Chapter 16

Integrated new product development

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The creation of high-valued products and services requires a process that is driven by anticipating the needs, wants and desires of key stakeholders, and Cagan and Vogel (2002) provide a strategy and series of tools to help companies navigate the earliest stages of product development. This is the portion of the process that is uncertain and undefined, often referred to as the 'fuzzy front end' of the process.

We argue that it is no longer sufficient to approach product development through the "form follows function" cost-driven process of much of the latter half of the 20th century. Instead, the mantra for the 21st century is that "form and function must fulfil fantasy". Fantasy, in this case, is the anticipation of an optimum consumer experience based on the value system of a particular market segment. When a product meets the anticipated desires of a customer a company can often generate greater profits. In some product categories this level of design has become the cost of doing business.

"Form follows function" is no longer sufficient. Products must capture the users' imagination.

In our research, we have discovered that while many companies say they are customer focused they often fail to maximise the fuzzy front end. Product development teams often focus on the wrong issues too early. Decisions are made with a concern for manufacturing quality and efficiency, overanticipating the needs of downstream processes. This concern for the back end of product development takes resources and attention away from the creation of user-centred product attributes.

It is important to use the front end to lay out a strategy that will connect to the desired market and help to establish or extend brand equity. The idea is not to ignore downstream quality issues, but instead to focus on development innovation in the early stages. If used properly the fuzzy front end establishes the innovation for the product and allows teams to focus on implementing quality processes downstream without costly overruns and changes.

The secret of great product development is to gain significant insight into the needs, wants and desires of the key stakeholders. This requires the use of a variety of qualitative methods that complement existing quantitative processes used by most marketing groups. This chapter highlights our integrated New Product Development (iNPD) process (Cagan and Vogel, 2002) and some of the tools that help a product development team understand the value needs of the product and work in an integrated way to achieve them.

The next section reviews some frameworks for product development found in the literature and introduces the iNPD process. An approach for dividing value into discrete attributes, called Value Opportunities (VOs), is presented, followed by a description of their application to product development through

the use of VO Analysis. A case study helps to illustrate the process. Finally, the difference between hard and soft quality and the need for both in any successful product is discussed.

Product development processes

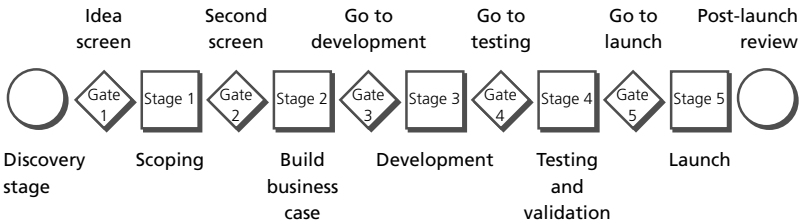
There are a variety of presentations of the product development process that have been discussed in the literature. All tend to take a particular discipline viewpoint, rather than a complete integrated team approach. However, each offers insights or organisation to help the discipline understand or improve the process. Many also discuss the challenges and the importance of addressing the early stages of product development, though few offer techniques to understand the true value that the end stakeholders seek.

One approach often used in industry is the Stage-Gate® (Stage-Gate® is a registered trademark of the Product Development Institute, Inc.; www.prod-dev. com) process of Cooper (2001). In that process, detailed requirements are specified and met at various stages (in terms of timing and development) throughout the process. There are principally five gates (see Figure 16.1) and five stages:

- scoping;
- building the business case;
- development;
- testing and validation;
- launch and post-launch review.

The process is effective and has helped many companies become more organised in their product development process; most companies that have criteria to move through design reviews are using the principles of the Stage-Gate® process. What the Stage-Gate® process does not do is tell you *how* to get through the stages themselves, especially early in the process, or how to enter the process itself, i.*e.* what is an opportunity for a new product.

There have been several presentations of an engineering-based process as found in Pugh (1990), Otto and Wood (2001), and Ullman (1996).



16.1 The Stage-Gate® process
The Stage-Gate® is a registered trademark of the Product Development Institute Inc.; www.prod-dev.com – image reproduced with permission of Dr. Robert G Cooper

Pugh is most noted for the development of what have become known as "Pugh charts", weighted matrices that help a product development team qualitatively compare, differentiate, and filter out competing design concepts.

Otto and Wood (2001) give a thorough discussion of the road map for the engineering design process. One of the most interesting chapters is the first, which presents the design processes, many with a Stage-Gate® flavour, of several design firms and corporations, including Ford, Raychem, Design EDGE, Raytheon, and Motorola. The chapter also presents a list of significant design theory developments from ancient Egypt through to today. The book is a good resource for the process from an engineering perspective once a product opportunity is understood and the conceptualisation process is to begin.

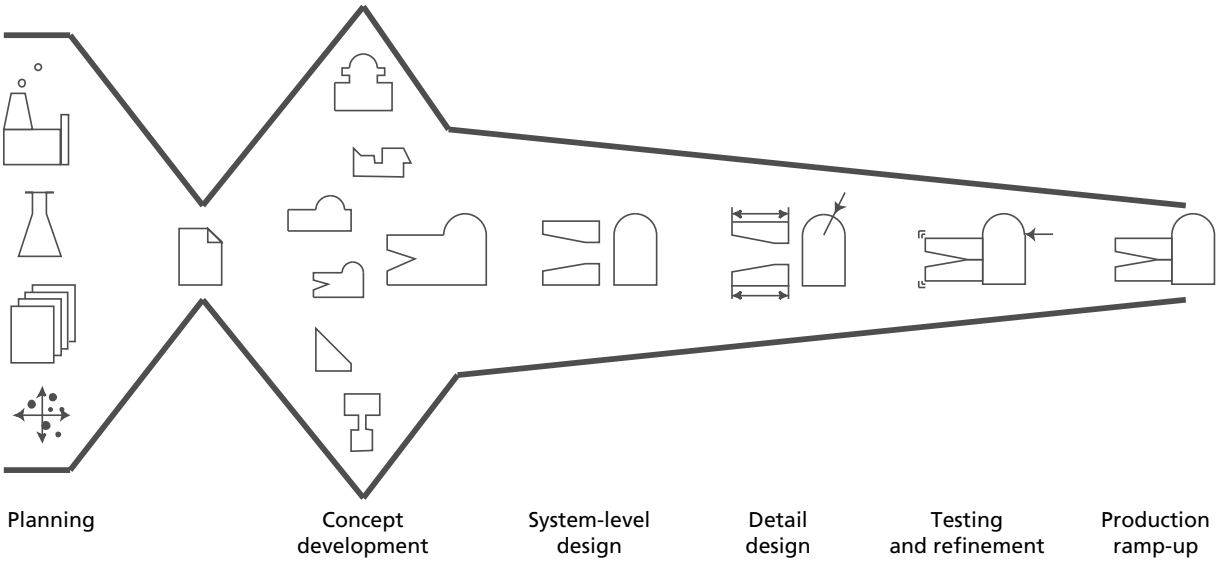
Ullman (1996) is a more succinct presentation of the same process, with particular emphasis on the downstream activities once the engineering specifications are ready to be articulated. In each of these approaches the process begins with product specification, followed by conceptualisation, then detailing, manufacturing specification and quality, and then production.

Ulrich and Eppinger (2003) present a broader view from both an engineering and business perspective (see Figure 16.2). Management and the economics of the process complement many of the engineering techniques included in the previous set of references. Ulrich and Eppinger discuss some of the benefits of industrial design as a player in the process, though they maintain a technical and business approach for the core methodology. Like the above engineering methods, and the Stage-Gate® process, the process assumes an understanding of the product opportunity and direction for product specification, but nicely leads the user through planning, specification, concept generation and selection, refinement, and design for manufacturing and cost assessment.

The variety of books available represent a wealth of information and guidance to help companies work through the product development process.

Other books focus on the business case. For example, Wheelwright and Clark (1992) detail specification and feature requirements, project and team management, and development timing, efficiency and acceleration. Smith and Reinertsen (1998) argue that time, rather than cost, is the critical factor in product development. They focus on the management of the process and teams to help move through the early stages quicker and more effectively.

Most of these books begin once a product focus is understood. They also take a discipline-specific focus and tend to represent the process and product in terms of marketing, manufacturing or functional goals alone. Together they represent a wealth of information and guidance to help companies work through the product development process.



16.2 An engineering and business perspective (reproduced from *Product design and development* by Ulrich and Eppinger, 2003)

Integrated new product development

In each of the processes presented above, there is little in the way of explanation or tools to help navigate the earliest stages of product development, what has been called the 'fuzzy front end' of the process. The use of the term fuzzy is not arbitrary – to many product developers the uncertainty and fast-evolving/chaotic nature of the early product definition stage is uncomfortable and to be avoided.

Most product development processes begin once it is known what technology a company wants to design and why it wants to design it. Engineers, in particular, are very comfortable taking a product definition and quickly moving it from function to mechanism, which often prematurely dictates product form and interaction.

Unfortunately, all too often, the early definition and purpose are not well understood, which leads to an ineffective or at least sub-optimal solution downstream. Engineering analysis and parameter optimisation tools then take a bad idea and work to make it acceptable.

In contrast, our iNPD process emphasises the earliest stages of product development with a focus on identifying and understanding product opportunities and the value required by stakeholder needs, wants and desires. In addition, equal participation is expected from engineering/manufacturing,

marketing/finance, and industrial design/interaction, *i.e.* all major participants in the process. Moreover, the concept of VOA gives everyone involved a set of value targets that engineering, design and marketing can share from the beginning of a program, which has deeper ramifications in how resources are allocated to the process (Cagan and Vogel, 2002).

If the timing and cost allocation of all parts are considered as equal, as is often done in traditional engineering or marketing approaches, then when parts are not detailed for cost and manufacture early, and system costs cannot be determined upfront, production timelines are threatened and cost targets are challenged.

An alternative is to recognise that all parts are not designed alike and take into account their lifestyle impact and aesthetic integration into the overall product. This requires new tools and methods to work through the development process.

Development of the iNPD process

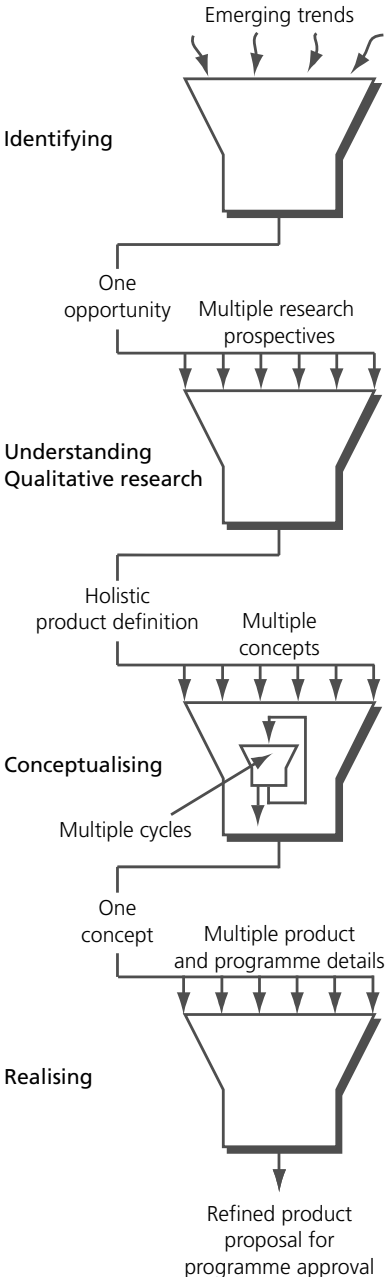
We have studied the very early stages of product development, the part that begins before the Stage-Gate® process when the product opportunity is just being formed as a vague description of intent. We have also studied industrial product development processes in a variety of industries, have consulted with consumer, medical, and business-to-business product and services companies.

The concept of VOA gives everyone involved a shared set of value targets.

We have taught an innovative product development class at Carnegie Mellon University for over a decade. This course requires engineers, industrial and communication designers, and marketing (MBA) students to work together to create patentable (and often patented) products in 16 weeks. It is a course that emulates the environment of the fuzzy front end.

We have developed tools and methods to help product development teams navigate through the early stages. Our approach uses four phases that bring each team from product opportunity identification through to the point of program approval where a company commits to patenting and manufacturing costs.

The methods and tools integrate with current processes within companies, or can serve as the basis for developing a new process for those companies looking to develop their own. In the next section the basic iNPD process is reviewed and then, in the subsequent sections, the part of the process most foreign to many engineers, namely understanding and articulating true customer value, is discussed.



16.3 Four-phase product development process (adapted from Cagan and Vogel (2002)) © 2002 Prentice Hall PTR

The iNPD process

The iNPD process is made up of four phases, namely: identifying; understanding; conceptualising; and realising. These are described below and summarised in Figure 16.3.

Identifying

Product opportunities are identified. We describe social, economic, and technology (SET) factors, which interact in a dynamic way to create product opportunities. By constantly scanning these factors, trends in culture and lifestyle can be identified. This reveals gaps in the marketplace otherwise known as Product Opportunity Gaps (POGs). Initial customer-based and secondary literature-based research lends credibility and insight to the opportunity, transitioning to the second phase.

Understanding

Qualitative research focused on a deep understanding of the key stakeholders leads to actionable insights that provide a framework for product form and feature development. This phase is what differentiates an insightful process that can break through existing solutions from the standard approach of minimal change and innovation. The challenge is to identify, understand, and articulate the key attributes of value to be developed in the product. In the next section, customer value is discussed along with VOA. The end result of this phase is an initial product description that indicates who the target market is, and what characteristics the product will articulate.

Conceptualising

A more traditional part of product development that takes the insight from phase II as a basis for generating concepts and resembles the second stage of the Stage-Gate® process, for example. The difference between iNPD and other methods, however, lies in having already conducted the research in phase II. This makes the conceptualisation more effective and meaningful; the initial product criteria developed in that second phase, in addition to serving as the point of departure, also serve to direct and confirm each concept developed. In order to reach an optimum conclusion at the end of phase III, it is important to use an iterative conceptualisation process. This requires multiple cycles of quick, interactive prototypes tested or discussed with the key stakeholders to help direct the process. At the end of this phase the basic product is now designed, setting up the fourth phase.

Realising

The concept is detailed to the point that the company can make a go/no-go decision as to whether to move the product to production. In the Carnegie Mellon class, for example, students have a complete and accurate form model, technical proof of concept often shown through a functional prototype, a marketing plan with complete financial and roll-out strategy, and a manufacturing plan. Even in phase IV the basis for success lies in the eyes of the stakeholders as identified by the team. Very often this phase can be compromised by internal groups feeling that the product is a success and rushing to judgement without customer feedback.

After the fourth phase the product goes into the stage of refinement toward production and launch. These steps are well understood, but the challenge is to protect the innovation created in the earlier phases. Because the product was developed with a good understanding of the customer, that knowledge provides the rationale to protect the features and to prevent cost reduction from reducing feature quality as well. We present tools to help the team carry out deep qualitative research on the customer. In addition, we argue for integration of an inter-disciplinary product development team, and introduce tools to help bridge the natural perceptual gaps between disciplines. In the next section the concept of product value and VOs, a tool that makes phase II of our process so effective, is presented. The iNPD approach is compatible and complementary with each of the processes discussed earlier in the chapter, giving effective guidance to the earliest stages of product development and completing the discipline perspectives.

VO characterise the impact of a product or service.

Value opportunities

It used to be that value was equated with having the most features in a product for the lowest price. For products that are highly desirable, value is not the number of features you can get for the least money; rather, it is how effectively the features meet the expectation of usefulness, usability and desirability of the desired market segment. Value is represented through impact of the product or service on the user's lifestyle, use of the product or service through enabling features, and meaningful ergonomics.

We have broken value into seven categories, each with distinct attributes. These categories are called VOs. A product development team can use them to assess the current state of products in each category and to determine where improvement is possible. Each of the seven VO classes (emotion, ergonomics,

aesthetics, identity, impact, core technology, and quality) contributes to the overall experience of the product. We map the VO attributes onto a VO chart.

The VO chart forms the basis for the VOA tool, which helps a product development team analyse the current state of products on the market, the ideal state of a product, or the realistic expectations of what attributes of value a new or next-generation product can achieve. These value categories make sense for all disciplines involved in the product development process and help teams to develop a shared understanding of their goals and to develop new products. Feedback from users indicates that they find the tool useful in structuring the qualitative goals of product programs. The seven VO classes and their attributes are now described.

The VO chart helps a product development team analyse existing and future products.

Emotion

This is closely related to a user's fantasies, and can be broken into six attributes:

- *Sense of adventure* – the product promotes excitement and exploration.
- *Feeling of independence* – the product provides a sense of freedom from constraints.
- *Sense of security* – the product provides a feeling of safety and stability.
- *Sensuality* – the product provides a luxurious experience.
- *Confidence* – the product supports the user's self-assurance and motivates him to use the product.
- *Power* – the product promotes authority, control, and a feeling of supremacy.

Ergonomics

The core of physical interaction, ergonomics is broken down as follows:

- *Ease of use* – product must be easy to use from both a physical and a cognitive perspective. It should function within the natural motion of the human body. The size and shape of components that a person interacts with should be logically organised and easy to identify, reach and grasp.
- *Safety* – product must be safe. Moving parts should be guarded.
- *Comfort* – product should be comfortable to use and not create undue stress during use.

Aesthetics

The aesthetic attributes are:

- *Visual* – the visual form must relate shape, colour, and texture to the context of the product and the target market.
- *Tactile* – physical interaction with the product, focusing primarily on the

hand but including also any other physical contact between the product and user, must enhance the product experience.
- *Auditory* – product development must determine and integrate the appropriate sounds and eliminate undesired sounds.
- *Olfactory* – product development must consider the impact of smell, providing appropriate aromas and eliminating undesirable odours.
- *Gustatory* – products that are designed to be eaten or used as a utensil, or that may otherwise be placed in the mouth (for example, a child's toy), must have an optimum flavour or no flavour at all.

Identity

Three attributes of product identity are:
- *Personality* – the two main issues in a product personality are (1) the product's ability to fit among and differentiate from its direct competition, and (2) the product's connection to the rest of the products produced by that company.
- *Point in time* – in order to be successful, a product has to capture a point in time and express it in a clear, powerful way.
- *Sense of place* – products must be designed to fit into the context of use.

VO include:
- emotion
- ergonomics
- aesthetics
- identity
- impact
- core technology
- quality

Impact

Connected to corporate brand and responsibility, and probably the least explored of all the VOs, impact has two attributes:
- *Social* – product can have a variety of effects on the lifestyle of a target group, from improving social wellbeing to creating a new social setting.
- *Environmental* – the impact of products on the environment is becoming an important issue in terms of consumer value. Design for the environment focuses on minimising negative environmental impact associated with manufacturing, resource use during operation, and disposal.

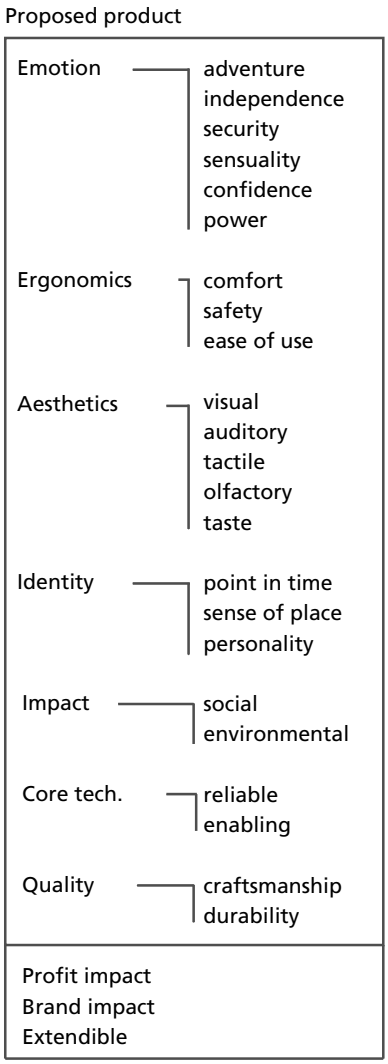
Core technology

People expect technologies to evolve rapidly and be increasingly:
- *Enabling* – core technology must be appropriately advanced to provide sufficient capabilities in a product. It may be emerging high technology or well-manufactured traditional technology, as long as it meets customer expectations in performance.
- *Reliable* – consumers expect technology in products to work consistently and at a high level of performance.

Quality

The quality VO includes two attributes:

- *Craftsmanship – fit and finish* – the product should be made with appropriate tolerances to meet performance expectations.
- *Durability – performance over time* – the craftsmanship must hold up over the expected life of the product.



16.4 VOs (Cagan and Vogel, 2002)

We have shown that this breakdown sufficiently describes the value quotient of over 20 products from consumer goods to industrial products to services like United Parcel Service Inc. (UPS), and even the emerging retro baseball parks in the USA. Firms have also used this breakdown proactively in product development in service industries, the medical products industry, the auto industry, chemical companies and commodity manufactures of raw materials. These concepts have been introduced to electronics consumer manufacturers and the durable goods industries. In each of these cases this approach has helped their clients understand what aspects of value relate to their target customer base.

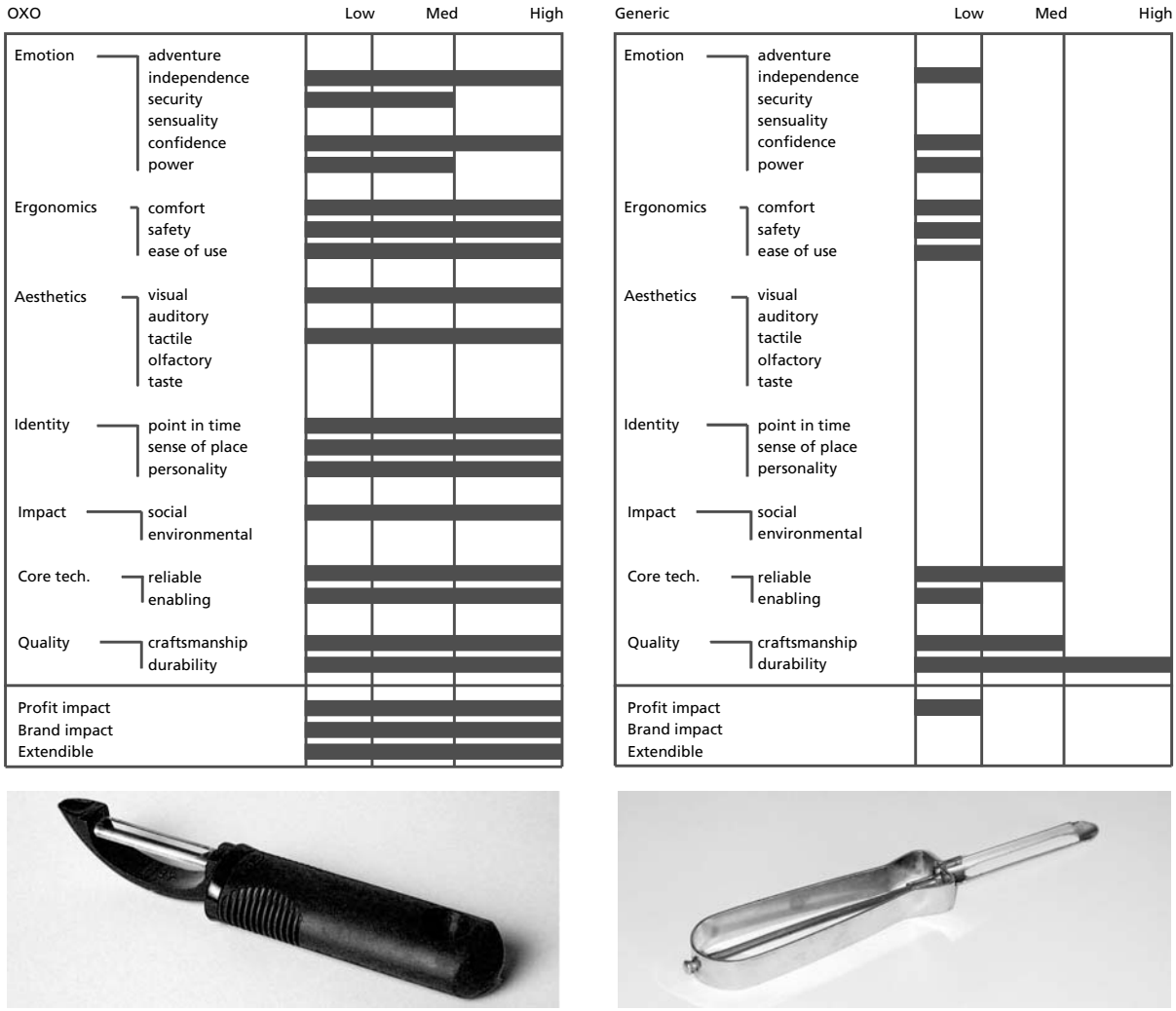
Figure 16.4 shows a complete list of VOs, where each VO can be evaluated qualitatively as zero, low, medium, and high, based on how well that attribute addresses the goal of the product. The resulting VO chart can also show the profit impact, brand impact, and extendibility of the product to other products in the company. The chart can be used to set expectations of where a new product ranks on the different attributes of value. It can be used to compare one product against a competitor. It can also be used to compare a current product to how a redesigned one should improve the value quotient.

Figure 16.5 shows a VOA, where one product is compared with another. Here, the OXO GoodGrips vegetable peeler is compared with its generic counterpart that was the standard for over 100 years prior to the OXO introduction. Visually, it is clear how much better the OXO product compares with the generic standard. The generic peeler ranks low in the emotions of independence and confidence, and meets a low level of the ergonomic attributes of comfort, safety and ease of use. The form follows function aesthetics are poor and the product makes no statement about brand identity. Although the durability is high (it will last forever), its VOA clearly indicates a missed opportunity in the marketplace.

The GoodGrips, on the other hand, excels in its ability to meet strong emotion VOs in independence, confidence, and even security, especially for the target of elderly or arthritic users. The product also excels in all aspects of

ergonomics, core technology and quality. The form and tactile design of the product make strong aesthetic and brand identity statements of value; it is a product people want to own and are willing to spend five times the cost of the generic counterpart to possess.

The GoodGrips also has very strong social impact, stemming from the success of the handle design that enables people to hold the product with a greater sense of security. As a result, the patented GoodGrips handle has



16.5 VOA of OXO GoodGrips vs generic peeler (Cagan and Vogel, 2002) © 2002 Prentice Hall PTR

helped the company launch over 350 products, including gardening tools, construction tools and other kitchen products.

VOA is a user-driven approach to product development that addresses the core value sought by the user.

The VO and VOA is a user-driven approach to product development that addresses the core value sought by the user. Understanding this value to begin with is a critical process that uses various qualitative research tools, including new product ethnography, human factors, task analysis and lifestyle reference. The VOA is just a first step. The major challenge is to convert this qualitative measure into what may be called 'actionable insights', namely goals that achieve each VO. This set of goals provides an early specification for a product well before the form or features are designed.

Case study: design of interior cleaning system for cars

In recent years the Integrated Product Development class at Carnegie Mellon has attracted corporate sponsorship where companies have had intellectual property rights to products created. Ford Motor Company sponsored the class twice, and from 12 projects they have submitted five patent applications (two of those patents have been issued so far). Most recently, two companies in the bioengineering field, Respironics and BodyMedia, have supported the course.

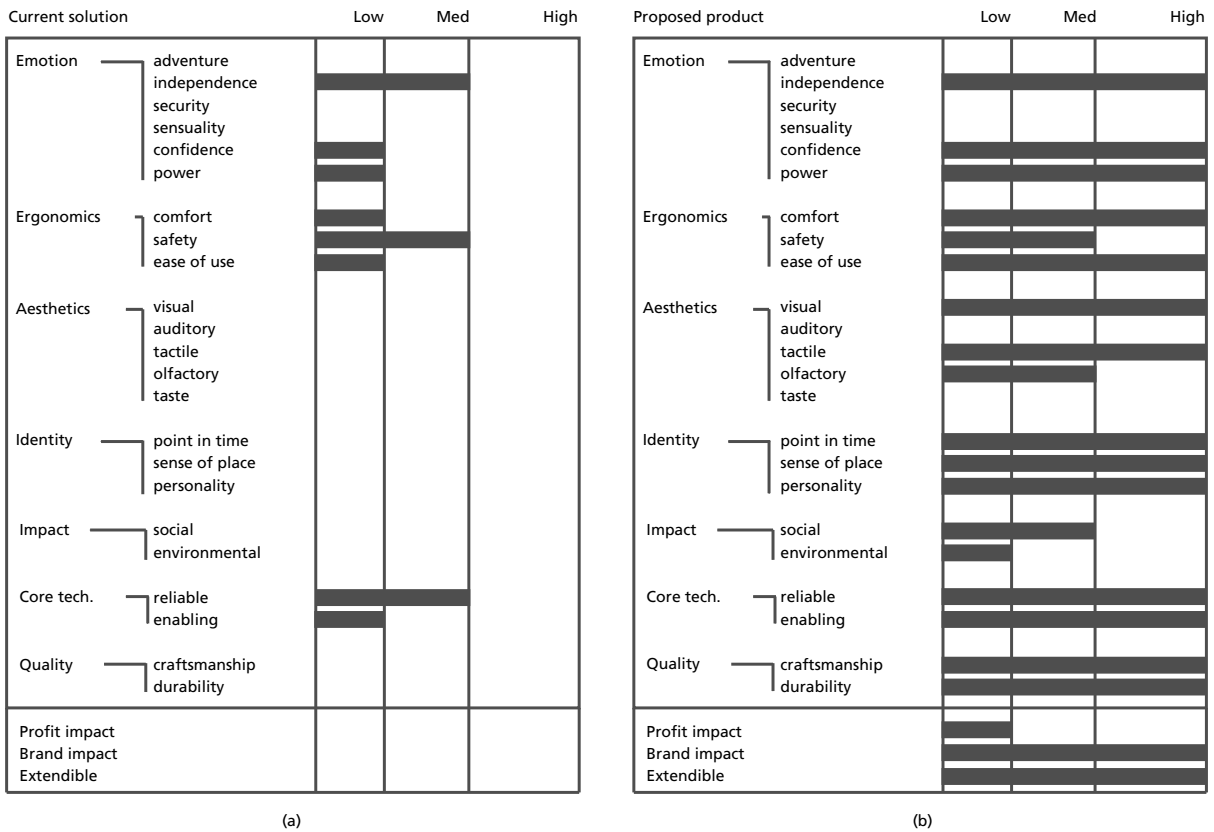
One project from this class, supported by Ford, focused on the design of integrated, interior lifestyle features for a small sport utility vehicle (SUV), the Ford Escape. In particular, it focused on interior update, or cleaning, of the vehicle and was designed by seven students: designers Joseph Genuardi, Jon Mayer and Lisa Villemure, engineers Andrew Birnbaum and Erika Wetzel, and marketing students Samir Kayande and Esperanza Lo.

After brainstorming over 100 possible product opportunities, they narrowed down to the opportunity of maintaining a clean environment inside the vehicle. They chose to focus on a particular market segment characterised as families with dual careers. These couples often have several young kids and lots of activities, and are always "on the go" but still with limited income. They need to maintain and clean their vehicles without spending the $100 it takes to detail an SUV at a specialty shop. The opportunity statement for this team was: keeping the interior of a car clean, as defined by the expectations of their chosen market segment.

The team then moved into the second phase and pursued multiple directions of field testing, primary and secondary research and observation to become experts in interior cleaning of vehicles. Their research with their target market gave them meaningful insights. Here are some of valuable quotes they obtained from their intended customers: "If there was some cheap, easy, quick

way of cleaning my car, that would be good", "I wish I had a dedicated spot where I could put my garbage", "My husband tries to clean it, because I don't", "I eat when I'm driving…I'll make time to clean when I can't stand it anymore", "I can't vacuum, because there's no power outlet near my car".

The team developed an overview of the opportunity presented by a continuum of trash and dirt in a vehicle. They determined what portion of that continuum their solution needed to address. This led to the proposal of the need to develop a cleaning system with two main components: a handheld vacuum and a trash bin. Their research on competitive products showed no current product that addressed the problem in a way that met the lifestyle needs of the target user. The research on their target market, both primary and through access to lifestyle-based databases, led to a VOA of the way trash is currently disposed and vehicles are currently cleaned (see Figure 16.6a), and of the goals of the new product they will design (see Figure 16.6b).



16.6 VOA of (a) current solution and (b) proposed product

The result of the second phase was a good understanding of the features and characteristics of the product opportunity. During the third phase the team focused on conceptualisation and reverse engineering. The specifications for the vacuum system were determined. The location of the system was decided (in the centre console). Because research from their users indicated that the one item currently stored in the console that they did not want to be without was their CDs, a CD holder was included in the concept. The vacuum cleaner needed to be constantly available and charged, so space became a challenge, especially with the size required to generate enough suction. Multiple vacuum forms were explored and tested with their target users.

The final phase led to the detailed design shown in Figure 16.7. The top of the centre console opened to hold a trash receptacle. Plastic shopping bags from local supermarkets were used to collect the trash, and a slit rubber cover kept the odour in. On the back of the console rested the constantly charging vacuum cleaner. The unit was specially designed to be ergonomic and meet the needs of hard to get to spaces in a vehicle. The vacuum swivelled closed to allow for compact storage. Finally, in the front was a CD case that held 10 CDs without the plastic jewel cases. The case also served to accent the Ford brand with a Ford logo and the case was portable to allow the user to take the CDs outside of the vehicle. Target user research showed that more than 75% of their market would want all or part of the system.

16.7 The final prototype for the SUV interior cleaning system

Resource allocation in the experience economy

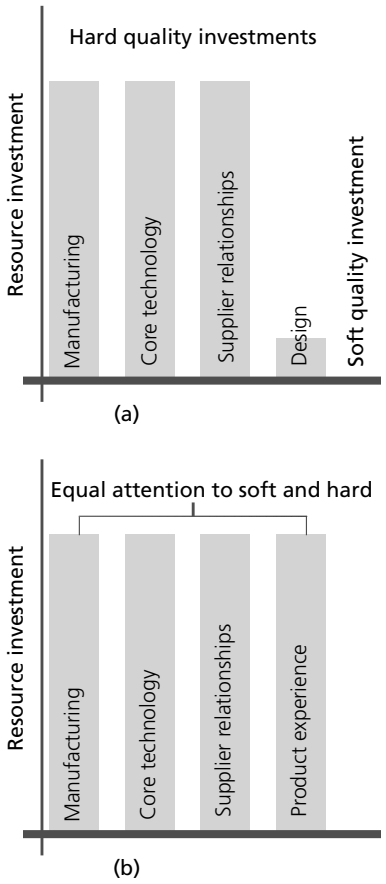
The goal of new product development today is to create not just a physical product or service, but to create or enhance an overall experience for the customer. To develop highly valued products requires a new commitment from companies, especially tech-driven ones.

As shown in Figure 16.8a, traditionally tech-driven companies have focused on hard quality attributes, those attributes of manufacturing and technology development, with the form design thought of almost as an afterthought for an industrial designer to complete to finish off the product. The problem with this approach is that high-tech products that are not usable or desirable often give poorer than expected performance in the market. At best, interaction with and experience of these products is never as good as it could be. At worst, a major investment of time and money can be compromised and additional damage done to the perceived brand equity of the company.

This new product service design challenge is the result of the 'experience economy' discussed by Pine and Gilmore (1999). In product terms, we argue that products and services are interrelated and together create or enhance the overall experience that a set of stakeholders undergo when interacting with a product. In many industries, where competition, especially from companies/countries with cheap labour and costs, has driven a product toward being a commodity, design for experience is the only way to move back toward high-margin product development.

Pine and Gilmore work with many companies fighting this pressure to succumb to low-cost commodity approaches. The problem is that this approach leads to a competitive downward cycle that ends up taking the heart out of a company, destroying the potential for competitive innovation. It has been observed that only one company can be the cheapest in a given market. The challenge is to compete by identifying value and to generate greater profits through innovation that creates anticipatory solutions connected to the VOs.

As shown in Figure 16.8b, to commit to product development in the experience economy is to commit to investing in both hard and soft quality. Soft quality is the combination of lifestyle features, user interaction, aesthetic attributes, and brand identity that create the emotional attributes of the product at purchase and initial use. Soft quality creates the brand identity of the product and the initial excitement that leads to the purchase of a product. Hard quality affects the brand identity of the company and the long-term satisfaction with a product.

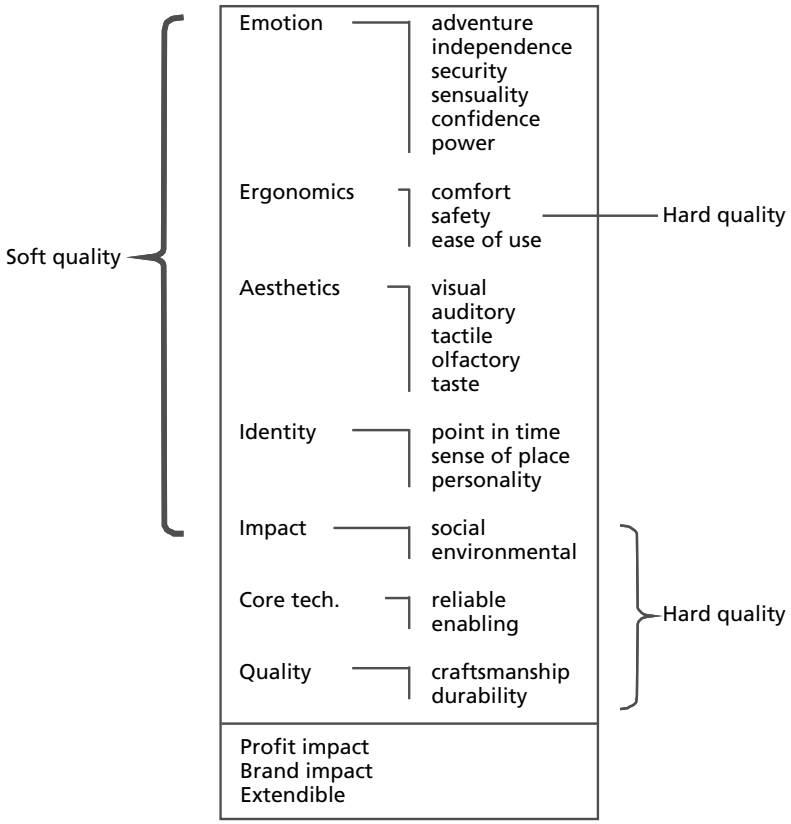


16.8 Shift of resource allocation from (a) hard to (b) both hard and soft quality in the experience economy

As shown in Figure 16.9, the VOs can be divided between hard and soft quality, emphasising the need for both in product development. What is hard for many companies to realise is that it is not just technology that constantly changes. Changes in product aesthetics and ergonomic preferences are as important as technology advances. Executives in tech-driven companies are usually sceptical about the true value of recognising that the soft quality changes are as significant as the hard quality ones.

As shown in Figure 16.8b, resources must move from treating the role of design as an afterthought to soft quality investment upfront. Soft quality investment implies not only industrial design involvement upfront, but commitment from all players.

Engineers should be active participants in the design of soft quality attributes. For example, the acoustics of a Harley-Davidson exhaust are specifically designed to support the experience of the ride. Engineers should be active participants in lead user research.



16.9 VO chart indicating both hard and soft quality attributes

Our iNPD method helps teams understand the importance of the soft quality attributes and provides tools, such as the VOA, to help them include these attributes in the product they are creating.

Conclusion

The fuzzy front end can be navigated effectively with the use of methods and tools specifically developed to maximise that part of the product development process. This process requires a commitment by management to support the use of multiple disciplines working in an integrated way, driven by valuable insights gleaned through qualitative research with intended customers.

A product development process that helps the user through the process can lead to effective and efficient downstream product development. The key is to translate the understanding of key stakeholders into VOs that can be translated into product criteria. A key attribute of the success of such a process is to recognise the advantage of both hard and soft quality features.

Devoting resources, including time, to the early stages of product development leads to a more balanced product with fewer downstream development problems. More important, it helps companies develop products and services that meet the needs and opportunities of the experience economy.

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