

CHAPTER



Products and Quality

What Is the Situation?

The perfect product would be a win for everyone: the makers would become personally fulfilled and wealthy, while the users would be forever grateful because their lives would be so improved. Distributors would be ecstatic because of the demand for the product, and the media would seize on it because of its obvious positive impact. The government would love the perfect product because the balance of payments would be improved, and environmental groups would respect it because it would not use limited resources or pollute the ecosphere.

Of course, there are no perfect products, but there have been some awfully good ones: the spring clothespin, the Volkswagen Beetle, the paper clip, the user interface developed initially by Xerox and further by Apple and Microsoft, the shovel, the DC-3, the Barcelona chair. What distinguishes these from similar products that were apparently not as good: the Pontiac Aztec, the first Apple laptop, the Chernobyl nuclear plant? Why do some products considered outstanding disappear? How do we explain products that are constantly criticized but seem to be eternal favorites, such as the Barbie doll, high-heeled shoes, and toy firearms?

Why do we accept the many day-to-day annoyances we live with? For example, why must we spend so much time playing nursemaid to our computer systems? They're supposed to serve us. Wouldn't it be nice if automobiles all had their gasoline filler caps in the same place and had clocks that did not require reading the owner's manual to reset them? Shouldn't it be possible to more easily open the packages that keep us from our new purchases? Why is it so difficult to find products that are consistent with the needs and desires of those who deviate from the norm, whether in physical dimensions and capability, intellectual interests and background, or sensitivity and taste? There are many people like me who find it difficult to leap agilely from low-slung chairs and who aren't happy campers when confined to a tourist-class seat on a long flight. These problems mostly have to do with the fit between products and the human user, but products also suffer from poor performance and overly high prices, unreliability, difficult maintenance, crude manufacturing, ugliness, ostentatiousness, unnecessary complexity, representation of people or places users don't like, and destruction of natural beauty and future health.

All products could be improved. You have evidence for this in your personal experience—after you have used a product for a while, you become critical of its specific details and can think of ways to make it better. The potential for product improvement can also be seen by watching products evolve—even though some stay constant for long periods (the straight pin) and others become worse (“classic” models of cars), most become better over time. This is not to say that all products are inherently bad—my grandparents would consider many products now on the market astonishing—it is just that they could be better. Since products are designed and produced by bright, educated, and well-meaning people, however, why *aren't* they better?

Looking at our history, it is easy to see why we are somewhat dazzled by the products of industry. We have only had anything approximating what we now call technology and science for about

one ten-thousandth of our history. We have been farming, domesticating animals, living in villages, and developing tools for 30 times that period, but as a species, we have spent most of our history with a scarcity of food, shelter, and safety, to say nothing of transportation, medical care, and toys. Much of the world's population continues to live in this way.

In the past few hundred years, the miraculous things that we call industrial products have become available. As areas of the world grew richer and more populated, increasing amounts of resources were devoted to producing and consuming these products. These changes worried some people, such as the Luddites and members of the Arts and Crafts movement, but most considered these products wonderful. It is not surprising that we would develop an extreme fondness for things that fulfill our needs.

Since around 1900, industrial products have proliferated. China is a good present example of this process in action, or look at Orchard Road, the retail and entertainment center of Singapore. Any Walmart store in the United States just before Christmas also displays this phenomenon in maturity. But we do have related problems, including huge gaps in access to products between the rich and poor, weapons that can destroy unacceptable numbers of innocent people, an increasingly contaminated ecosphere, an ominously growing population, soaring expectations, and industrially produced products that should serve us better. Exponential growth, however, never continues forever, despite the hopes of some economists and the theories of Adam Smith, nor do empires, religions, companies, or values. Industrial products and the process that brings them to us will be as different (or more so) 100 years from now as they were 100 years ago.

Future Trends: Population Growth and “Taste”

Future trends in industrially produced products will obviously serve a society with different needs, as populations continue to

grow (for a while at least). It can only be hoped that poor individuals will also continue to become wealthier. Will we increase the number of products we produce and consume forever? No—the finite nature of the Earth places limits on us, and it will be a long time before we build cars on the moon. Also, there is a tendency among individuals to become more discriminating about products. As we acquire more money, products, and experience, we are not as tempted to buy things simply because they are cheap or we want new toys. The very wealthy, for example, do not especially buy more products. If Bill Gates were to keep up with me in number of products per dollar of net worth, he would have to fill several thousand houses and yards.

Will “taste” change? Most assuredly. We have all gone to enough museums, read enough books, and studied enough history to know this. I have been fascinated over my 40 years at Stanford University to watch the frequent and radical changes in students’ desires for products, starting with the anti-industry hippie days when students were listening to folk LPs, playing acoustic guitars, and wearing bell-bottoms and ending with today’s students sporting shorts and athletic shoes while plugging into iPads and laptops, with cell phones in hand. In the interim, there has been continual movement.

Whatever the situation will be in the future, product quality will be essential to business success. Most products are produced by businesses interested in making money for their owners and growing. An essential part of these goals is retaining and motivating high-quality employees. Increasing product quality adds to the pride and satisfaction of employees as well as the reputation of the company. But one way to achieve short-term profits is to decrease expenses by shortening the time to market and lowering the cost of design and production. Another is to decrease expenditures on new product development and product improvement. Both of these will result in lower quality.

Since higher production means lower costs and higher profits, products are promoted by advertising and other means of hawking their advantages (whether real or imaginary) in order to increase demand. Such actions boost sales, but they may also result in disappointment if the products do not live up to their billing. Beyond these factors, we in the United States have a culture that venerates “more”: bigger, faster, and cheaper. In the process, product quality can be, and often is, compromised. Rapid company growth does not always correlate with product quality.

Improved product quality, however, brings added value, increases competitive ability, does not necessarily add to cost, and leads to higher demand. There also seems to be a stable demand for high-quality products that are not cheap. For example, the Apple iPhone is a high-quality product as far as function and appearance is concerned (until the battery fails). At the time of this writing, the International Data Corporation (IDC) claimed that the iPhone had only 4 percent of the world cell phone market at the end of 2010, but it was apparently making 50 percent of the world’s cell phone profit.¹ Apple is fielding many products and services that fulfill the criteria for high quality, and at the time of this writing its gross corporate profit margin was hovering around 40 percent.²

An Example of Quality Improvement

The late 1960s and ’70s were a rude awakening for the United States in all sorts of ways. For me they were especially rude because I innocently moved from a job as an engineer at Caltech’s Jet Propulsion Laboratory (JPL), happily designing lunar and planetary spacecraft, to my life as a professor in a university that was just about to (literally) burst into flames. But certainly, it was a time of questioning and increasing awareness. In the context of

this book, it caused many people to become much more critical of technology, and therefore of products.

Before this time, people would often grumble about products that would fail, or that were unusually inconvenient, but seemed to accept product failures in return for their gifts. When I was a child, my grandfather complained about his Fordson tractor, which would overheat and occasionally threaten to kill him by rolling over backward. But he never seriously considered reverting to horses. My mother cursed her Easy Spindrier washing machine because the clothes would never arrange themselves symmetrically enough in the drying drum to prevent the machine from bouncing into things it shouldn't, but she never wanted to go back to a wringer. My first automobile was a 1941 Chevrolet Club Coupe, and although it would not have done very well on a skid pad, I loved it greatly.

Why shouldn't we in the United States have loved our products more unconditionally in the past? After all, they were U.S. products, and therefore, we assumed, the best in the world. Hadn't we in the United States brought the world the Model T, concentrated orange juice, and the atom bomb? Hadn't we built 300,000 airplanes during World War II? In fact, had not our industrially produced products played the major role in defeating unprecedented evil? If there were problems in the world, technology and its products were helping cure them, not add to them. Weren't there to be cars that converted to airplanes and unlimited free atomic energy in the future? Also, the growth of industry and mass production were the engines of capitalism, which brought us all jobs and money. We could all get richer and buy more and more products.

But I was at JPL because of Sputnik, which delivered a cruel message to the United States in 1957. The dreaded Soviet Union had successfully exploded both atomic and hydrogen bombs by then, but we had been first. Now they had done something that

we had not. The result was the “Space Race,” and since space was fascinating, the technology was exotic, and the country seemed to be uniformly behind beating the Soviet Union in this race, no matter what the cost, how could I not join the Jet Propulsion Laboratory (JPL), which had the leading role in the festivities? As we know, the United States closed the “space gap” and pulled ahead, but to our amazement, people began questioning whether the result was worth the cost. Shouldn’t we be spending the money on such things as hunger, health, and equality? Shouldn’t we clean up our act on Earth before we colonized the moon? The 1960s were happening, and social conscience was beginning to grow.

In the 1960s, environmentalism hit the front pages (Rachel Carson wrote *Silent Spring* in 1962) and we began to worry about the effects of technology and our capitalistic lifestyle upon the ecosphere. In fact, in the late 1960s we began to worry about all sorts of things that most of us had taken for granted, from ethnic and gender biases to abortion rights and social justice. The products of industry were not ignored, but there was relatively little impact upon industrial or government policy at that time.

In the United States, worry about product quality was to come a few years later, when some of our products and industries were first threatened and then displaced by those from other countries. The impressive success of Japan was a particularly large shock, since we had clearly beaten them in World War II and convinced ourselves that they were only capable of making cheap copies of our products.

In 1997, Charles O’Reilly and Michael Tushman wrote an excellent book entitled *Winning Through Innovation: A Practical Guide to Leading Organizational Change and Renewal*.³ In the book they listed the following industries in which the leaders (often U.S. companies) rapidly lost their market share through the 1970s, ’80s, and ’90s:

14 GOOD PRODUCTS, BAD PRODUCTS

Watches	Food processors
Automobiles	Microwave ovens
Cameras	Athletic equipment
Stereo equipment	Semiconductors
Medical equipment	Industrial robots
Color televisions	Machine tools
Hand tools	Optical equipment
Radial tires	Consulting services
Electric motors	Computer hardware
Photocopiers	Textiles
Shipbuilding	Airlines
Software	Financial services
Steel production	

They also named the product class leaders they considered to have become victims to their own success (note the United States companies again), which are shown in the following list. All of them lost market share during this period. Some have recovered. Some have not.

ICI (chemicals)	SSIH (watches)
IBM (personal computers)	Oticon (hearing aids)
Kodak (photography)	Bank of America (financial)
Sears (retailing)	Goodyear (tires)
GM (automobiles)	Polaroid (photography)
Ampex (video recorders)	Bausch and Lomb (vision)
Winchester (disk drives)	Smith Corona (typewriters)
U.S. Steel (steel)	Fuji Xerox (copiers)
Syntex (pharmaceuticals)	Zenith (TVs)
Philips (electronics)	EMI (CT scanners)
Volkswagen (automobiles)	Harley-Davidson (motorcycles)

This shake-up occurred initially in such resource-dependent industries as shipbuilding and steel. The initial reaction in the

United States was bafflement, because we considered ourselves rich in resources, production skills, labor, and management and believed that our products were superior. Our rationalization on the success of our competition was that they were cheating through use of low wages, government-industry collusion, and unfair trade practices. However, we then began losing markets in higher value-added products (consumer electronics, automobiles, machine tools) and foreign products began to be seen as “better.” Our trade balance suffered as we imported more and exported less. And now that many of these “overseas” companies are manufacturing in the United States, it is difficult to think that countries such as Japan were cheating through low wages and industry-government collusion. We had to accept the fact that they had simply moved ahead of us.

Finally admitting that something was amiss, the United States focused on improving one particular aspect of product quality—*manufacturing quality*, an area neglected after World War II that was particularly approachable by the technical and quantitative thinking of industry. The campaign to improve manufacturing quality has been remarkably successful, both in the United States and in other industrialized countries. The benefits have ranged from increased product reliability (100,000-mile automobile warranties), to cost reduction (remarkably reduced reject rates), to appearance improvement (fits and finishes).

I had the pleasure of watching this process in action in many companies, but particularly at Hewlett-Packard and Ford Motor Company. The CEOs of these two companies, John Young and Donald Petersen, put manufacturing quality improvement at the top of their priorities, and it trickled down to all levels of the companies. The programs resulted in astonishing improvements in the reliability of their products, cost savings, communication between different functions and disciplines, and pride among the employees. U.S. companies in fields such as automotive and electronics learned from companies like Toyota and were able to

catch up with the Japanese. A major focus on the improvement of manufacturing quality was to decrease defects and part variability. These factors are key in improving any sort of process quality as focusing on small process details can lead to large improvements.

There were major changes in organizational structure and procedures that were instrumental in improving manufacturing quality, including the strengthening of functional interaction, particularly between designers and manufacturing people. The old approach of “throwing it over the wall,” in which designers would complete the design and then ship it to manufacturing, was successfully suppressed, resulting in “design for manufacturing” and increased sensitivity to the manufacturing process. Although designers and manufacturing people lost the pleasure of blaming each other for product problems, the products benefited a great deal. Other benefits came from inaugurating stronger supply-chain management, which included exporting manufacturing quality approaches to vendors, just-in-time inventory, minimizing investment in backlogged parts and assemblies, and standardizing components and parts.

Responsibility for manufacturing quality was pushed down the organization due to the realization that the actual manufacturers not only knew more about the process than managers but also were the people looking after the quality of the work itself. This helped flatten organizations and create high-functioning teams. Total Quality Management (TQM), worker empowerment, motivation of and close work with suppliers, encouragement of creativity in the manufacturing process, and use of more sophisticated quantitative approaches to eliminate waste and improve output all became common. Companies also learned to design more flexible assembly lines and products that could be more easily manufactured.

Unfortunately, not all companies had such campaigns, and it is not clear that the effort has remained as strong in those who

did. W. Edwards Deming and Joseph M. Juran, the original quality gurus who moved to Japan and inspired breakthrough efforts in increasing manufacturing quality there after their teachings had little response in the United States, taught that improving manufacturing quality was to be an ongoing goal. Unfortunately, I suspect that once the United States learned the new game, many U.S. manufacturers relaxed again. The effort spent on this “revolution” was immense, as was its success, but it did not broaden into a revolution in overall product quality. Manufacturing quality, and not necessarily overall quality, was the focus. Improving manufacturing quality was consistent with the quantitative approach preferred by managers and engineers in industry, so it was possible to use measurements and metrics to set specific goals, while overall quality, less susceptible to such tools, sometimes fell by the wayside.

Beyond Manufacturing Quality

We can learn a great deal from the successful campaigns to improve manufacturing quality. For instance, we know that it is possible to dramatically improve product quality, but it may take major setbacks to cause this to happen. Hopefully setbacks are not omnipresent, but it certainly was the case with manufacturing quality in the United States. In U.S. industries where high product reliability was required, such as military missile and spacecraft manufacturing, attention to manufacturing quality was essential. But many industries simply paid no attention. U.S. competitor countries had been severely set back during World War II, and the United States was rightfully impressed with itself for its manufacturing ability. The post–World War II demand for products was huge. Profits could be high. And when things are good, people unfortunately (or fortunately) act as though they will remain that way—witness the economic

“bubbles” and subsequent “busts” of the 1990s and early part of this century. Think of the companies that have gotten into trouble because they delayed too long in moving to a new technology or those that do not realize performance criteria are changing.

Since U.S. companies had been successful for so many years, they saw no reason to change their practices. Large inventories were comforting, and it was assumed that inspectors could ensure adequate quality. Companies, especially large ones, became complacent with success and underestimated the time and effort it would take to change. And improving quality requires change. Procedures defining allowable deviations in part dimensions were developed during the long period when humans controlled machine tools, so shouldn't they work fine when computers took over? Instead of worrying about production details, top managers saw their jobs as more financial. It took the competition of Japanese companies, using the tools of Juran and the approaches of Deming, among others, to wake the United States up.

It also takes effort to maintain a program to increase quality. Unfortunately, business goals and management theories run in cycles. For instance, the hot topics at the time of this writing seem to be *innovation* and *entrepreneurship*. There is little in the media anymore about manufacturing quality—the little attention that exists is oriented toward potentially radical changes through continued advancement in digital technology, such as products built by three-dimensional printers, input directly by designs created with computer modeling programs. Much of the interest in innovation is focused on breakthroughs in technological processes, applications of the Internet, and discovering the next “big thing” (nanotechnology, for example) rather than toward improving overall product quality.

Could we improve overall quality as radically as we improved manufacturing quality? I think so. And in fact we could use many

techniques (goals, benchmarking, rewards, better understanding of the components of quality) utilized in those earlier campaigns to do so.

Global Competition

Fortunately (or worrisomely), the United States has an excellent motivation to increase overall product quality: global competition. Industries in many, if not most, other countries are devoting increasing effort to developing higher-quality products. Airbus is successfully competing with Boeing, and U.S. streets are featuring more German and South Korean cars. The United States is reliving the 1970s and 1980s fears of Japan in the present concern with China, whose name appears on so many products bought in the United States nowadays.

Like many emerging economies, China began its surge on the basis of cost. I bought my first Chinese drill bits about 15 years ago. A full set of fractional, numerical, and letter sizes in a metal box cost just \$39.95—unbelievable. My friends laughed at me and said the bits would break. Indeed, they did just that. I just bought another set a year ago—still for about the same price. None of them have broken! China is climbing the quality curve due to practice, education, and the experience of manufacturing components and products for leading industries based in other countries that have higher quality standards. China is also focusing on indigenous products, in which quality is also rapidly rising. China's companies are even broadening their competencies. For example, the country is extremely competitive in international large-scale construction. The new eastern span of the San Francisco–Oakland Bay Bridge contains 24 huge steel modules, each half the size of a football field, manufactured in China and shipped to the United States. Attention gained through local projects such as the Beijing Capital International Airport, and the

Three Gorges Dam has resulted in successful large-scale projects from Saudi Arabia to New York City.

India is coming online as a major player in product exports. It is also following the trend toward higher overall quality, realizing that quality *is* value and there is more profit in higher value-added products. Contrary to old assumptions, the United States does not have a monopoly on good engineers and managers, creative approaches to production, or outstanding marketing and design ability—countries such as India are catching up.

Increased visibility of foreign products in the international marketplace is no surprise to those of us who teach in universities and travel extensively. In the United States, foreign students have been top performers in schools for a long time: the old saw that they are good at theory but bad at application and low in creativity has never been true. Neither is it true at present that U.S. engineers are better because they grew up on farms or spent their youth working on cars and radios. There aren't that many farmers anymore, and cars and radios are no longer easy to repair without proper equipment and a great deal of specific knowledge. It is pretty easy to change ignition points in an older car—you can set them fairly well by eye—but you can't diagnose a modern ignition control system in the same way.

In fact, present U.S.-born engineering students are more typified by their performance in high school math and science courses than their skill at application and their creativity. There is nothing inherently superior about U.S. thinking. A stable economic base and national priorities are all that is needed for engineers worldwide to do outstanding work. If companies are short on required specialties, they can hire them. Nor does U.S. birth automatically guarantee that U.S. businesspeople are better than those overseas. We in the United States have always acknowledged the abilities of managers in European countries, but we are now becoming educated about the abilities of those in other parts of the world as well.

The business ability of Indians, Japanese, Singaporeans, Chinese, and people from other Asian countries is startlingly apparent in businesses ranging from doughnut shops to Silicon Valley start-ups. Consider the people who run the Tata Group in India, which consists of 114 companies that create products ranging from tea to steel and from agrichemicals to Jaguar automobiles. Their 2009 release of the Nano, known as the one-lakh car because it only costs around 100,000 rupees, or one lakh (about \$2,500), suggests innovative ability as well.

Onward

Improving product quality must pervade all aspects of an organization. It requires a high-priority effort at all levels and in all functions of a company, which means that the board of directors, CEO, and other top managers must be believers. A goal of universal pride throughout the company from being associated with delivering products that are the best in their class and an appropriate reward and recognition system must be established. Companies producing high-quality products must have a high degree of interaction between all functions, disciplines, and levels of management. In particular, engineering, manufacturing, and marketing need unusually good communication and understanding of each other's capabilities, techniques, and goals. A company seeking higher-quality products should also have a high level of traditional skills in solving engineering and business problems, since sophisticated technology, business ability, and an increasing number of disciplines and approaches are required in producing even simple products.

Pricing and profit receive considerable attention in most companies, as do strategy and the setting of goals, although one can argue about the amount allocated to product development and improvement and the overall attention paid to quality. In the

early days of Hewlett-Packard, the founders decided that company growth would be determined by the need to provide enough resources to keep new product development strong and engineers motivated and proud of the product line, and that their products would be the best of their kind. This goal required strong growth, but it is definitely different from a goal simply of beating the profit made in the corresponding quarter of the previous year.

Chapter I *Thought Problem*

Choose an industrially produced product that in your opinion exhibits extremely high quality, and one that has extremely low quality. In each case, speculate why this is so. In the case of the low-quality product, what could be done to increase its quality? Could this be done without increasing its cost? If so, why do you think it has not been done?

In the class from which this book grew at Stanford, the students are asked to write a short paragraph justifying their choices. We also encourage them to search widely so they don't all converge on their favorite Apple product and their most hated piece of software. The students' choices and speculations appear on the website of the course so that they can see each other's thinking, which makes for good discussion material. Fortunately for the popularity of the books I write, I am not able to give required assignments to readers. But you might find it interesting to discuss your choices in these exercises with friends, coworkers, your girlfriend or boyfriend, or, if you have a good marriage, your spouse.
