IGNORING USER-CENTERED NEEDS: ADDRESSING THE FACTORS THAT ALLOW MULTI-FUNCTION AND MULTI-PURPOSE PRODUCT PROLIFERATION

A Thesis

Presented in Partial fulfillment of the Requirements for

the Degree Master of Fine Arts in the

Graduate School of The Ohio State University

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ABSTRACT

By combining different products into one or adding functions to an existing product, most companies believe it is a convenient way to increase product compatibility in the market. The ease of companies to extend the laundry list of functions or increased computational power is even more prevalent with ubiquitous circuitry and interfaces. Users with the attitude that more is better, see these 'developments' as improvements. Superficially, developing multi-purpose products is a win-win solution. However, the investigation shows a significant gulf between the functions in mobile phones and the functions used.

Companies keep producing complex, hard-to-use multi-purpose products with useless functions which are already far beyond most users' needs and capabilities to manipulate. This study will utilize multi-purpose mobile phones as an example to investigate ways to increase product design usability.
By recognizing that user-centered design becomes diluted through a range of compromises, this research will highlight the issues and areas that generate this vicious cycle. This study will apply previous knowledge and understand this phenomenon from various perspectives, such as user-centered design, psychology, and business. Further, possible solutions will be proposed based on the discoveries.
Dedicated to my dear parents
&
Chao-Feng
ACKNOWLEDGMENTS

I would like to thank my advisor Wayne Chung for his enthusiasm and guide which leads me through my graduate studies. I won’t be able to finish this thesis without him.

I would also like to thank Dr. Elizabeth B.-N. Sanders, PhD for her valuable support and critique during the process.

I would like to acknowledge Dr. Phil Smith for his professional input for the thesis.

I thank my friends who ever support me and help me in the two years’ study.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Dedication</td>
<td>iii</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>iv</td>
</tr>
<tr>
<td>Vita</td>
<td>v</td>
</tr>
<tr>
<td>List of Figures</td>
<td>viii</td>
</tr>
<tr>
<td>List of Diagrams</td>
<td>ix</td>
</tr>
<tr>
<td>Chapters:</td>
<td></td>
</tr>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>2. Products</td>
<td>3</td>
</tr>
<tr>
<td>2.1. Single-Function, Multi-Function, Single-Purpose, &amp; Multi-Purpose...</td>
<td>3</td>
</tr>
<tr>
<td>2.2. Why do we create MPP?</td>
<td>5</td>
</tr>
<tr>
<td>2.2.1. The Belief in Numbers</td>
<td>5</td>
</tr>
<tr>
<td>2.2.2. Technology Fairy Tales</td>
<td>6</td>
</tr>
<tr>
<td>2.2.3. Technology Over Used</td>
<td>6</td>
</tr>
<tr>
<td>2.2.4. Competition between Companies</td>
<td>10</td>
</tr>
<tr>
<td>2.2.5. Designer’s trap</td>
<td>10</td>
</tr>
<tr>
<td>2.2.6. Consumer’s Culture</td>
<td>11</td>
</tr>
</tbody>
</table>
2.3. The Advantages & Disadvantages of Multi-Function, Multi-Purpose Products

2.3.1. Advantages

2.3.1.1. Advantage to the Companies

2.3.1.2. Advantage to the Consumers

2.3.2. Shifted Values

2.3.3. Disadvantages

2.3.3.1. Challenges To Company

2.3.3.2. Use Experience To Users

2.3.3.2.1. Feature Overloaded

2.3.3.2.2. Cognitive Friction

2.4. Why improve? & How to improve our conditions?

3. Users

3.1. Understanding User's Needs

3.1.1. Users in Numbers

3.1.2. Users through Observation, and Discussion

3.1.3. Users in Design

3.1.4. Let users speak for themselves

3.2. Understanding How User's Experiences Affect Human-Artifact Interaction

3.2.1. Simplified Product Using Experience Model

3.2.2. First Phase: Search and Select

3.2.3. Second Phase: Using Artifacts

3.2.4. Third Phase: Reflect and Memorize

3.3. Example of Product Use Experience Model

3.4. Product Use Experience to Companies

4. Make Multi-Purpose Product Easier to Learn and to Use

4.1. Human Learning

4.1.1. Habits

4.1.2. The anchoring adjustment heuristic
4.1.3. Schema ................................................................. 35
4.2. Reduce Users Frustration .............................................. 36
   4.2.1. Avoidance Behavior ........................................... 39
   4.2.2. Learned helplessness ......................................... 40
4.3. Consistency ............................................................. 40
   4.3.1. Match Prior Experience and Knowledge ...................... 42
       4.3.1.1. Mental Model ........................................... 42
4.4. Memory Cue .......................................................... 43
   4.4.1. Visual Cue .................................................... 46
       4.4.1.1. Component Model .................................... 46
       4.4.1.2. Prototype theory .................................... 47
   4.4.2. Motion, Posture, Gesture Cue ............................... 48
   4.4.3. Correlation Cue ............................................. 49
4.5. Gestalt Principles & Visual Communication Design Elements .... 50
4.6. Mental Map and Structure ......................................... 51
   4.6.1. Transition .................................................. 53
   4.6.2. Automation and Adjustment ................................ 53
4.7. Examples .................................................................. 55

5. Evaluation .................................................................. 58
   5.1. Company Evaluation .............................................. 58
       5.1.1. Return of Investment .................................... 58
       5.1.2. Re-Visiting, Re-Using, & Re-Purchasing Rate .......... 59
   5.2. Design Evaluation ............................................... 59

6. Conclusion ............................................................. 61

Appendix A ................................................................. 62

Bibliography ............................................................... 64
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1 – Traditional North American style refrigerator</td>
<td>4</td>
</tr>
<tr>
<td>Figure 2 – Net refrigerator from Teco Electric &amp; Machinery Corp.</td>
<td>4</td>
</tr>
<tr>
<td>Figure 3 – U-shape curve of complexity</td>
<td>7</td>
</tr>
<tr>
<td>Figure 4 – Old Radio</td>
<td>9</td>
</tr>
<tr>
<td>Figure 5 – Old style table radios</td>
<td>9</td>
</tr>
<tr>
<td>Figure 6 – AM/FM/TV Portable Radios</td>
<td>9</td>
</tr>
<tr>
<td>Figure 7 – Phillips Stark designed Radio “Poe”</td>
<td>9</td>
</tr>
<tr>
<td>Figure 8 – Telephone/AM/FM/Clock /CD Player</td>
<td>10</td>
</tr>
<tr>
<td>Figure 9 – advertisement from Palm</td>
<td>16</td>
</tr>
<tr>
<td>Figure 10 – an example made by model making tools</td>
<td>25</td>
</tr>
<tr>
<td>Figure 11 – Two different phones’ cancel key is on different side</td>
<td>35</td>
</tr>
<tr>
<td>Figure 12 – two different generation’s Nokia cell phones</td>
<td>42</td>
</tr>
<tr>
<td>Figure 13 Component Model theory</td>
<td>47</td>
</tr>
</tbody>
</table>
Figure 14 — a shadow from an animal.........................................................48

Figure 15 — posture and gesture.................................................................49

Figure 16 — posture and gesture when people using products....................49

Figure 17 — Heater’s interface concept from Axis.......................................50

Figure 18 — keyboard with color keys .......................................................51

Figure 19 — keyboard with color keys.......................................................51

Figure 20 — Site map..................................................................................52

Figure 21 — Screen shot from Nokia’s cell phone.......................................52

Figure 22 — level of automaticity ...............................................................54

Figure 23: Palm Zire71 in PDA mode (front & rear view) .........................55

Figure 24: Palm Zire71 in Camera mode (front & rear view) ....................55

Figure 25: Sony SO505i in cell phone & PDA mode ................................56

Figure 26: Sony SO505i camera in close mode .........................................56

Figure 27: Sony SO505i camera in open mode .........................................56

Figure 28: Sony SO505i uses as camera mode .........................................57
# List of Diagrams

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagram 1 – Simplified Product Using Experience Model</td>
<td>26</td>
</tr>
<tr>
<td>Diagram 2 – First Phase: Search and Select</td>
<td>28</td>
</tr>
<tr>
<td>Diagram 3 – Second Phase: Using Artifacts</td>
<td>29</td>
</tr>
<tr>
<td>Diagram 4 – Third Phase: Reflect and Memorize</td>
<td>31</td>
</tr>
<tr>
<td>Diagram 5 – Example of First Phase: Search and Select</td>
<td>32</td>
</tr>
<tr>
<td>Diagram 6 – Example of Second Phase: Using Artifacts</td>
<td>33</td>
</tr>
</tbody>
</table>

xii
CHAPTER 1

INTRODUCTION

The evolution of products has evolved as a result of the Industrial Revolution and the Information Revolution. The Industrial Revolution saw the extension of the human capabilities increase in power, speed, and certain scales of efficiencies through mechanical devices. Many of these products and mechanical systems afforded increased physical capabilities. The Information Revolution brought a different potential to the humankind. By harnessing electrical circuitry, microchips, and computer processors, humankind’s psychological capabilities have been extended in new and different ways. The capability to store and retrieve data, capture images, and communicate through various mediums is some of the unique capabilities that have been achieved.

Many of the Industrial Revolution’s product design were inherently intuitive. This was a result of the immediate feedback intrinsically born into a physical object. The nature of manipulating a product or part of the product created a very understandable mental model of action – reaction. There are incalculable benefits from the Information
Revolution. However, specific issues continue to prevail with the proliferation of multi-use products. Dr. Donald Norman classifies this phenomenon as Creeping Featurism. We need extensive Excel charts or visual aids just to categorize the excess specifications to compare one item to another. The culprits consist of the cell phone-camera-calculators or the PDA-MP3-email-organizers or the microwave-web browser-entertainment appliances. These are just a few of many growing product lines that have been married together because of good intentions, poor judgment, or a combination of reasons. Regardless of the corporate decisions, the result is a poor product interaction experience.

The goal of this paper is to provide product interface/interaction design principles for industrial and product interface designers. The principles are created based on product using experience model which is built to explain how important product interface is, how the interface impacts interaction experience, how the experience impacts on the product itself and the company, and where product interface designers can have influence. To establish the model, various domain knowledge and methods are adopted. Through the problems caused by MPP understand the ways product using experience impact product, its brand, and company.
CHAPTER 2

PRODUCTS

2.1. Single-Function, Multi-Function, Single-Purpose, & Multi-Purposes

The function of a product can be defined as: the useful things that it does. And a product's purpose can be defined as: the reason for which it is made or done.

Each product has at least a function and a purpose, such as pencils, glasses, and typewriters. Some products are created for a purpose and add several task-related functions to enhance the intentional task. For example, a North American's refrigerator's major purpose is to keep a large amount of foods cold and fresh. The addition of icemaker, adjustable shelves, and other design elements are the functions that make the major purpose, keep foods cold and fresh, more convenient and easier to achieve. (Figure 1)
MPPs (MPP) are the products combining several different purposes. And each purpose may come with several functions. Most of the MPPs are extended from multi-function products. Using the refrigerator as an example, today’s companies combine a computer with the refrigerator to create a “net-refrigerator.” This allows the
ability to check email, get online recipes play music, take picture and so on. The main purpose to keep food fresh is extended. The refrigerator becomes a communication and entertainment center too. (Figure 2)

2.2. Why do we create MPP?

Much of product design, interface design, and business decisions are made separately. This lack of integration leads to poor overall product interaction experiences. And because of this history, users are used to living and accepting difficult interface interaction.

2.2.1. The Belief in Numbers

The numeral system is a widely used representation tool in our daily life. Science further establishes the unshakable status of the numeral system in terms of its objectivity. As educated by science, the numeral system’s authoritativeness is deep-rooted in our mind and becomes one of the scales which helps us to make judgments. Therefore, through the representation of numbers, such as numbers of functions and purposes, companies can easily convince consumers their products have more value than others.
2.2.2. Technology Fairy Tales

Technology fairy tales is an illusion companies create for consumers. By presenting scenarios through short films or advertisements, the companies demonstrate how more technology in a consumer’s life can supposedly improve it. Characters in such scenarios have the ideal life just like prince and princess having happy life in most of the fairy tales. NTT DoComo’s “Vision 2010” short film series (http://www.nttdocomo.com/vision2010/) are the good examples.

Through technology fairy tales, companies can make consumers believe technology can make their life better. This creates false justification for consumers to pay more for products with more functions and advanced technologies that they may not use.

2.2.3. Technology Over Used

“The same technology that simplifies life by providing more functions in each device also complicates life by making the device harder to learn, harder to use. This is the paradox of technology” (Norman, 1999, p31)

“Technology is a queer thing. It brings you great gifts with one hand, and it stabs you in
the back with the other.” – C.P. Snow (Raskin, 2000)

Norman (1999, p.30) observed that the development of a technology tends to follow a U-shaped curve of complexity (figure 3). It begins at a high level of complexity. With the demand of market, the technology’s complexity drops to a low, comfortable level. However, ironically due to companies’ competition, the complexity climbs again. Here is an example about the radio’s evolution.

![U-shape curve of complexity](image)

Figure 3 – U-shape curve of complexity (Norman, 1999)

At the earlier phase of radio evolution, a radio is hard to install and complex to use (see figure 4). The product was so new that only a few people could understand and know how to use it. Most of the technologies in this phase are not user-friendly. The main selling point was it’s ‘newness’. Progressively, cheaper, easier to handle, and smaller
models came to the market (see figure 5 and 6). During this phase, products compete with each other by providing more enhanced functions such as digital tuning, station shortcuts, or miniaturization of the components. These convenient functions all served for one purpose – let users listen to the radio conveniently.

After the technology was widely spread, most radios have similar functions and are very affordable. The product’s profit drops down because of the level competition. New values need to be added to attract potential buyers. For this reason, some companies add value by using different styles, material, or color to the products (figure 7). However, many companies believe that they can attract more customers by combining several products into one (figure 8). This is seen as increasing the products power, capability, and convenience. Nevertheless, this kind of MPP’s functions share the same interface with each other. This exponentially increases the product’s complexity, and decreases its usability and reliability and overall positive user experience.
Figure 4 – Old Radio

Figure 5 – Old style table radios

Figure 6 – AM/FM/TV Portable Radios

Figure 7 – Phillips Stark designed Radio “Poe”
2.2.4. Competition Between Companies

Clearly, one of the major reasons that MPP has been created is competition between companies. To increase product’s market value, companies use various ways. Some of them through quality controlling, some through changing appearance, and some through reduce cost. Nevertheless, one of the most adopted ways is adding function into product and the result is today’s MPP.

2.2.5. Designer’s trap

Designer plays an important role between product and its users. Designers not only create the product’s appearance but also influence the way users use the product. However, in order to achieve a company’s and designer’s personal goals, designers tend to fall into following traps without awareness.
2.2.5.1. A designer’s contribution is hard to measure for companies. Therefore, companies tend to use design awards to evaluate design quality. However, product designers and design awards’ judges sometimes do not take into account actual product use or users. They are judged by their profession rather than from the product’s use experience, a true user’s point of view, and prolonged testing of the product through its life cycle.

2.2.5.2. Belief in innovation: no need for reticence, innovation is one of the most critical values to designers. However, product interface innovation may not help users use the product well. Because newness and change is seen as a function of design, it is seen as improving the chances for recognition and possible awards.

2.2.6. Consumer’s Culture

It is the nature for consumers to spend less money for more functions when they are purchasing products. This mentality is reinforced by many of the previous concepts. Nevertheless, many consumers do not think far for the future when they are purchasing products.

For instance, when purchasing printers, most of consumers will compare each brand’s
price and printer performance. Yet printer cartridge’s price is rarely considered. Thus, companies sell their printers at a cheaper price to attract consumers. This technique allows companies a constant revenue stream on products that need ‘feeding’ and maintenance.

2.3. The Advantages & Disadvantages of Multi-Function, Multi-Purpose Products

2.3.1. Advantages

Basically, MPP is a win-win solution to both consumers and companies. To the companies, MPPs reduce total cost and enhance the product’s competitiveness in the market. To the consumers, MPPs let them spend less money and get more functions. However, actual use and experience is compromised.

2.3.1.1. Advantage to the Companies

Since the information revolution, semiconductor chips and programs are widely used in various products. Through integrating computing power into products, products get brains which could let products provide more accurate information, execute simple actions, and so on. By programming into system embedded products, adding functions is
much easier and cheaper. Second, combining semiconductor and software code’s low-cost replicate attributes, companies can save a huge sum of manufacturing costs and add functions easily and relatively quickly. These reasons increase MPP’s existence value and competitiveness in the mass market.

2.3.1.2. Advantage to the Consumers

Multi-purpose, multi-function products let consumers spend less money while having more functions in one product. Second, MPPs combines several different products into one, making the product become smaller and lighter. This is seen as a desirable attribute, especially important to urban residents and early-adopters of technology. Third, because of the combination, users don’t need to worry about platform exchange problems. For instance, users don’t need to prepare different batteries, power adapters, or expansion memory for different products.

2.3.2. Shifted Values

Indisputably, most users will compare products before purchasing. The products may be compared by price, product’s specification, style, brand, and so on. Nowadays, the
comparison can be done much easier than before with the help of internet. These
so-called “market values” are established by comparing other products and each feature.
From advertisements and internet formats, it is obvious that this is one of the leading
ways companies compete. However, this competition tends to lead company into endless
vicious cycle of competition and it does not create a good product using experience for
users, nor help companies be profitable.
After a product has been purchased, the product’s value changes. Its price, number of
functions, and values are not as important to the user at the time of comparison or sale.
Instead, the ease of use, product reliability, ease of maintaining, customer service, and
other product-using values become more critical to users.
Two major latent issues need to be taken care of during the shift from the product’s
purchasing to using. First, the person buying the product may not be the one using the
product. This issue has been recognized and widely discussed in many other product
design, software design, and interface design journals and books. Hence, the importance
of this issue is significant.
Second, a product’s use value is not typically addressed. Most of MPP’s design,
manufacturing, and marketing resources are used to increase the product’s short-term
market value rather than product’s long-term use value.

User-experience specialists Garrett (2003) addressed the biggest reason why user experiences should matter to a company. If the company doesn’t provide customers with a positive experience, customers will not use or purchase the company’s product. Most major dot-com companies, such as Amazon.com and Dell.com, recognize this fact and invest significant amount of money to continuously improve their website’s using experience. However, it has been observed that only a few companies notice the importance of product-using experience.

Most of MPPs compete with each other at a product’s market value rather than on a use value. Consumers may be attracted by a long list of functions or a good price. However, after they have purchased the product, the complexity of the product and other product using related issues surface. Providing customer technical support to help users should not be the first choice. Companies should invest in understanding good product using experiences should be the primary goal of the product. To do this, understanding a target user’s need and capabilities is essential to designing appropriate product interface and interactions.
Figure 9 – advertisement from Palm which addresses on the mount of features the device has

2.3.3. Disadvantages

MPPs have advantages in price and efficacy. However, it also brings a lot of overt and covert problems. The most serious one is the inconvenience and difficulties of using the product. Over time, the negative product using experience can be the invisible killer of the company’s brand and profitability.

2.3.3.1. Challenges To Company

Compared to other products, the MPP is a high-risk investment. It needs huge quantities
to balance the investment. Its product life cycle is around one quarter to two years. Its design and development is very complex.

Nevertheless, to balance among user’s needs, cost, product functions, production time and competitor’s products is a daunting task. We have seen many good products fail in the mass market due to the inability to balance the complex variables. Any one of these factors may cause a MPP’s totally failure in the market.

2.3.3.2. Use Experience To Users

MPPs attract buyers by its powerful and numerous functions. However, if companies do not design and integrate the interface well, the complexity of the product can easily cause a negative product use experience.

2.3.3.2.1. Feature Overloaded

Many journals and magazines (appendix A) pointed out MPPs are feature-overloaded. Dr. Norman called this phenomenon as “creeping featurism” (Norman, 1988) or “rampant featurism” (Norman, 1999). Elimination or removal of multi-purpose or multi-function products is impossible. Rather it is the understanding of the target users’ capabilities,
actual needs, and long-term use that is important to the success of a product and creating a good user experience. This statement is even more critical when combining functions and purposes amongst products.

2.3.3.2.2. Cognitive Friction

The term cognitive friction is proposed and defined by Cooper (1999):

*Cognitive friction is the resistance encountered by a human intellect when it engages with a complex system of rules that change as the problem permutes.*

A mechanical product during the industrial age caused less cognitive friction, because its mechanism was inherently intuitive. Manipulation of parts or the product resulted in easier predictions of action/reaction. This allowed for a direct and accurate mental model of the object and user interaction in the environment or world. On the other hand, most products in the information age is powered and actuated by programmed chips. Therefore, users need to understand how products work through testing and observing a products’ interface. Comparatively, an interface’s feedback can be limiting. The type and amount of information and communication between a user and a product interface can create cognitive loading when they are attempting to complete a task.
2.4. Why improve? & How to improve our conditions?

Providing the functions and making it work properly is not enough for products. Cooper (1999) gives an interesting analogy:

*If you are stranded on a deserted island, you don't care much that your rescue ship is a leaky, rat-infested hulk. The difference between having a software solution for the problem and not having any solution is so great that we accept any hardship or difficulty that the solution might force on us.*

In the future, MPP’s competition will not merely compete in market values. But by establishing entire product using experiences, MPPs can create higher profit, have longer product life cycles, and increase repurchasing rates. All these issues naturally reduce a companies’ investment risk. Some companies provide technical support and product warranties to enhance a product using experience after the consumers have purchased their products. Some companies go one step further by establishing companies’ brand image as additional value. However, the most direct manner of maintaining a consumer is a concerted effort to creating appropriate product interface and interaction. This directly and indirectly influences users’ impression to the product, the brand, and the company. Most dot com companies understand the importance of their website’s interface. If they
cannot make web users feel satisfied while they using the website, users will leave immediately and may not come back again. A good using experience needs tremendous effort to establish, but they are difficult to be substituted by others.

To understand target users’ needs and their physical/psychological capabilities is essential for a successful product interface.
CHAPTER 3

USERS

As mentioned before, this paper mainly focuses on human-artifact relationship. Since we discussed products in the earlier chapter, we come to discuss how human beings explore, interact, and learn to use products. In order to know what human beings experience when using multi-function, multi-purpose, and hybrid products, it is important to understand the human being’s capabilities and limitations.

Understanding users is always a difficult but necessary task to most designers. Through demographics, statistics, interviews, focus groups, etc., and the methods we adopted from other disciplines, designers are eager to learn more about users through different perspectives in order to better our designs. However, in the market, inappropriate designed products still can be seen from time to time.

Inappropriately designed products make users feel frustrated, uncomfortable, and even cause unintentional errors. Most of the times, the products may not cause any physical or psychological trauma. Nevertheless, negative impressions of the product, the
brand, and even the company are imprinted in the users’ memory.

These flaws affect the product using experience. Most of these happened due to insufficient understanding of both the target user group and the technology capability demands.

Most of time, the information of technology capability demands and limitations could be easily learned or found through various channels. On the contrary, target users’ information is relatively harder to retrieve. It is more dynamic and abstract. Due to context, such as time, space, culture, age, and so on, users’ traits are different from each other. However, we human beings still share common attributes across time and space.

Human beings are not like machines or computers. Machines and computers can improve performance by changing or adding components. On the contrary, human beings are different. At least until now, we cannot run faster or jump higher by changing our legs, store more information or learn quicker by adding something into our brain. However, we can solve problems creatively with new strategies, improvised methods, and other creative manners. But most importantly, we have emotion which machines and computers do not have.

To overcome our biological and mental limitations, we invent tools, such as machines
and computers, to enhance our capability. Since these tools are invented and designed for people to use, the human being's limitations and capabilities should be considered and understood holistically. Understanding human beings holistically is a tough and impossible task. Therefore, examining human beings from as many perspectives as possible is needed.

3.1. Understanding User's Needs

3.1.1. Users in Numbers

The easiest way to understand user's needs is through numbers. All kinds of surveys and demographics are the most common methods we are using today. These methods can help to artificially quantify certain users' needs. Nonetheless, numerical data may give misleading information.

3.1.2. Users through Observation, and Discussion

Interviews, focus groups, and shadowing are widely accepted research methods for companies. Through these methods, companies can closely watch and listen to what users do in their daily life. In some cases, researchers will focus on particular tasks or habits
for improving particular conditions or products. In a general sense, companies try to predict and decipher users' needs through analyzing collected data.

3.1.3. Users in Design

Personas and scenarios are well known methods to industrial designers. A persona is a representation of an ideal person who symbolizes a target group. This persona is generalized from a designer's observations, interviews, and other collected data. A scenario is a narrative method which designers use to reconstruct a product use context. Designers employ both of the methods together to highlight and discover a user's potential needs and product's problems. These methods are interesting to use and are very attractive to listeners. However, the scenario created by a designer's own wishful thinking tends to be quite subjective. It may cause a great gap between the user's real needs and capabilities.

3.1.4. Let users speak for themselves

What is a users' true need? The voice and preferences in a user's mind is very hard to discover. Surveys or interview methods are heavily relying on an observer's skill and a
participant’s willingness and truthfulness towards a particular situation. Through these methods, designers still cannot clearly understand what the user’s needs and actual capabilities. To solve this problem, Dr. Sanders establishes the “Do, Say, Make” method, which allows users to participate in the design process. Through story telling and expressive tools, such as drawing, collage, and Velcro model making and paper prototypes, a user’s need is clearly expressed by themselves. This method can allow researchers and designers a more direct understanding of a user’s needs, wants, thoughts, and capabilities. (see figure 10)

Figure 10 – an example made by model making tools
3.2. Understanding How User’s Experiences Affect Human-Artifact Interaction

3.2.1. Simplified Product Using Experience Model

![Diagram 1 – Simplified Product Using Experience Model](image)

3.2.2. First Phase: Search and Select

In the simplified product using experience model, we addressed how prior product using experiences influence users’ Searching, Comparing, and Selecting of artifacts for the task at first. Then in the second and third phase we attempt to explain how the Experience is created, intensified, and memorized when using and after using the product. Finally, the product using experience comes back and gives impact to the Compare and Select phase becoming a cycle once a new impact (need to accomplish a task) occurs.
Based on prior knowledge and context, the overall goal is divided into smaller tasks with task goals. According to the Task Goal, the situation at the moment, and the prior knowledge affects the task’s mental model. If the Task needs *artifacts involved, the subjects will start searching for it in the environment and cognitively retrieve prior knowledge simultaneously. The ability to help users identify artifacts’ purpose and functions becomes the fundamental issue for designers.

Followed by identifying potential artifacts, subjects begin to evaluate and compare them based on prior product using experiences and other factors, such as personal preferences and capabilities. At this moment, artifacts for the task have been chosen and prior product using experience has an impact on how users select artifacts.

*Artifacts we use here could be any kind of tools which expand human’s physical or mental capability.
Diagram 2 – First Phase: Search and Select

3.2.3. Second Phase: Using Artifacts

In the second phase of the model, how human-artifact-interaction influences the user’s using experience will be established.

After an artifact is selected, the subject shifts to the second phase Task Execution (see Diagram 3). Here the mental process splits into conscious and unconscious parts. In the conscious mental process, the subject focuses on the task itself such as the information needs to talk on a cell phone, or the information needs to write on a PDA.

In the unconscious mental process, the subject starts to recognize the artifact’s interface
through perception and memory systems. At this stage, the mental model of the artifact for the task is built. After interacting with the artifact based on the mental model, feedback from artifact occurs. If the feedback meets the subject’s expectations, the task can be easily accomplished. However, if the feedback does not meet the subject’s expectations, the subject may try to find another way to interact with the artifact. The subject will keep modifying their actions until they are mentally frustrated. At this point, the subject either gives up or looks for alternatives to solving the task. This incident and interaction between subject and artifact already causes *cognitive friction* (Cooper, 1999).

The subjects mental attention shifts from unconscious to conscious and the *flow* (Csikszentmihalyi, 1991) was broken.

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*Diagram 3 – Second Phase: Using Artifacts*
3.2.4. Third Phase: Reflect and Memorize

After the task (see Diagram 4), the whole experience is stored into LTM. If the task was accomplished fluently, the positive experience will be stored. Next time when a similar situation comes up, the chance for the subject to choose the artifact is increased. If the task was accomplished but the subject needs to make some adjustments during the interaction, the product using experience could be either positive or negative.

However, if the subject was unable to accomplish the task and gave up or looked for alternatives, it caused a significant negative experience. When the subject meets a similar task next time, there will arguably be less of a chance for the subject to choose the artifact.

This concise overview demonstrates how a product using experience influences a product’s selection and how human product interaction intensifies a product using experience. The value for companies to create positive product using experiences through good interaction design becomes obvious.
Diagram 4 – Third Phase: Reflect and Memorize

3.3. Example of Product Use Experience Model

In this section, we will create a scenario to explain the model.

Bob, the subject, purchased a couple books from Barnes and Noble (B&N) online. After he got the package, he did not like some of the books and wanted to return them (goal)(see Diagram 5). He starts planning the way to return these books (planning). He decides to contact the B&N customer service to find out their return policy and get information about nearby stores (task goal). He begins to think about what he should ask the agent. And he needs a tool to communicate with (task planning) the agent. He
searches the environment and thinks what tools he could possibly use (search for potential tools). His PDA has a wireless connection and a cell phone. However, he remembered last time when he tried to use the PDA to call his boss, the reception and overall communication was poor (prior experience). So he decides to use his cell phone instead (tool selected).

Diagram 5—Example of First Phase: Search and Select

He picks up the cell phone and starts dialing the numbers on the keypad (cell phone mental model). Unlike the last time he used his PDA, (feedback matches expectation),
this time he fluently contacts the B&N customer service and gets the needed information (feedback as expected and successfully accomplished the task).

Diagram 6– Example of Second Phase: Using Artifacts

3.4. Product Use Experience to Companies

From the model, we can clearly understand how the product use experience impacts the user’s impression. Prior experiences affect future selections of product, system, brand, and company. A good product use experience relies greatly on the interaction with the product. Although companies can provide customer service and technical support as remedial measures, good product interaction experience is omnipotent.
CHAPTER 4

MAKE MPP EASIER TO LEARN AND TO USE

4.1. Human Learning

4.1.1. Habits

"The simplest of all forms of learning is habituation, a decline in the tendency to respond to stimuli that have become familiar through repeated exposure. In habituation the organism learns that it has encountered a stimulus before. " (Gleitman, 1995)

When human’s action/reaction becomes habit, cognitive friction is reduced. However, because of habituation’s automation characteristic, it also causes slip/error easily.

4.1.2. The anchoring adjustment heuristic

The anchoring adjustment heuristic means human being’s estimation is hardly adjusted after the very first evaluation which also known as first impression.

By utilizing these two human psychological attributes strategically, it will help designers
and companies establish standards that will help and aid intuitive interface interaction.

For example, the following two phone's cancel key is placed on opposite sides of the cell phone (figure 11). Therefore, when brand N's customers change their phone to brand M, they will produce many mental slips of error because of their previous habit. This may give the impression that brand M's cell phone is harder to use because the sequence of events and experience was opposite of the users natural habits and expectations.

![Figure 11 - Two different phones' cancel key is on different side](image)

4.1.3. Schema

A *schema* (plural: *schemata*) (Bartlett 1932, 1958) is a set of hypothetical mental structure organized and generalized from repeated experience and stored in long-term-memory (LTM).
In a cognitive system, schema provides abstract mental framework for human to understand, remember, and predict information. The framework includes a set of related slots which could be filled in by context or by the information processed through a sensory system. Most of us store knowledge by generalizing pieces of relative experience into a generic structure.

Another important attribute of schema is that it can be embedded into other schema. This mechanism allows human to build a complex knowledge system.

According to Stein and Trabasso (Coe, 1996), schemata have these attributes:

1. Schemata are composed of generic or abstract knowledge; used to guide, organization, and retrieval of information.

2. Schemata reflect prototypical properties of experiences encountered by an individual, integrated over many instances.

3. A schema may be formed and used without the individual’s conscious awareness.

4. Although schemata are assumed to reflect an individual’s experience, they are also assumed to be shared across individuals.

5. Once formed, schemata are thought to be relatively stable over time.
6. We know more about how schemata are used than we do about how they are acquired.

Why schema could help interface design?

By understand schema theory, designers could know more about what is going on in users’ mind when interacting with artifacts and how human learn to use artifacts. Designers could use it to leverage interface design quality, reduce users’ frustration, and create positive artifact using experiences. Coe (1996) provided several principles for interface design to leverage users’ existing and new schemata:

1. Use Universal metaphors and examples.

2. Use specific metaphors and examples you know your users’ schemata match.

3. Build on existing schemata.

4. Start with the general and add the specific.

5. Build complexity layer by layer.

6. Control the pace of the schema creation.

Through this approach, by using users existing schemata directly or indirectly could help users use and learn artifacts with less cognitive friction.
4.2. Reduce Users Frustration

How much time and effort should users spend learning to use a product? This is relative.

We appreciate airplane pilots and power plant engineers expert training to deal with complex machines and situations. However, their level of training is definitely not suited or expected for today's articles of daily use. Yet, consumer products such as telephones, air conditioners, ovens, or stereos in the cars are becoming more difficult.

Some people may argue, "The product is new. It won't hurt users to learn to use it for one time." I believe most people will agree with it, as long as the learning won't cause frustration.

Nevertheless, it seems that technology updates so fast to such an extent that most people can hardly keep pace with it. If we look back on our experiences, Microsoft almost announces a new version of their operation system Windows every two years. Each time a newer version demands a faster CPU, larger hard disk space and memory. It is not the worst thing to spend a couple hundred dollars to update most of the equipment. The crux of the problem is the company changes the interface every time they update the OS. This means users need to relearn what they have known. This lack of consistency impedes task completion and learning.
Interacting with a new interface will not help users to accomplish their major tasks easily and efficiently. HCI specialists, ergonomic engineers, cognitive psychologists, interface/interaction designers, and many other disciplines endeavor to find ways to make interfaces more usable and effortless for users. Yet most of the efforts pour into computer software and web design and development. Only a few efforts pay close attention to MPP interface/interaction design. The attributes of this type of products are similar to software or the web, and even more complex. For example, recording is an essential function to most of today’s VCR systems. However, to set up a scheduled-recording on a VCR system is never an easy task.

4.2.1. Avoidance Behavior

The negative experience elicits aversive stimuli and causes avoidance behavior (Schwartz, 1989). For instance, people will carry an umbrella with them on a cloudy day to avoid getting wet which caused a bad experience before. Some of the avoidance behaviors are useless, an extreme example is phobia. The subject knows it is unnecessary to avoid, but it is hard for them to overcome the habit of doing a particular action.

No matter how the negative experience happened, both the user and company have to pay

39
a great price to overcome the avoidance behavior. Therefore, designers should pay attention to user's frustrations carefully, even it seems trivial.

4.2.2. Learned helplessness

Seligman's experiment (Seligman, 1975; Seligman & Maier, 1967) shows when people unable to control their environment, learned to feel and act helpless. Even if control or power is given back, they still will not do anything. Indian people use this knowledge to train elephants for a long time. When elephants were small, they tied tightly to a small peg. At first elephants will struggle to free themselves, but they can't. After awhile, the elephants gave up. After they grow up, they have the ability to escape from the peg easily. However, they will not do it, because they remembered they can't.

4.3. Consistency

The importance of consistency is continuously mentioned in many web design and usability (Neilsen, 2000; Krug, 2002) books and websites. It is an efficient way to reduce user's cognitive load when interacting with new products. It is also a way for companies to strategically establish customer loyalty.
The meaning of consistent from Collins Cobuild Dictionary is “Someone who is consistent always behaves in the same way, has the same attitudes towards people or things ...” which means the action and reaction is predictable. If a product’s action and reaction is easy to be predicted, then users will feel the product is easy to use and control. Keeping design consistency does not mean designers have to keep the surface or aesthetics the exact same. What we suggested is in cognitive level’s consistency which includes the structure of the system functions, the position of certain critical keys, interface’s color scheme, the process to interaction with the product, and so on.

In this decade, cell phone becomes a popular MPP. The evolution of the product changes much faster than any other product before. Some companies create new designs every quarter. This entails new technology, different appearances, and even radical interfaces. But some companies do not change everything. Nokia provides a very good example of the importance of a product interface’s consistency (see figure 12). Although the technology used in products changed and the material appearance of the product changed, Nokia cell phone’s function structure and the way to interact with the product do not change much. The consistency of the product makes the product easier to learn and to use for existing and return customers. Therefore, customer loyalty is established allowing
Nokia to become one of the biggest and successful cell phone makers.

![Nokia cell phones](image)

Figure 12 – two different generation’s Nokia cell phones

4.3.1. Match Prior Experience and Knowledge

4.3.1.1. Mental Model

The notion of mental model has been well discussed in the field of psychology. It tries to explain how human’s mind work to help human deal with all kinds of different and complex situations. Rouse and Morris views mental models as a mechanism, whereby “humans generate descriptions of system purpose and form, explanation of system functioning and observed system states, and predictions of future system states” (Rouse and Morris, 1986, p360). Some other scholars view mental models as structural analogues of the world, that propositional representations and images are all symbols or correlate that correspond to outside of minds (Johnson-Laird, 1983, p.165).
When a user attempts to apply knowledge from a mental model for one task to another, the transfer may be synergic or conflicting. For instance, Douglas and Moran (1983) report users who were familiar with traditional typewriters had more difficulty in learning electronic word processors than others.

4.4. Memory Cue

It is important for a MPP to let users know clearly its current status. Drawn on psychology, some scholars suggest human beings process information through both bottom-up and top-down processes (Warren 1970) (McClelland, Rumelhart & Hinton, 1986). Therefore, providing appropriate cues to trigger user’s memory may increase human-product interaction performance.

Through providing sensory cues, such as visual or tactile cues, MPP may have higher rate to trigger correct mental prototype and induce proper schema to construct appropriate mental model which alleviates learning difficulty. On the other hand, during the Top Down process, users’ mind prepares adequate schema and generate appropriate mental prototype geared to particular context cognitive unconsciously, according to their prior experience. The matching of product interface representations and users’ schema will
lower the threshold to learn and use the product.

If the product’s interface representations cannot match users’ existing schemata, users will detect the differences and need to modify or even reconstruct their schemata and mental model. Typically when users activate schemata and construct mental models match prior knowledge, they are cognitive unconscious which means they almost automatically execute it without using too much attention resource. Therefore, a good interface/interaction design (definition) should be able to help users perform the major tasks they want to do and focus on it without breaking the flow. (Link to the definition of good interface/interaction) When the user needs to move attention from the task to interface, the flow has been broken.

Human perception includes top-down and bottom-up processes simultaneously. Without bottom-up perception process, outside stimuli loses effect. We have illusions instead of perceptions. Without top-down process, knowledge and expectations lose effect then we are not able to know what we perceived.

It is important for a MPP to let users clearly be aware of its current status.

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Through providing sensory cues, such as visual or tactile cues, MPPs may have higher rate to trigger correct mental prototype and induce proper schema to construct appropriate mental model which alleviates learning difficulty.

Top Down: When users need to use certain functions under particular context, their mind will be based on prior experiences. This entails cognitive unconsciously preparing adequate schema and generating appropriate mental prototype. If the products interface representations match the schema, users will have a lower threshold to learn and use the product. (Schemata already exists in users' mind. Mental model constructed when need it.)

If the product's interface representations cannot match up with users' existing schemata, they will detect the differences and need to cognitive consciously modify or even reconstruct their schemata and mental model. Typically when users activate schemata and construct mental models, they are cognitive unconscious which means they almost automatically execute without paying too much attention resource. However, a good interface/interaction design should be able to help users perform the major tasks they
want to do and focus on it without breaking the flow. When users need to move their
attention from the tasks they focused and turn into interface, it breaks the flow.

Human perception includes a top-down and a bottom-up processes simultaneously.
Without a bottom-up perception process, outside stimuli loses effect. We have illusions
instead of perceptions. Without a top-down process, knowledge and expectations lose
effect then we are not able to know what we perceived.

4.4.1. Visual Cue

4.4.1.1. Component Model

Irving Biederman proposed a component model with a list of thirty more geometric
components that he calls geons (see figure 13) – three-dimensional figures such as
cylinders, cones, pyramids, and so on. When human beings see an object, we perceive its
geons and their relationships, and then see whether there’s an object that matches up
according to our memory. If there is, we can recognize the object (Biederman, 1987)
(Gleitman, 1997, psychology, p 220-221)
4.4.1.2. Prototype theory

Some psychologists (Rosch, 1973) believe a human stores typical examples in LTM. The way human beings recognize things depends on the similarity of the hint and the typical examples, for instance figure 14 shows a shadow of an animal, from the shadow’s characteristic, we can easily recognize it could be a cat.
From these two theories, we know people recognize things based on existing experience. Therefore, from the very surface level, if designers want to design a product interface for users to use intuitively, one of the methods is to investigate the product’s prototype and its shape elements and put these elements into a product’s design.

4.4.2. Motion, Posture, Gesture Cue

Posture and gesture is another kind of representation. Occasionally, we will use posture or gesture to communicate with each other. Figure 15 shows a man with a camera posture. Although he does not hold anything, through his posture we still can know he acts like he is using a camera. Posture and gesture also represent a user’s typical way to use products (see figure 16). Therefore, utilizing these well-known representations is another possible leverage point for appropriate product interface design.

Figure 15 – posture and gesture
4.4.3. Correlation Cue

Combining the nature of the product and similar physics phenomenon in semantic level can help users easier to make connection to understand and recognize the product’s interface, for instance when we see something in red, we may guess it is hot. Therefore, to use this physics phenomenon on a heater’s interface can let users recognize and make connection with its temperature immediately (see figure 17). If the knob becomes red, the heater sets in higher temperature. This is a natural connection. Users don’t need to find other input or output devices to know the temperature settings.
4.5. Gestalt Principles & Visual Communication Design Elements

The Gestalt principle refers to the grouping of individual elements into wholes is a well
known theory to designers. It comes with following principles: closure, proximity,
similarity, and continuation. It happens during early visual perception. Designers can use
these principles to combine with visual communication design elements, such as shape,
color, proportion, etc., to organize complicated interfaces into several groups. For
example we can easily recognize there are several significant groups on a common
English keyboard without reading printed characters on it by using the principle of
proximity (see figure 18). It is a way to reduce a user’s cognitive loading when using a
complex product. On the contrary, if designers over-use grouping in shapes or colors
(figure 19), users’ cognitive loading will increase.
4.6. Mental Map and Structure

As mentioned earlier, human beings naturally want objects that are controllable and products that are predictable. To get control of a MPP, it is important to know where the function is in the complicated structure. For the reason that organized information can enhance human memory while encoding and decoding, designers put functions into a structural and well organized hierarchy to let users easier to learn and to use MPPs. However, interface’s size is a critical limitation to most of the MPPs. MPPs cannot show the whole structure map as a website on a computer screen. Thus, it is relatively difficult to inform users what the structure is and where they are at the moment. To achieve this,
product interface designers adopted breadcrumbs and scroll bars from web design.

Breadcrumbs can let users know their absolute position inside the structure while scroll bars can help users know the relative position in a certain level of the structure (see figure 20 & 21). These indicators help users map where they are in the interface.

Figure 20 – Site map

Figure 21 – Screen shot from Nokia’s cell phone
4.6.1. Transition

With the improvement of technology, making animation on screen becomes possible on most of the MPPs. By using animation, transitions can be utilized between different screens which can simulate pan effect. The movement of pan effect let users be aware of the connection and relation between different screens.

4.6.2. Automation and Adjustment

Since we know how to utilize computing power to create product functions, one of our dreams is to make a product automatically work by themselves, which is a way to reduce user's cognitive loading and interface complexity. Norman (1999) noticed companies add more and more features into products but do not equally turn some of the product's functions into automated. This result in increased product interface-complexity and user cognitive loading (see figure 22). However, automating product interfaces is not the final solution. Occasionally users need to make adjustments to these automated functions. Nevertheless, these automated functions are mostly placed in the deep level of the hierarchy. As a result, to make automated functions easier to adjust becomes another challenge to designers.
Palm's Zire71 PDA shows a good example of automaticity. In its normal position (figure 23 & 24), it is just like other PDAs. To turn to camera mode, users only need to simply push the center part up the PDA. This intuitive action will immediately turn the MPP into camera mode. When users pull back, it turns on photo album software to let users examine the pictures which smartly reduces user's cognitive loading while enhancing the product use experience.
Figure 23: Palm Zire71 in PDA mode (front & rear view)

Figure 24: Palm Zire71 in Camera mode (front & rear view)

4.7. Examples

Sony’s new cell phone SO505i provides a good example of employing users’ existing cell phones, PDAs, and camera schemata. Figure 25 shows SO505i in cell phone mode (left) and PDA mode (right). These explicitly match common cell phone and PDA schemata. Figure 26 and 27 describe the way to turn to camera mode. This obvious and intuitive approach works with a users previous schemata and mental models. Although the new device includes several major purposes, it is relatively easier to learn and to understand
when the purposes match our prior knowledge and existing schemata.

Figure 25: Sony SO505i in cell phone & PDA mode

Figure 26: Sony SO505i camera in close mode

Figure 27: Sony SO505i camera in open mode
Figure 28: Sony SO505i uses as camera mode
CHAPTER 5

EVALUATION

5.1. Company Evaluation

5.1.1. Return of Investment

The most common way for today's companies to evaluate the successfulness of a product is through return of investment (ROI). ROI measures how effectively the firm uses its capital to generate profit, which means if the investment cannot generate profit, it failed. It is not a good method because the measuring period is too short to gauge user feedback. Since MPPs have a certain product life, users will not purchase another one immediately. They will give their feedback on their next or next-next purchasing. Although Nielsen (2003) used ROI method to explain the importance of web usability, it is not suggested that designers use the same method for MPP use. A website is directly connecting a company to its customers, if customers do not like the website, they can go to other websites in a moment. However, selecting or moving to another product is not as easy. After users purchased the product, it is hard for them to change to another product.
immediately. Especially if the product used in offices. Once a company purchases the
product, most of time the employees have to get use it, regardless of preference or design.

5.1.2. Re-Visiting, Re-Using, & Re-Purchasing Rate

It is hard to set criteria to evaluate how products improved after conducting design
changes. Nevertheless, companies need a way to measure the result of investment and
performance of designers. What I suggest here is to extend the measurement period to at
least three product life cycles. The reason for such a long evaluation period is to
understand previous, current, and future purchase and re-purchase decisions. Within these
decisions are not just the traditional comparison of specifications, but actual scales and
levels of user comparison that is from actual use and experience. This long-term
tracking of personal decisions and the rationale for re-purchase or new product purchase
needs to be taken into consideration for improved product design.

5.2. Design Evaluation

From the earlier sections, we know various principles to determine appropriate interface
design. However, how can we predict if users will be partial to our designs or not? The
most objective way to evaluate a product interface design’s successfulness is through a product’s target users. If the target users can clearly understand how to use the product and even like it, they may have better chance to have a positive product using experience.

Today’s web design is already developing and using many usability test methods (Neilsen, 1999; Krug 2002) to detect a companies’ website’s flaws and providing solutions through a users’ point of view. Therefore, we believe by adopting these methods into product interface design could help industrial designers to know a user’s feedback before putting a product in the market.
CHAPTER 6

CONCLUSION

Consumers and companies should realize it does not matter how many functions or purposes they put into a product, there can always be more. Therefore, companies need to understand their business at its core value – people. People will demand better products.

And the people will purchase, repurchase, recommend and use products that are designed appropriately for their abilities, task, and environment.

MPP’s using experience deeply relies on product’s hardware and software interface design integration. Good product interface design counts on designer’s holistic understanding of target users in both physical and mental then implement into design projects.

For further researchers, it is recommend to find out user’s emotional reaction and connection when using product’s interface, and find out more ways to implement psychology principles into design projects.
APPENDIX A

THE OPINIONS ABOUT TECHNOLOGY FROM MAGAZINES

1. Like the carnivorous plant in the movie Little Shop of Horrors, today’s popular applications software cries out to user, “Feed me!” More RAM, more hard disk space, more CPU speed – it seems like you never have enough… Many users have reported that flabware impairs usability,” says Betsy Fortin, director of graphics – product marketing at Lotus. “you have what I call a ‘bag of tools.’ And the more tools you have, the harder it is to pick out which one to use.” April, 1993:“Fighting Fatware.” Ed Permatore, Tom Thompson, Jon Udell, & Rich Maloy, BYTE magazine

2. Almost any adult can step into any car sold today and competently drive it across the state. By contrast, most adults – even sophisticated, computer-literate folks – are frequently baffled by their PCs, and are made to feel stupid by the attendant technobabble. It’s no coincidence that the most popular PC books go by names like, “Windows for Dummies.” Detroit doesn’t sell books like “Oldsmobiles for Idiot” or “A Foul-Up’s Guide to Fords” December 29, 1997:”What Detroit can teach Silicon Valley.” Patrick L. Anderson, Wall Street Journal

3. Bill Gates, the chairman of Microsoft, once said that if automobile manufacturers had kept up with technology as well as computer industry had, people would all be driving $27 cars. E-mail boxes throughout cyberspace quickly filled with whimsy, including a statement attributed to an automaker: “Yes, but would you want your car to crash twice a day?” And how would a car function if it were modeled after a computer?” Occasionally, executing a maneuver would cause your car to stop and fail and you would have to re-install the engine,” and the airbag system would day, “Are you sure?” before going off. May 28, 1998: “Do computers have to be hard to use?” Katie Hafner, New York Times
4. If the frustrations of all the world’s computer users were brought together, the resulting explosion would make the big bang look like a Roman candle. This is true even though computers have come a long way in the decade since the industry pronounced “usability” a necessity. 

5. This personal column was launched in October 1991 with the intent of looking at personal computers and other consumer technologies from the point of view of the average, nontechnical user. These folks aren’t afraid of computers. They’re just frustrated with them. And they aren’t dumb. They just have little interest in learning the technical details of computer or the Internet just to use PCs and the Web or e-mail.
Every October since, I’ve tried to review the computer industry’s progress — or lack thereof — in keeping its many promises to make its products easier, simpler and more reliable for these casual users. This year, I think things actually went backwards. Complications, in general, mounted. Few, if any, advances were made in reducing complexity, and reliability seems to have declined.
October 28, 1999: “Using a PC got harder, but New Age is Dawning,” Walter Mossberg, Wall Street Journal

6. Complex gizmos are driving Americans nuts. The message to manufactures: Simplicity sells... [W]ith the technology industry enduring its first bear market since gadgets became the hot new things, many companies are scrambling to find out why consumers aren’t falling in love with the latest stuff. The answer? Most folks are still trying to figure out how to work the devices they already have.

7. “This year’s trend: many functions, One device.” — Electronics manufacturers are getting it together in 2003. Instead of product breakthroughs, the emphasis is on, as Sony puts it, “combining technologies into single products to enhance consumer lifestyles” — you know, MP3 meets digital camera meets cell phone with built-in electric shaver. But won’t this strategy only make things more complicated? "Engineers would like to squeeze in every possible feature,” says Paul Liao, chief technology officer of Panasonic USA. “That can be a nightmare, because the consumer can’t figure out what the device is good for.”
April 2003: by Suzanne Kantra Kirschner, Popular Science
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