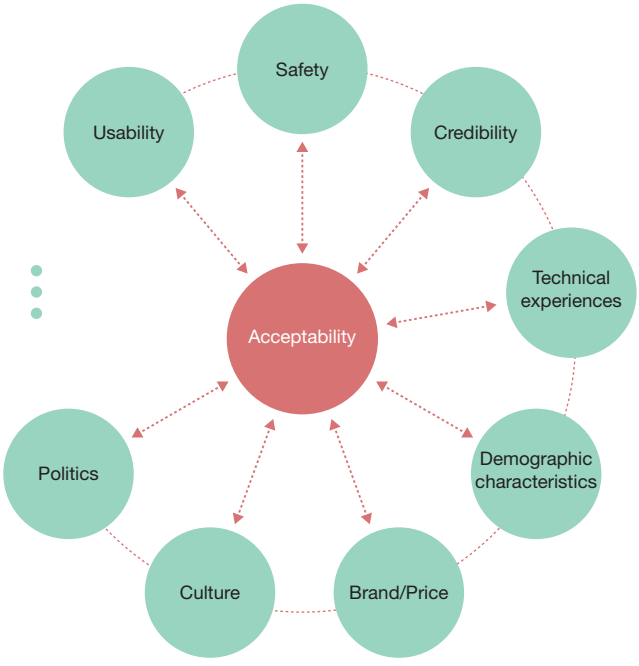

Fig. 7. The tradeoff among factors affecting acceptability.

- *Experts*. The innovativeness of early adopters is accounted for by their exposure and experience in using computers (Watier, 2003; Chau & Hui, 1998).
- *Greater social participation*. Early adopters are more socially active and connected to interpersonal networks (Kauffman & Techatassanasoontorn, 2009). They are also more cosmopolitan, in that they communicate with people outside of their immediate social group more often than later adopters.
- *Information seekers*. Early adopters seek information more actively, and check for new products on the market, or dig deeper for information to support their adoption decisions and to mitigate risks. Due to their desire to acquire as much information as possible, they typically gain greater exposure to mass media communication channels (Kauffman & Techatassanasoontorn, 2009).

6.2. Roles

Early adopters typically possess characteristics that distinguish them from later adopters, and are able to perform important roles in the adoption and diffusion process of technological innovations.

- *Adoption initiators*. While the majority of target users are skeptical about new products, early adopters are not hesitant to initiate adoption. IT companies and developers rely on this behavior to have people act as role models and demonstrate the advantages of new products to other potential users, thus encouraging further adoption. For example, Pedersen (2005) showed that later adopters of the multimedia message service platform had more of a tendency to use the mobile service when they were able to observe its use by others.
- *Information disseminator*. Early adopters tend to spread information about new products within their social networks through interpersonal communication, which is a key factor in the diffusion of innovative technologies (Wright & Charlett, 1995). Being socially active, and particularly via social networking sites and other digital media channels, they can disseminate information and influence a wide range of potential adopters. For example, YouTube gained popularity in 1995 when its early users began sending links of a particular video around the Internet (Kauffman & Techatassanasoontorn, 2009).
- *Opinion leaders*. The influence of early adopters over other users also stems from their high degree of opinion leadership. Because of their personal experiences with and expertise on a given technology, their opinions about innovation can influence the adoption decisions of others. Indeed, consumers trust the opinions of peers more than media advertisements (Chau & Hui, 1998).
- *Product evaluators*. Early adopters also act as good test users. Louis Gray, running Google Developers Live initiative, who is an early adopter, shared questions that he asked himself when trying a new product and analyzing its advantages and usability: "What are we already doing that these new tools make better? What can I do that I couldn't do before?" (Kauffman & Techatassanasoontorn, 2009). In marketing wearable computers to consumers (Watier, 2003), researchers used early adopters to examine features and functionalities as well as the issues with and attitudes toward the products. These early adopters gave suggestions on how to improve the devices.

7. Acceptability Engineering

As a provisional definition, AE is the study of the design, evaluation, and implementation of innovative computing technologies to fulfill user acceptance, and the generation and validation of relevant theories, methods, and phenomena. Accordingly, AE aims to capture a balanced understanding of innovative technologies and user acceptance. In addition, it is an area in which research efforts focus on crossing the chasm between early and late adopters, and between early and mainstream markets.

In this section, we characterize AE considering several different aspects.

7.1. Human-centered engineering

AE focuses on research on human-centered innovative technologies, concerns the relationship between innovative technologies and user acceptance, and addresses the following questions: Which factors affect user acceptance? When many innovative technologies fail, how do we design acceptable alternatives? Although there are many related areas of inquiry, how do we evaluate user acceptance and predict the success of innovative technologies?

AE should be understood as a discipline that provides methodologies to investigate user acceptance based on a number of cognitive, emotional, and social factors. What is important in AE is how to make innovative technologies acceptable to users, rather than how to build technologically good systems. AE is therefore human-centered.

AE is interdisciplinary, primarily because it is human-centered engineering. Therefore, AE is a fusion of humanities and engineering. In particular, many research methods from human and social sciences are critical to AE. This is because they are necessary to investigate and study the people that use innovative technologies.

AE requires research methods from engineering disciplines including computer engineering, electrical engineering, and industrial engineering, as well as those from human and social sciences, including psychology, cognitive sciences, sociology, marketing, and art. In this respect it is similar to HCI. Many of the theories and methods in HCI can also be used in AE. Figure 8 shows an overview of the different aspects of AE.

7.2. Study of innovative technologies

As discussed earlier in the paper, innovative technologies are intrinsically unpredictable and complex. There are many risk factors that provide barriers for investment. Gaining a scientific and systematic understanding of user acceptance of innovative technologies for predicting the success of these technologies is one of the principal aims of AE. In general, people recognize that evaluating the future and potential of innovative technologies is important; however, theories and systematic methods to achieve this are not yet well developed.

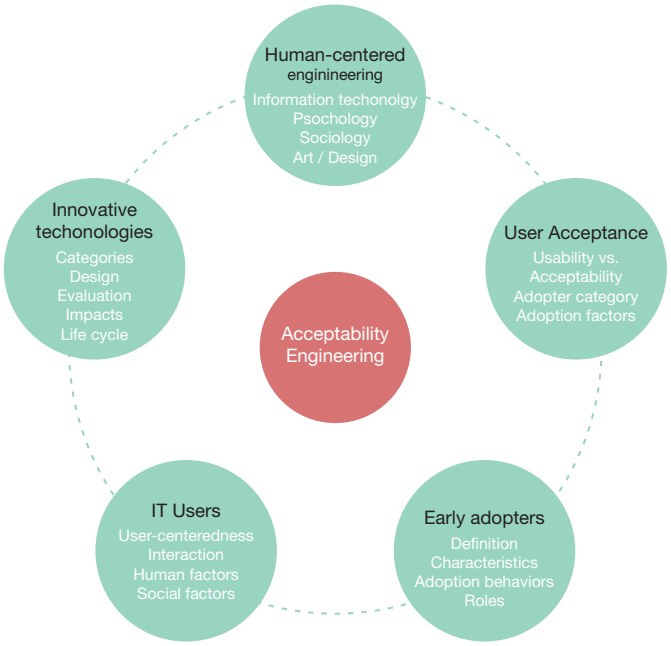

Fig. 8. Characteristics of Acceptability Engineering.

One of the most critical research issues concerning innovative technologies is how to develop methods to evaluate user acceptance. Importantly, although there are many ways to evaluate legacy systems and technologies that have already been shown to be successful, there is a lack of methods for assessing innovative technology. In this respect, systematic and scientific methods to assess innovative technologies in terms of user acceptance are required. In particular, understanding the life cycle of innovative technologies, from birth to disappearance, is interesting. With such an understanding, both technological developers and investors can plan the expansion of innovative technologies more effectively. In addition, processes and methods of design should also be explored in AE. Furthermore, there should be a number of ways to categorize innovative technologies. This is important because meaningful categorization implies an understanding of innovative technologies. Such a classification is arguably the first step in the development of AE.

7.3. User acceptance

While HCI concerns usability, AE deals with acceptability. For instance, there are cases in which a system is user-friendly, but users do not accept it. Conversely, there may be systems that are inconvenient, yet enjoyed by many users, such as text-based multi-user domains.

Comparative studies between usability and acceptability provide insight into notions of user acceptance in AE. In general, acceptability can be understood as a higher-level concept than usability, and serves as a tradeoff among a variety of factors affecting the adoption of new technologies.

Much work is required to identify and explore adoption factors. Usability is a factor, and accuracy or credibility can be crucial in certain systems. Demographic characteristics such as age, gender, education, and background may also help determine user acceptance. In many cases, people who have more experience with technology are more likely to adopt innovative technologies. In this respect, technical experience is a significant factor affecting the adoption of innovative technologies. As far as social aspects are concerned, user acceptance may depend on cultural dimensions as well as economic and political aspects. There are many different angles that should be considered in the study of the adoption of technology. Adoption factors are at the heart of the study of user acceptance.

7.4. Study of IT users

AE primarily concerns users of IT, and although other types of technology fall under the scope of AE, the major focus is IT. Note that many devices and technologies are already fused with computer technologies. For example, automobiles are no longer the realm of mechanical engineering alone, and IT and systems engineering are important aspects of the development of automobiles. Smart/intelligent cars are a good example of this, in that communications technologies, artificial intelligence, and HCI all play significant roles in their development.

Houses, medical devices, vehicles, phones, televisions, and home appliances demand IT. Computing technologies are indispensible in technological development. In this respect, IT users can be users of other devices. We must consider the rapid growth of IT and its fusion with other technologies.

However, the primary research targets for AE are not only machines but also people, particularly those who use IT. IT users have long been studied in disciplines including ergonomics, HCI, and computer-supported cooperative work. Therefore, AE should employ some of the theories and methods used in these disciplines. In particular, AE pursues the philosophy of user-centeredness, as with HCI and similar disciplines; therefore, issues such as interaction, human, and social aspects are emphasized in AE.

7.5. Early adopters

Although AE does not neglect general users, the major focus is on early adopters, also called innovators and technology enthusiasts. To date, early adopters have been largely unexplored by the HCI research community, whereas some groups of users have been extensively investigated, including the elderly, the disabled, and children. In other words, although HCI concerns innovative technologies to some extent, in general, the field has tended to overlook the importance of early adopters who play a crucial role in the diffusion of innovative technologies. This is perhaps one of the greatest problems in the study of user understanding in HCI. Early adopters are of great interest for AE because without understanding early adopters as adoption initiators and technology disseminators, it is impossible to predict the success of innovative technologies.

There remains much work to do in AE. First, to understand the acceptance of innovative technologies, the question of who can be categorized as early adopters in a particular emerging system should be addressed. This is because it is important to

define the potential target users who can lead to diffusion of the given system. Second, how to study these early adopters is equally important. Whereas similar methods to user studies employed in HCI and ergonomics will be helpful for AE, new and different approaches are required to understand the behavior of early adopters. Third, it is particularly important to understand the roles of early adopters in society. This aspect of AE has primarily been an area of business and marketing. However, given the importance of the diffusion of innovative technologies, it also becomes an essential component in human-centered engineering fields including HCI and AE.

8. Conclusions

Innovative technologies have much potential to drastically change our ways of life. However, because they are unpredictable and prone to failure, it is not easy to determine how to invest in their development. Therefore, systematic methods to assess the future of such technological developments from user perspectives are desirable.

In this paper, we have proposed the discipline of AE, which concerns the design and evaluation of innovative computing technologies to fulfill user acceptance. HCI has primarily focused on mature technologies, and thus has some limitations in the study of innovative technologies and in particular the users of such technologies. The discipline of AE seeks to predict and evaluate the future of innovative technologies, addressing the chasm between early and mainstream markets.

AE is not yet well developed; however, we hope that the work described here will form a starting point for researchers to discuss what and how to study user acceptance of innovative technologies. Much work remains, and there are many interesting issues to explore in the future, including how to specify and classify innovative computing technologies, who the early adopters are, what acceptability is, how to define acceptability indexes, how to build and verify theories, and which research methods should be employed.

Acknowledgements

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