Delighting Customers with Quality Function Deployment: *Voice of Customer meets Voice of Process*

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Abstract
W. Edwards Deming is widely acknowledged as planting the seeds of statistical process quality control in Japan. The Japanese, as willing learners, carried forward his use of data-driven management into broader company-wide applications. One of these applications, Quality Function Deployment (QFD) begun in 1966,[1] applies Deming's quality principles to the field of new product development. The goal of QFD is to uncover positive quality that will excite the customer, and then to assure the quality of all downstream activities in design, manufacturing, service, etc. This paper will explain some of the modern QFD tools with examples.

Key words
Quality Function Deployment, QFD, Deming

The Influence of Dr. Deming in QFD

Among Dr. Deming's legacies are his 14 Points for Management, the red bead experiment,[2] and the System of Profound Knowledge.[3] These permeate the QFD process in many ways. Elaboration of the 14 points shows the following influences.

1. Constancy of purpose in QFD means to improve tomorrow's products to help people to live and work better – to bring value to the customer. **3.** QFD is a quality assurance approach by solving/preventing problems and creating positive value during design and development. Inspection is used to validate that quality has been achieved and maintained. **4.** When customers seek a single source supplier we call that brand loyalty. QFD helps product developers understand which customer needs are key to repeat and referral business. **5.** Reducing waste and variation in "chief quality characteristics" is aided by QFD tools such as the House of Quality (HoQ) which quantifies which quality characteristics are critical to customer satisfaction. **6.** Modern QFD implementation is custom tailored for each organization and training is done on real projects. **7.** Deming replaces supervision with leadership – developing stable systems that assure quality. QFD creates a reproducible process for identifying the intent of a new product and translating the intent into design and the actual product. **8.** Fear of knowledge is replaced by having customer satisfaction drive innovation and development. **9.** QFD promotes cross-functional teams consisting of marketing, sales, R&D, engineering, design, manufacturing and production, procurement, quality, service, etc. **11.** QFD is one of the methods to achieve numerical management goals for revenue, market share, profitability, etc. **12.** Pride in a job well done, but in whose eyes? QFD clarifies what the customer needs and then translates that

Deming's 14 Points

1. **Create constancy of purpose for the improvement of product or service.**
2. **Adopt the new philosophy.**
3. **Cease dependence on inspection to achieve quality.**
4. **End the practice of awarding business on the basis of price tag alone. Instead, minimize total cost by working with a single supplier.**
5. **Improve constantly and forever every process for planning, production and service.**
6. **Institute training on the job.**
7. **Adopt and institute leadership.**
8. **Drive out fear.**
9. **Break down barriers between staff areas.**
10. **Eliminate slogans, exhortations, and targets for the work force.**
11. **Eliminate numerical quotas for the work force and numerical goals for management.**
12. **Remove barriers that rob people of pride of workmanship. Eliminate the annual rating or merit system.**
13. **Institute a vigorous program of education and self-improvement for everyone.**
14. **Put everybody in the company to work to accomplish the transformation.**

into key activities at every level and department in the organization.**14.** QFD diagrams how each stage in product development works with the next and preceding stages toward quality the customer will "boast about."

The Red Bead Experiment (Figure 1) was demonstrated by Dr. Deming to the Japanese (they misunderstood him and offered him beans instead). Deming showed the futility of rewarding or punishing production workers when the source of the undesirable red beads was the supplier selected and the process created by management. QFD might raise the question, though, why does the customer demand white beads? Could the specifications be wrong? What is their purpose? If the customer wishes to decorate a heart-shaped box of chocolates, perhaps the inclusion of red beads might be even more attractive to the consumer than just white beads. In other words, QFD encourages the product development team to go beyond stated customer specifications and understand the true needs underlying them. After all, customers may not be as expert in the supplier's domain.

Figure 1 Red bead experiment

System of Profound Knowledge is expressed by the "F" in QFD. Dr. Shigeru Mizuno, who cofounded QFD with Dr. Yoji Akao,[4] applied function analysis to the product development organization in order to optimize its performance as a **system**. This is critical for cross-functional teams because though they may share a common project goal, they are evaluated and rewarded by their functional managers. In other words, a purchasing department goal for 10% cost reduction could conflict with a costly new product feature that delivers the most value to the customer. QFD can deploy customer needs into cost targets to justify the need to spend more on certain components in order to deliver maximum customer value.

Managing **variation** requires mathematical precision. While traditional QFD methods misapplied ordinal scale numbers, modern QFD has improved precision by converting to ratio scale numbers using Saaty's Analytic Hierarchy Process.[5] Prioritization in multi-criteria decision making was advanced by the research of Dr. Thomas Saaty in the 1970s at the U.S. Department of Defense and later at the Wharton School of Business at the University of Pennsylvania. Saaty found that decision makers facing a multitude of elements in a complex situation innately organized them into groups sharing common properties, and then organized those groups into higher level groups, and so on until a top element or goal was identified. This is called a hierarchy and when making informed judgments to estimate importance, preference, or likelihood, both tangible and intangible factors may be included and measured. The Analytic Hierarchy Process (AHP) was created to manage this process in a manner that captures the intuitive understanding of the participants and also yields mathematically stable results expressed in a numerical, ratio scale. A numerical, ratio scale is preferred for the following reasons:

- Numerical priorities can be applied to later analyses to derive downstream priorities.
- Ratio scale priorities show precisely how much more important one issue is than another. Ordinal scales only indicate rank order, but not the magnitude of importance.
- Numerical scales can be tested for judgment inconsistency, sensitivity, and other useful properties.

Process variation is a natural concern for customer satisfaction. In QFD, production, assembly, and service variation is addressed through statistical quality control, process improvement, and worker training, much as in every quality improvement effort. Function analysis of non-manufacturing processes including marketing, engineering, planning, etc. spread the quality message to all business activities that affect product quality.

Theory of Knowledge describes management's role in prediction. In QFD, product developers pair data from the market (voice of the customer) with data from company activities (voice of the process) in order to predict which internal processes (design, build, service) are most critical to satisfying the most important needs of the most important customers. **Knowledge of Psychology** is used to invigorate productive development teams by allowing downstream processes a role to play in upfront decision making that improves their work. Also, understanding customers and their work or life by analyzing their processes encourages new products that aim to improve customer and consumer experience. Thus, the demands of the customer become the external authority that aligns developers and builders to do their best.

Fundamentals of QFD

Traditional approaches to assuring quality often focus on solving problems within the work process, whether it is manufacturing, service, or software. However, consistency and an absence of problems are often insufficient to create lasting value for the customer, especially when customers are more demanding. With traditional quality approaches, the best you can get is nothing wrong – but is this good enough? In addition to eliminating negative quality, we must also maximize positive quality end-to-end throughout the organization. This creates value which leads to customer satisfaction.

Quality Function Deployment is a comprehensive quality system aimed specifically at satisfying the customer. It concentrates on maximizing customer satisfaction (positive quality) by seeking out both spoken and unspoken needs, translating these into actions and designs, and communicating these throughout the organization end-to-end. **(Figure 2)** Further, QFD allows customers to prioritize their requirements and benchmark us against our competitors, and then directs us to optimize those aspects of our product, process, and organization that will bring the greatest competitive advantage. Most projects cannot afford to apply limited financial, time and human resources to low priority issues. With budgets, time, and personnel always limited, QFD helps organization get their biggest bang for the buck by enabling a data driven approach to allocating constrained resources. Priorities can be derived using psychologically friendly judgments that can be transformed, based on sound mathematical principles, into proportioned weights they can be used to calculate money, man-hours, and staff.

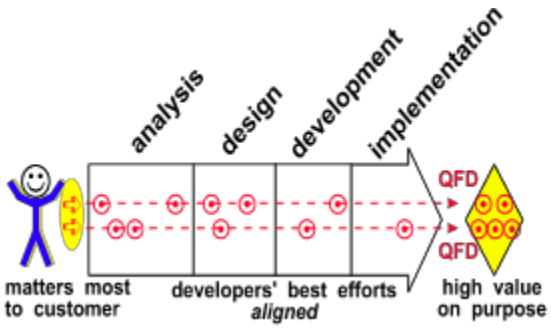

Figure 2 QFD Aligns Development Efforts to Assure Value to Customer

The underlying principles are as follows. Voice of the Customer analysis helps identify critical stakeholders and their most important needs. Cause-and-effect helps clarify the complex relationships between different levels of design. Prioritization facilitates compromise by limiting the scope of the issues, assembling relevant data, and building a defensible argument of the conclusions.

Voice of the Customer

Early QFD concerned itself primarily with end-to-end alignment of requirements in the production side of the organization. As internal business processes improved, QFD began to look upstream at where the requirements came from and where improvements could be made. As a result, QFD encouraged marketing and sales input, traditionally the most customer oriented. In recent years, QFD has devised numerous tools to bring this fuzzy front end into clearer focus. The problem is exacerbated when customers are not always able to articu-

late what outcome they want, and instead attempt to demand what features the product itself should have. Successful product developers know that just doing what the customer asks is not sufficient, and that by analyzing the stated "voice" they can understand the underlying outcomes and needs. Modern QFD has several new tools to aid this analysis. These tools are engineer-friendly in that they help parse complex customer problems into discreet elements that can be analyzed more easily.

Cause-and-Effect

QFD models the cause-and-effect relationships of customer needs (effect) and design issues (cause).This is especially useful in trying to understand true customer needs that underlie customer words and behavior. Cause-and-effect also helps explain the relationships among product characteristics, process characteristics, and material properties. By parsing complex problems into groupings like customer needs, design characteristics, manufacturing and process characteristics, material properties, etc. and showing their cause-and-effect relationships, technical people can analyze the nature of the design intent and how to achieve it.

Prioritization

The Analytic Hierarchy Process (AHP) is used by customers to prioritize their needs which are then deployed through various levels of design, build, and service to identify critical-to-quality actions and measures to assure the needs are fulfilled. Matrices, like the House of Quality, and tables are often utilized.

Tools of Modern QFD

Early QFD models from the 1960s used cause-and-effect analysis diagrams (Ishikawa or fishbone diagrams) to map customer needs into critical-to-quality characteristics.[6] **(Figure 3)** The concept was that if the causes of negative outcomes could be diagrammed, couldn't the design elements that contribute to positive outcomes, such as customer needs, be identified the same way?

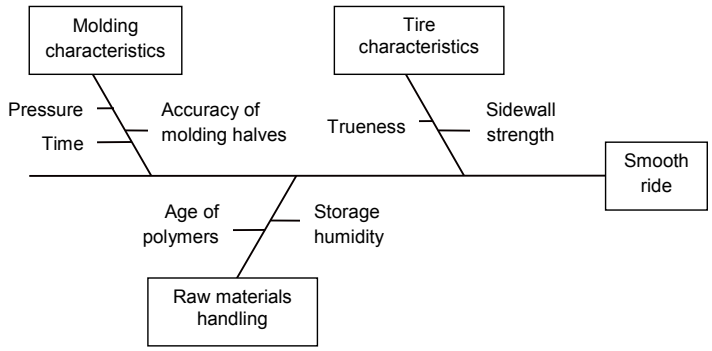

Figure 3 Cause and effect analysis applied to positive outcomes (customer needs)

The above example was from a tire company, and its success led, by 1972, to more complex applications such as ship design. This simple diagram was replaced with a more comprehensive series of matrices, the first of which came to be called the House of Quality, due to its various "rooms" or attached tables. **(Table 1)**

In some applications, the House of Quality grew to as many as 1000 customer needs and 1000 technical characteristics, taking two years to complete. And this was only the first of several subsequent matrices necessary to deploy down to manufacturing and production parameters. 21st century businesses rarely have the luxury of time and staff to complete such a comprehensive analysis. This constraint lead to the development of a more streamlined approach called Blitz QFD®. **(Figure 4)**

Table 1 Traditional House of Quality matrix for umbrella

Technical Characteristics / Customer Needs	Size	Number of ribs	Weight	Material dry time	Importance Rating	Our Current Product	Tote	Burberrys	Plan	Improvement Ratio	Sales Point	Absolute Weight	Customer Need Weight
Fashionable	○ 75	△ 25			3	2	1	4	4	2.00		6	25
[illegible]in	⊙ 468	○ 156		△ 52	5	3	2	5	5	1.67	1.5	12.5	52
[illegible]asily	⊙ 36	△ 4	⊙ 36		1	2	1	3	2	1.00		1	4
Stores easily	⊙ 171	○ 57		○ 57	3	2	1	3	3	1[illegible]0		4.5	19
Absolute Weight	750	242	36	109									
Technical Char. Wt.	67			9									
Current Product	90			30									
Tote	80			45									
Burberrys	110	8		[illegible]									
Design Target	100	8	225	20									
Unit of Measure	Dia (cm)	#	g	min									

Leg[illegible]
⊙
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2. Customer satisfaction

3. Competitive Benchmarking

4. Strong causal correlation

1. Business and marketing strategy

5. Multiple correlations summed

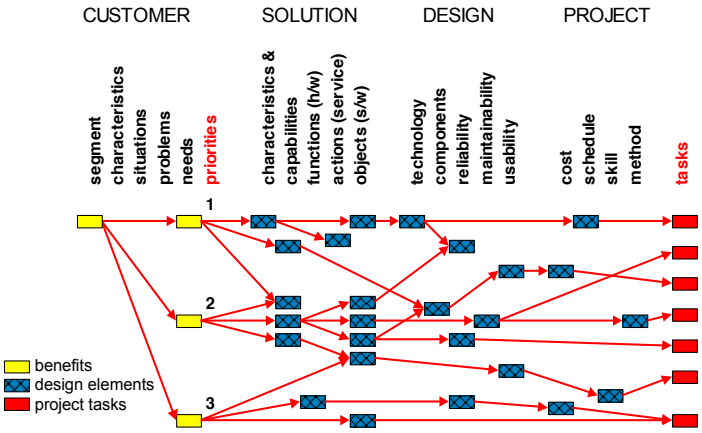
6. Technical Benchmarking

Figure 4 Blitz QFD® flow chart

In this modern approach, the House of Quality and the downstream matrices are optional, "heavy artillery" to be deployed only when deeper analyses are required. Other issues with Traditional QFD have also been addressed in the Blitz QFD® including filtering customer needs out of other Voice of Customer statements and using AHP to correct math problems resulting from improper use of ordinal scale numbers.

The key to Blitz QFD® is limiting scope. As shown in Figure 2 above, only a small number of customer needs are analyzed end-to-end across the organization, while in the House of Quality and downstream matrices, hundreds of needs are analyzed. Instead, only the key data are be included in a single analytic tool, the Maximum Value table, shown in step 6 in the above flow chart. **Table 2** illustrates the conceptual framework of the Maximum Value table, and it is here that the voice of the customer (needs) meets the voice of the process (solution, design, and project requirements). In essence, Figures 2 and Table 2 illustrate the same thing.

Table 2 Maximum Value table links voice of customer to voice of process (Step 6)



Analyzing the Voice of the Customer (Step 2)

Key to narrowing the scope of the QFD process is focus on a small number of customer *needs*. The problem is that customers do not always give us clear statements of need; instead they interleave them in their minds with wants and wishes for product features, and then talk to us about those features. **(Figure 5)** That is because customers are untrained at requirements giving. They have no tools or techniques to fully explore their requirements space. They are average at articulating what requirements they are aware of. You will not get a complete set of requirements from any customer, ever. Further, even if they could, you don't have the time or resources to do all their requirements anyway, do you?

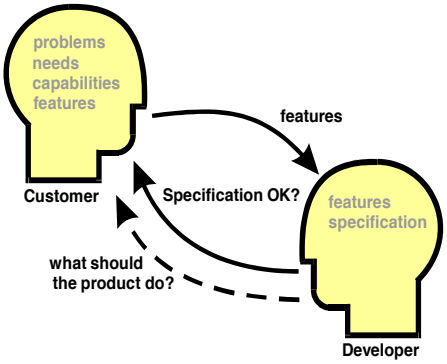


Figure 5 Customers interleave problems, needs, and features

Fortunately, you don't have to completely fulfill all the customer's requirements to satisfy the customer. But to understand why this is the case, we must understand: (1) the relative effect on customer satisfaction of doing certain types of requirements; (2) the relative importance of the customer's requirements, and (3) what 'requirements' are—and how they are different from 'needs' and 'features.' In QFD we take a very different approach to exploring and then engineering requirements. We ask customers to define "value" by telling us or demonstrating important problems they face that prevent them from achieving their personal or business goals, by identifying opportunities they cannot currently seize, and by revealing things that make them look good to others or feel good about themselves. These become the starting point for further analysis.

- Problems (negative statements of what is wrong or what needs to be changed) can be reworded into positive needs or benefits (what to change to)
- Opportunities and image issues which are usually already positively stated, can be reworded into needs or benefits

Remember, customer problems are not the same as complaints or problems with your product. Customer opportunities are not the same as your product features or solutions. Regardless of how the customer ex-

presses himself, his words or behavior must be analyzed for greater breadth and depth of meaning. Don't stop with customer verbatims – they can express the same to your competitors. Advantage belongs to those who make the effort to go beyond the obvious. You must learn both what the customers are saying and why they are saying it. Even if the customer is wrong, it is your responsibility to find out what they really need. *Caveat emptor* has become *caveat vendor*.

Thus, we define customer needs as the positive restatement of customer problems, opportunities, or image issues independent of the product or solution. All other requirements, features, specifications, and technical issues are sorted and translated in the Customer Voice table. **(Table 3)** The example here is from an American health insurance provider, Blue Cross Blue Shield of Florida, trying to develop new products to meet the needs of small to medium enterprises (SME).[7]

Table 3 Customer Voice table for health insurance provider

problems	customer needs	characteristics & capabilities	functions	reliability	technology	information	communications
"Attract and retain key employees"	I can hire best new college graduates						
	I can attract best employees from competitors						
	My employees know exactly what they are entitled to		Publish coverage	Employees feel cheated			"Health plans are easy to understand"

Customer verbatim are in quotations, and include a customer problem statement – "Attract and retain key employees" and a product attribute – "Health plans are easy to understand." Following the arrows, we see that the QFD team translated "attract and retain key employees" into customer need statements of "I can hire the best new college graduates" and "I can attract best employees from competitors." "Health plans are easy to understand" is a product attribute because it is the health plan that is easy to understand, not the customer that is easy to understand. The QFD team saw this as a communication issue to prevent a failure mode of "employees feel cheated." This requires that the insurance company perform the function of "publish coverage" in a way that is clear and complete, so that "employees know exactly what they are entitled to." This analysis is similar to the fishbone diagram shown in Figure 3, where the columns to the right represent the various bones and sub-bones, and the customer needs are the heads. The analogy can be carried further as there is a causal correlation between the bones and the head, with the bones being independent *x* variables over which the insurance company has control, and the heads being dependent *y* variables which are the outcomes of a well designed product. In Design for Six Sigma, this is called the Y=f(X) transfer function.[8] Steps 3-5 in the Blitz QFD® flow chart in Figure 4 then have the customers prioritize their needs, and the key needs are deployed in the Maximum Value table shown in Table 2. Then, if more detailed analyses are required the House of Quality and other tools would be deployed (step 7).

Thus, the Customer Voice table is the modern QFD tool used to translate any customer input into customer needs, which are then prioritized and deployed into solutions and quality assurance activities by a cross-functional team. These various tools are linked in an end-to-end system that can be replicated across different market segments, product lines, and product generations, can be used to predict the effects of quality deci-

sions on customer satisfaction and competitiveness. It can be used to document product and technical knowledge, and aid in the training of new employees, as well.

Conclusion

Dr. Deming's teachings were transformed by the Japanese to carry the quality message to all operations in an organization. When applied to new product development, they called it Quality Function Deployment. As business conditions have changed, QFD has adapted to become faster and more customer focused. The Blitz QFD® approach uses several new tools to understand how to design new products and services that address key customer needs. In the global internet economy of the 21st century, customers have more choice than ever, and success will come to those businesses that make the effort to understand their customers, regardless of where they are located.

About the Author

Glenn H. Mazur has been active in QFD since its inception in North America, and has worked extensively with the founders of QFD on their teaching and consulting visits outside Japan. He is a leader in the application of QFD to service industries and consumer products, conducts advanced QFD research, and is the Conference Chair for the annual North American Symposium on Quality Function Deployment. Glenn is the Executive Director of the QFD Institute and International Council for QFD, Adjunct Lecturer on TQM at the University of Michigan College of Engineering (ret.), president of Japan Business Consultants Ltd., and is a senior member of the American Society for Quality (ASQ), and the Japanese Society for Quality Control (JSQC). He is a certified QFD Red Belt® (highest level), one of two in North America. He is a certified QFD-Architekt #A21907 by QFD Institut Deutschland. Additional papers and related topics may be found at **www.mazur.net**

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