EFFECT OF TECHNOLOGY-DRIVEN PRODUCTS IN THE FUTURE OF PRODUCT DESIGN AND DEVELOPMENT

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Abstract

Recent products tend to incorporate multiple functionalities, embedded electronics or multifunctional behavior. The trend has been to increase the number of features available in a single product. The increasing availability and decreasing price of circuitry facilitate these "advanced products".

However, this trend has its downside. Many users do not take advantage of most of the product features, some users do not realize the entire range of functionalities in products they purchased, and often users cannot even keep up with the complex features that keep being added to products, often causing frustration or incorrect usage.

We argue in this paper that this effect results from natural competition, due to the need of providing differentiating products. This trend has resulted in specific product designs that allow users to interact with all available functionalities. Moreover, we argue this trend will necessarily reach a threshold when a reversed effect might be observed and where the majority of users will demand a simple and effective "basic product" with multiple add-ons, following a modular product architecture philosophy, and which will create entirely different needs in terms of product design.

In this paper we discuss what that change may imply and which type of product architectures offer competitive advantages for such solutions.

Introduction

It is widely accepted that contemporary technological developments have lead to fundamental changes in production processes. These changes are stated as revolutionary, resulting in a transition from industrial to post-industrial stage [1, 2]. According to Schmid [3], digitization of information and availability of new media such as the Internet, personal computers and digital communication devices, lead to highly flexible technologies and fast dissemination of knowledge and flow of information, thus altering at a fundamental level both manufacturing and design processes. In this arduous environment, firms aim at utilizing available technology in novel ways to achieve competitive advantage in the global market.

Under contemporary market conditions, being the first to enter the market is crucial to maximize market share and achieve high profits. Evidently, firms compete with their rivals in a time-based context, as competition mostly relies on fast development of novel products [4, 5]. One of the preliminary outcomes of the increased competition and rapidly changing market structure is the shortening of product life cycles and development processes [6].

Another fundamental determinant of a company's success in the contemporary market is innovativeness, or the capability to innovate. The time pressure on production processes forces companies to find new ways to increase their market share through the introduction of novel products and services.

Innovativeness has turned out to be a target feature, as innovative companies can increase their sales more than rival corporations, resulting in a "lucrative business" [7].

As firms are urged to continuously introduce novel products in the market in order to remain competitive, they attempt to direct consumer demands towards their path of continuous innovativeness. Therefore, a product's obsolescence is mostly reliant on the introduction of goods with new features, rather than its inadequacy to perform a certain task. The concept of developing products that meet minimum specifications has long been abandoned, in favor of products that offer customers what *they know they want* plus what they *should want* but do not yet realize it. The speed of technological change is stated as a dominant factor on the length of product life-cycles, as newly introduced technologies fade current ones [7].

Therefore, technological change is seen as a potential to increase the competitiveness of products in the market. Norman [p.ix in 5] argues that "each successive new product boasts of improved technology: faster, more powerful, better

this, better that. Technology rules the day, guided by feature-driven marketing".

Progressively, computing systems entered into everyday use, both by software companies that went into the consumer market and by the existing companies, which integrated novel technologies into their products in widespread use [5, 8]. The continuous decrease of the cost per function ratio of integrated circuits, the pervasiveness of microprocessors in consumer products, such as domestic appliances [9], and the tendency towards miniaturization of devices, have all played a significant role in product development (mostly) over the past three decades.

It can be said that products are designed as "solutions in search of problems", pushed by companies onto the market and marketed through great commercialization to create demand [10]. However, technological change is actually faster than changes in consumer demand, which implies that, market changes operate as a 'supply-driven', rather than a 'demand-driven', process.

In high-tech markets, the main drive that directs novelties is stated as 'technology-push'. Thus, the firm begins the product development process "with a new proprietary technology and looks for an appropriate market in which to apply this technology" [11]. Nevertheless, the phenomenon has evident effects on the way technology is integrated in products, which may be an overriding cause to complexity of products.

According to Norman [p.4 in 5], the prevailing complexity of high-tech products is a consequence of the developments with "technology for technology's sake" approach by which "the real needs of consumers are ignored".

For instance, Hennemann [12] states that, in a typical product development process, technology-driven view is admitted, thus, users are not considered as components of the system. According to Sade [p.65 in 13], "In spite of today's user-centered design philosophy, it is obvious that many products are designed in a machine-centered atmosphere".

Limitations arising from current trends

The aforementioned developments in digital technology, and the way it is utilized by companies in the consumer market to increase their sales, evidently altered content and use of everyday products.

Users demand more and more from the products, as they realize that technology is transforming the way they interact with other people and with their surroundings. It should be obvious from the previous discussions that this increasing demand is mostly created and promoted by companies, and users are educated to *be aware* of new needs and to accept new solutions offered by products. Nevertheless, every day there are more consumer goods in the market embedded with new technology, transforming the away we see products and their role in our lives and in society. The current trends have transformed simple products into hybrid-products, in many cases with very good acceptance by the market and the general public (e.g., mobile phones with digital photo cameras) although some of the embedded features are actually not comparable with the 'standard' product alone.

Evidently this advent of increasing introduction of technology into products is not seen in the same way for all the products and all their features. Although people now know the meaning of the word *interaction* and, in some cases, are even aware of its importance and benefits, in other cases the complexity of theses new products are overwhelming for the typical user.

As products get smaller and more often integrate multipurpose functionalities, most of these features are not providing additional satisfaction or benefit to users, but rather result in frustration. In many *supposedly* product upgrades, the value of products thus decreases, rather than increase.

One of the main reason is that these products are based on the assumption that they provide an advantage by including multiple features which broaden the tasks performed by that product, even though, most of these features remain ever unused [14]. As stated by Norman [p.229 in 5], a reason people feel frustration and estrangement towards technology is because technology is evolving by "pushing ever harder to newer, faster, and more powerful systems, with nary a moment to rest, contemplate, and reflect upon why, how and for whom all this energy has been expanded".

Users have different needs and different understanding of the products, independently of the embedded technology. Because of this, many users are facing problems in dealing with this type of products, as the utilization of technological advances to produce superior products is being conducted without considering users' requirements and limitations in use [13].

Therefore, it can be stated that a technology-driven design approach has considerable implications on the emergence of usability problems. This issue is discussed in more detail in the next chapter.

Role of complexity on usability

Implementation of electronic components or systems into consumer products has altered user-product interaction patterns through its impact on

the product's function content. As previously stated, new technology provides flexibility, which opens the way to the integration of more features into a single product. However, the increased complexity of the interaction can induce problems in use. This is because "in spite of today's user-centered design philosophy, it is obvious that many products are designed in a machine-centered atmosphere" [p.65 in 14]. Cooper [p.33 in 15] claims how users respond to complicated products that include multiple features as, "They take the minimum they need from it and ignore the rest. Each user learns the smallest set of features that needs to get his work done, and he abandons the rest". In other words, users attempt to simplify the use of the products by purposefully ignoring some (or in many case, most) of the product's features.

A market-research study conducted in the United States of America [16] indicated that Americans have to devote approximately 43% percent of the time they spend with newly purchased electronic appliances in finding out how they work. Even with such time investment, the number of people who actually figure out all the functions is extremely low. Moreover, according to the same study, these people only take advantage of 35% of the technology integrated in these appliances.

One common view regarding this type of phenomena is that problems in user's understanding of the devices are mainly due to the invisibility of the functional processes to the user, in general terms. According to Cooper [15], as the functioning of mechanical devices is based on physical principles and their interactions allow relatively limited functionalities, even if they are difficult to use, they rarely cause misinterpretations. On the other hand, the mechanisms of high-tech products with embedded electronics can be digital or at the microscale, which leads to interfaces that do not "foster a coherent conceptual model" and do not make "the functionality apparent and comprehensible" [p.1159 in 17].

Discussion

It is evident that the compatibility between the mechanisms for user understanding of a device with the product's form and function deserves particular emphasis in the product design process. As pointed out before, in high-tech markets, novelties are driven, in fact pushed, by technological developments.

This kind of procedure - putting the technology first - has resulted in most consumers/users not being able to have a complete understanding of the products. As products get more complex and integrate more functionalities, their form and user interface are evidently affected.

A similar statement is also given by Asatekin [18], stating that a reliable product should communicate itself to the user "*with its shape as a whole and with its smaller parts*". In practical terms, he suggests that the product shape should encompass pointers to its functions, so that users clearly understand how it will operate simply by looking at it.

Any extra features that extend beyond user needs will result in efficiency problems and poorer interaction, as each added feature requires a new control, display, button or instruction. All these will inevitably complicate its use.

The connection between the continuously evolving high-tech products, their multi-funcional character, and the future products arquitectures that can match real customer wants, are discussed in the following sections.

Achieving customer needs for product customization through decomposition

In the markets in which these companies operate, political and economic factors have resulted in a combination of increased affluence of the individual and a human vanity that has developed a lack of tolerance to mass produced *generic* products and has stimulated a demand for customized products [19].

Combined with technological advancements, this inevitably had to result in the everlasting evolution of the appearance of products and their features. The obvious impact of that on the product development process has already been discussed. According to Bergman [20], "new products will be developed from outside in, instead of from inside out". In practical terms, this implies that the core of the product's function, that is the user interface, has to be designed first before the hardware and software that will support those functions.

The user interface needs to meet user expectations, while simultaneously delivering all the available functions in a simple and effective way. It is vital to create synergic links between the physical product and its digital functions. In other words, the physical product must improve usability and understanding of the digital functions, while the digital functions must maximize the quality of the user's experience. In the end, there must be recognizable associations between the product's functions and the user's recognition of them.

Modularization is an approach to product development where the different functions featured by a product are achieved by different and (as much as possible) independent physical components [21]. More than that, the interfaces between the different physical components are

achieved by following a set of interface standards that ensure seamless links between them. The importance of standardization in modular design must be emphasized. Modular design is in contrast to integral design, an approach where a single component may feature several functions, and where each function may be ensured by several components. In integral design, the interfaces between components are tailored specifically for that product and create a interdependence between the different components. Conversely, in modular design, the independence between the different components means that it is possible to adapt/improve a function with very little impact on other functions.

Modular product design thus intends to reduce complexity in product design by featuring a set of self-supporting independent sub-systems of components. If adequately explored, this can reduce uncertainty and improve user interaction with the product [21]. However, the implementation of modular design requires careful planning. It is necessary to perform total product decomposition, both physical and functional, before moving into the design stage (and defiantly before component selection). If decomposition is not adequately performed at that early stage, the functions will most likely not be correctly delivered and a significant re-design may be needed later on.

Reversing the trend towards increasing integral multi-functionality

As previously stated, products are incorporating more integrated features and multi-functional purpose, despite the problems arising from that trend. On one hand, as the number of functions embodied in a device increases, the conceptual model of the device operation becomes more complicated. On the other hand, as the number of steps to achieve an end goal in the interaction process increases, the amount of information that the user is required to remember increases as well, hindering easy interpretation of the conceptual model of the product.

Nevertheless, some companies are facing these problems through innovative 'technological products' with the user in the center of the development process. One of the best examples of this is the extremely popular product named IPOD (which spawned a large number of copies and variations, none achieving the success of the original).

One of the main aspects that make the IPOD so interesting is that its broad acceptance by the market has made Apple maintain this popular product and its interface essentially unaltered. Its 6 versions since October 2001 (the most recent to date on September 2007) have featured increasing storage capacity, integration of the buttons into the control wheel and minor modifications to the housing design.

Although more and more features appear every day to expand the capabilities of the IPOD, none of these new features is integrated into the product itself. They are available as add-on products that connect seamlessly to the IPOD through firewire or USB connections. Users can make these additional features available by buying the specific add-on products that they desire. The overall benefits are that users can customize their products (with additional technology) as they feel the need, while the basic way they interact with the product remains unaffected.

Modular product architecture requirements for future products

As the discussion in the previous section clearly shows, it is possible to have products offering a wide scope of features and functionalities, without having to increase their complexity to unfriendly levels. One of the solutions is to have a core product to which many other add-on products can be coupled. The add-ons may provide new functions, such as speaker sound, holographic projections, or Bluetooth communication, or it may provide enhancements to already existing features, such as increased data storage.

It is vital that the core product contains in itself the essential features that will be of interest to the vast majority of users, so it can still be used as a stand-alone product. It also needs to exhibit a simple, user-friendly, and more important than anything else, expandable user interface. This core product thus promotes the development of add-on applications, in a way that does not complicate user interaction even when a very large number of add-ons are used.

This also paves the way for new businesses to be created around the core product, with companies coming up with new features that may be of interest to a meaningful group of users. The add-on products must be developed so they are synergic to the core product, without replicating its essential features in an attempt to usurp its place in the market, in fact mimicking what is observed in many natural ecosystems.

Finally, the core product must be developed following a modular design approach so that interfaces with the add-on products are seamless. The interfaces must require no special technology, nor can they demand any complex or lengthy operation by the user.

Conclusions

The current trend observed in technological products of integrating more features into a single product is not sustainable as it leads to increased complexity inducing user frustration. Moreover, most users dislike being forced to purchase features they do not feel they need. This is represented, in qualitative terms, in Figure 1.

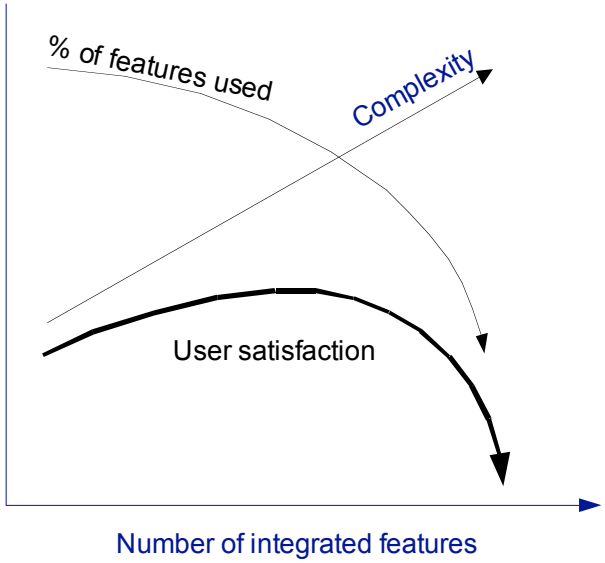

Figure 1. Qualitative evolution of different parameters with the increasing number of features integrated into a single product.

Thus, we strongly believe that future products will tend towards modular architectures, with families of core products and add-ons products, enabling users to customize them as needed/wanted. This will require careful physical decomposition and functional decomposition of product specifications during the early stages of the design process. It will also demand a much stronger effort than is currently typical in the development of interfaces, with a focus on allowing new features from add-on products to be added seamlessly to the interface without complicating its use.

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Keywords

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