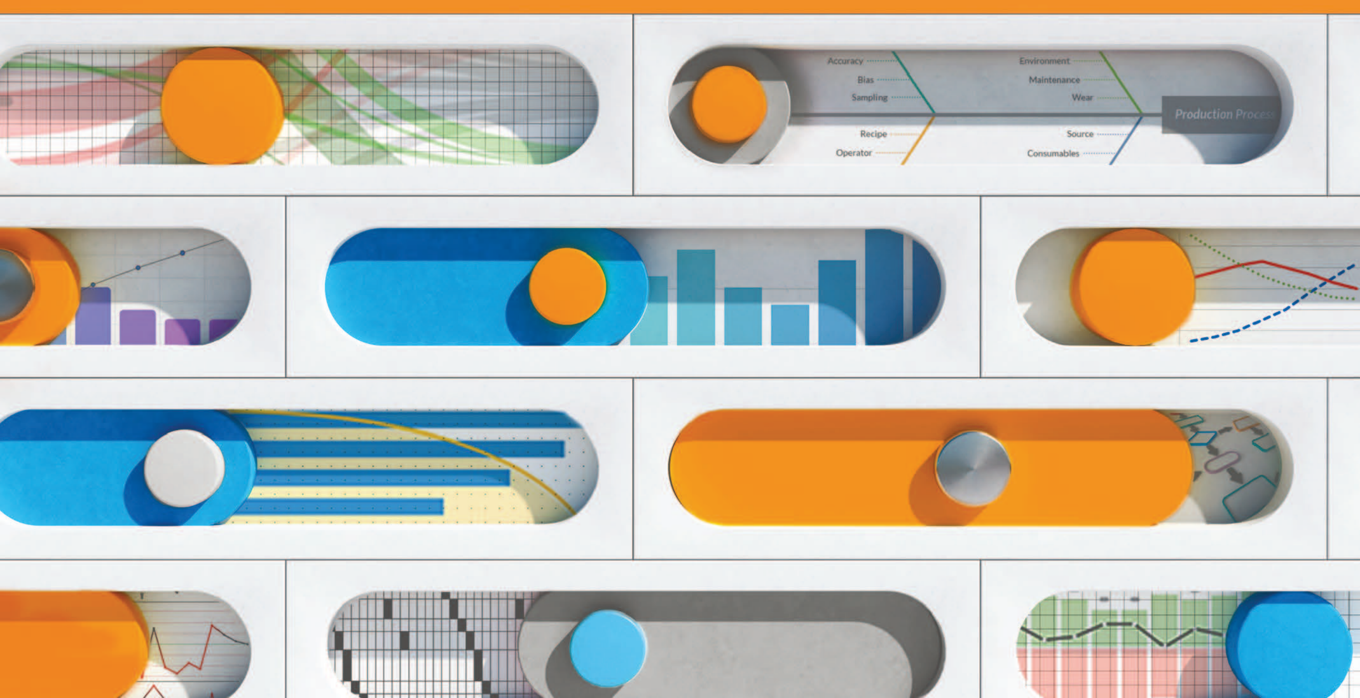
THIRD EDITION

#1 BESTSELLER ON QUALITY TOOLS

THE QUALITY TOOLBOX

NANCY R. TAGUE



The Quality Toolbox

Third Edition

Nancy R. Tague

QUALITY PRESS™

Milwaukee, Wisconsin

American Society for Quality, Quality Press, Milwaukee 53203

Printed in the United States of America

27 26 25 24 23 [LS] 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data
Names: Tague, Nancy R., 1955–, author.
Title: The quality toolbox , third edition / by Nancy R. Tague.
Description: Includes bibliographical references and index. | Miwaukee, WI: Quality Press, 2023.
Identifiers: LCCN: 2023945885 | ISBN: 978-1-63694-122-6 (paperback) | 978-1-63694-123-3 (pdf) | 978-1-63694-124-0 (epub)
Subjects: LCSH Quality control. | Production management--Quality control. | Organizational effectiveness. | Industrial management. | BUSINESS & ECONOMICS / General | BUSINESS & ECONOMICS / Development / Business Development | BUSINESS & ECONOMICS / Leadership | BUSINESS & ECONOMICS / Organizational Development | BUSINESS & ECONOMICS / Production & Operations Management | BUSINESS & ECONOMICS / Quality Control | BUSINESS & ECONOMICS / Strategic Planning
Classification: LCC HD30.28 .T33 2023| DDC 658.4/036—dc23

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For my parents

who taught me the most important lessons about quality
and who have always believed in me.

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Preface

The idea for this book originated when a group of facilitators in my company, well down the road of quality improvement, asked me to teach them new tools to use with their quality teams. They were stuck in a rut of using just a few familiar standards: brainstorming, multivoting, and fishbone and Pareto diagrams. They had limited knowledge of the wide selection of methods and techniques that can be used in quality improvement. I became frustrated by how few of the available tools could be taught in a training session, so I decided to create a reference that they could use to locate and learn new tools on their own.

After asking "What tools exist?" the facilitators asked "When do we use them?" They knew more tools than they commonly used, but they did not know how to choose and apply the tools at the appropriate times during the process of quality improvement. So woven throughout the handbook was guidance on fitting the tools into the quality improvement process.

Groups just getting started with quality improvement also used the handbook. It gave them more confidence with the basic tools and the quality improvement process they had just learned. It also provided a way for them to continue learning just-in-time, as they encountered a need for new methods. Team members, facilitators, and team leaders all had copies of the Toolbox on their shelves and referred to it between or during meetings.

The first published edition of *The Quality Toolbox* in 1994 was an expansion of that original handbook: a comprehensive reference to the most commonly used methods and techniques for quality improvement, including many that were less commonly used, plus a half dozen that I had created and were not available elsewhere. Tools were included for generating, organizing, and evaluating ideas, analyzing processes, determining root causes, planning, and basic data-handling and statistics.

By the time the second edition was published, the value of other tools, especially statistical ones, had become more widely acknowledged. Thanks to Six Sigma, statistical tools such as hypothesis testing, regression analysis, and design of experiments, which had always been powerful tools for understanding and improving processes, were used more regularly within quality improvement projects. A variety of previously lesser-known nonstatistical tools were also taught by Six Sigma, lean, and other methodologies that had become widespread. The second edition also added some tools from other fields, such as the social sciences, that had recently been adopted into quality improvement.

Some of the tools—for example, design of experiments and benchmarking—are too complex to be learned from the description in the book, but an overview was provided so the reader would know when a tool was appropriate, or even essential, to the improvement process and would be encouraged to use it, with expert assistance.

The second edition included examples from a wider range of applications, such as education and healthcare, and detailed case studies from Baldrige Award winners. A new chapter put the tools into two contexts: the historical evolution of quality improvement and the quality management systems within which the tools are used.

The ten years between the first and second editions coincided with an explosion in the use of computers. The second edition recognized the computer as a valuable assistant to remove drudgery from many of the tools' procedures. However, it was critical for users to know the tool well enough to set up the computer's task and to understand and act on the results the computer provided, and the book gave the reader that knowledge.

Also, icons had become familiar for navigating computers, so I included icons with each tool description to help the reader know what kind of tool it was and where it was used within the improvement process.

It has been almost twenty years since the second edition. The many thousands of readers who have come to depend on *The Quality Toolbox* as a standard reference on their bookshelf deserve a new edition that reflects the changes in quality practice during that time. In this third edition, the content has been brought up to date while retaining the features that have made it so useful.

Chapter 2, "Mega-Tools: Quality Management Systems," has been updated to continue the historical evolution of quality improvement, especially changes to the major quality management systems. Throughout the book, revisions were made to include innovations in the use of traditional tools, to write procedures and explanations more clearly, to update examples, and to reflect changes in terminology.

When I wrote the second edition, I learned that I could spend years discovering the many varieties of quality improvement methodologies and the numerous creative applications of tools for improving work processes. At some point, I had to say "Enough!" and send the book to print. This third edition became an opportunity to include more tools, especially some that are key to Six Sigma and FMEA, or are widely applicable to most quality improvement processes. And finally, the Resources section has been updated to include more current references and internet links, while still including original sources for classic tools.

Above all, I retained the book's original purpose and value. *The Quality Toolbox* is an instruction book, where the reader can find and learn new tools or discover new variations or applications of familiar ones. It was written and organized to be as simple as possible to use, without a teacher. It also is a reference book, organized so a half-remembered tool can be found and reviewed easily and so the reader can quickly identify the right tool to solve a particular problem or achieve a specific goal.

With this book close at hand, a quality improvement team becomes capable of more efficient and effective work with less assistance from a trained quality consultant. As well, quality and training professionals have a handy reference, a training aid, and a quick way to expand their repertoire of tools, techniques, applications, and tricks.

I hope *The Quality Toolbox* continues to help teams and their advisors work more easily and effectively together, improve the quality of their processes, create value for their customers—and perhaps inspire them to innovate and create new approaches in quality.

—Nancy Tague

Acknowledgments

The tools of quality improvement have been developed by many people over a long period of time. Some of the toolmakers are well known, but many of the tools have been talked and written about so often that their origins are lost. I have been able to identify originators of many of the tools and have given credit to their inventiveness in the Resources section. I am equally grateful to those whose names I do not know. Everyone who has contributed to the body of quality knowledge has helped us all find the satisfaction of learning, improving, and becoming just a bit more excellent.

Creating this book required the guidance and help of many people. My first teachers, mentors, and colleagues in quality improvement were Tom Dominick and Mark Rushing, and I am grateful for the experience of working with both. Tom introduced me to quality improvement as a discipline and shared his enthusiasm for the value of quality methods in an organization. He taught me to borrow, adapt, and customize from many sources. Mark's depth of understanding, innovativeness, and integrative thinking make him a source for a wealth of ideas and insight. I have learned much from working beside him and from our conversations about new ideas and applications.

Too many people to name individually have helped me understand the concepts and methods of quality improvement, especially my colleagues in quality. My thanks to each of you who have shared your ideas, successes, and failures with me. I am grateful to all the people of Ethyl and Albemarle Corporations, whom I have taught and learned from, as we labored together to apply these methods to improve our work and organizations.

I am indebted to my colleague, Dave Zimmerman, who created initial drafts of several tools when this book was first expanded beyond a thin compendium of the most basic ones. He first brought brainwriting and list reduction to my attention. The entertaining example for the importance–performance analysis was also devised by Dave.

For the second edition, many people were generous with their time and knowledge. My thanks to Romesh Juneja for sharing his perspective on Six Sigma and to Sharron Manassa for invaluable research assistance. When I searched for applications outside my experience, many people generously stepped forward with experiences and insight that made the examples and case studies come to life. Thanks to Lance Casler, Anne

Papinchak, Traci Shaw, and Lyn Tinnemeyer-Daniels of Medrad; Patty Gerstenberger and Alan Huxman of St. Luke's Hospital of Kansas City; Sandy Cokeley-Pedersen and Susan Grosz of Pearl River School District; Pam Misenheimer, Cheryl Niquette, Marsha Plante, and Lesley Steiner.

I am indebted to Roger Berger and Davis Bothe for their painstaking reviews of the second edition manuscript, their awesome attention to detail, and the depth of their knowledge. Their comments improved the book greatly.

My thanks to Matthew Barsalou for his help with the third edition. He introduced me to 8D and A3 reports, boundary and parameter diagrams, control plans, Perkin tracker, and changes to FMEA. He dreamed up scenarios for those tools' examples and helped research recent resources. Matthew brought a European perspective as well as broad experience with FMEA and discrete manufacturing.

I am grateful to Giselle Jurkanin and Meredith Krugel for being such good listeners and offering valuable insight and feedback.

Deep appreciation goes to Dianne Muscarello, who provided computer expertise and manuscript review, as well as constant support and encouragement. In addition, she created many of the graphics. I couldn't have done this without her help.

Finally, my gratitude to the readers of previous editions, whose use of the book confirmed that it fills a need. I continue to be amazed and humbled that the toolbox idea has benefitted so many people and organizations. Thank you for using it to improve your workplace and our world.

1
How to Use This Book

A carpenter with only a hammer, a screwdriver, a pair of pliers, and a straight blade saw can build cabinets that are functional, but plain and crude. The carpenter with many different tools at hand will be able to create unique and well-crafted items and solve problem situations.

Like a carpenter's toolbox, *The Quality Toolbox* provides you with a choice of many tools appropriate to the wide variety of situations that occur on the road to continuous improvement. In fact, 148 different tools and variations are described with step-by-step instructions.

What is a quality tool? *Webster's New World College Dictionary* defines a tool as: "Any implement, instrument, or utensil held in the hand and used to form, shape, fasten, add to, take away from, or otherwise change something. Any similar instrument that is the working part of a power-driven machine. Anything that serves in the manner of a tool; a means."[1]

So tools are relatively small, often parts of a larger unit; they do something, and each is designed for a very specific purpose. Thus, concepts are not tools, because they don't do anything, and methodologies or systems are not tools, because they are large and do too many things, although all of these have been called tools. Quality tools are the diagrams, charts, techniques, and methods that, step by step, accomplish the work of quality improvement. They are the means to accomplish change.

If the *Toolbox* were only a step-by-step guide to many tools, it would be difficult to use. No one wants to read such a book cover to cover. How can you know a tool will be useful if you don't already know the tool? Several aids help guide you to the right tool for the situation.

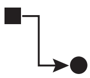
THE TOOL MATRIX

The Tool Matrix (Table 1.1 at the end of this chapter) lists all the tools in the book and categorizes them in three different ways to help you find the right one. To search for a tool, ask yourself three questions:

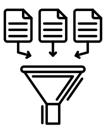
1. *What do we want to do with this tool?* A carpenter who wants to cut something will look for some type of saw, not a screwdriver. Quality improvement tools also can be grouped according to how they are used.

Project planning and implementing tools: When you are managing your improvement project.

Idea creation tools: When you want to come up with new ideas or organize many ideas.



Process analysis tools: When you want to understand a work process or some part of a process. Processes start with inputs coming from suppliers, change those inputs, and end with outputs going to customers.



Data collection and analysis tools: When you want to collect data or analyze data you have already collected.

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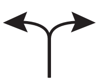
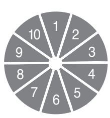
Cause analysis tools: When you want to discover the cause of a problem or situation.



Evaluation and decision-making tools: When you want to narrow a group of choices to the best one, or when you want to evaluate how well you have done something. This includes evaluating project results.

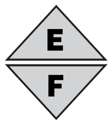
The tools in the Tool Matrix are grouped according to these categories. Notice that some tools show up in several categories. These versatile tools can be used in a variety of ways.



2. *Where are we in our quality improvement process?* A carpenter would use fine sandpaper only when the cabinet is almost done. Some tools are useful only at certain steps in the quality improvement process.

If you are not sure what this question means, read Chapter 3. It describes 10 steps of a general process for quality improvement. This process was deliberately written in ordinary, commonsense language. A translation to standard quality terminology is shown beside it. Your organization's process probably is written differently and has more or fewer steps. However, you should be able to find all the elements of your process in the 10-step process.

In the Tool Matrix, the columns list the ten steps. Each step of the process in which a tool can be used is marked with an X. The versatile tools that appear in several categories often have different steps marked from category to category, as their use changes.



3. *Do we need to expand or to focus our thinking?* The process of quality improvement goes through alternating periods of expanding our thinking to many different ideas and focusing our ideas to specifics.

The expanding period is creative and can generate new and innovative ideas. The focusing period is analytical and action oriented. To obtain results, you eventually must stop considering options, decide what to do, and do it!

See Figure 1.1 for an illustration of how the expand–focus sequence works. To choose the most worthwhile problem to attack, first expand your thinking to many different problems—big, small, annoying, and expensive problems—by analyzing the process and collecting data. Next, focus your thinking: with evaluation tools, use a set of criteria to choose one well-defined problem to solve.

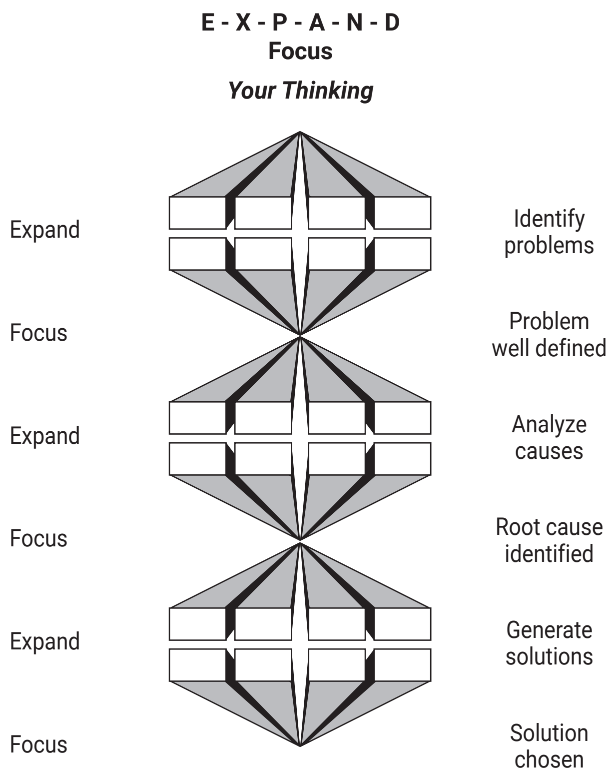


Figure 1.1 Expand-focus sequence.

Now, expand your thinking to many possible causes of the problem using tools like the fishbone diagram or fault tree analysis. *Could it be this? Could it be that? Maybe what's happening is.* After getting lots of ideas, use methods such as data collection, analysis, and logical reasoning to narrow all possible causes to the few that really are the culprits.

Finally, expand your thinking once again to many ways to solve the problem, using tools like idea creation and data analysis. From a variety of solutions, use evaluation tools to choose the one most likely to work in your unique circumstances.

Some tools are designed specifically to help you expand your thinking. Others are designed solely to help you focus. A few encompass both modes: the first few steps of the tool expand your thinking and the final steps lead you through focusing. Some tools can either expand or focus your thinking, depending on how and when they are used. For example, flowcharts can be used to expand your thinking to all possible problems in a process, or they can guide a group to focus on the one way everyone has agreed a process will operate from this time forward.

The third column of the Tool Matrix shows an E for *expansion* or an F for *focusing*. Tools that encompass both modes or that can be used for either purpose are indicated by E/ F.

Example

Let's look at an example of the Tool Matrix in use. Suppose your team has tested a solution; it worked, and you are ready to install it throughout your organization. Suppose that as you are beginning to plan how to do that, your team wants to consider what might go wrong. How do you find potential tools to help you?

First ask, "What do we want to do with this tool?" You need to plan and implement, so look at the Tool Matrix in the group labeled "Project planning and implementing tools." There are 28 tools in that group.

Then ask, "Where are we in our quality improvement process?" You are at step 9: "If it worked, how can we do it every time?" or, in quality jargon, "Standardize." On the Tool Matrix, under the column for that step, you find 24 tools marked with an X.

Your third question is, "Do we need to expand or focus our thinking?" By considering everything that might go wrong, you are expanding your thinking, so you eliminate the 11 tools marked F. That leaves 13 possible tools.

What next? Now you are ready to turn to Chapter 5, the main part of the book, and browse through the tools.

THE TOOLS

The tools are listed in alphabetical order, rather than by categories, so that whenever you know the name of the tool, you know exactly where to find it. Each tool has six sections.

- *Description*. A few sentences explain what the tool is and what it does. In addition, the icons identified under the section "The Tool Matrix" appear again to remind you to what category the tool belongs, at what steps of the process the tool can be used, and whether it is an expanding or focusing tool.

- *When to Use*. This section describes the situations in which you would want to use this tool. A situation might be a particular stage of the quality improvement process, a certain kind of problem, or after another tool has been used. If two or more situations should be true when the tool is used, "and …" links the statements. Otherwise, "or …" shows that the tool can be used if any of the statements are true. "Especially" means that the statement following is a situation where the tool is particularly useful.
- *Procedure*. A step-by-step numbered procedure guides you through using the tool. This section is very basic, so you can always use it as a quick reference.
- *Example*. You are introduced to a situation when the tool was appropriate for a team's situation, and the tool's use is explained. Calculations, the thinking behind various steps, and the conclusions that could be drawn are also explained. Some of these examples are fictional; others are based on actual situations. Whenever a tool involves a chart or diagram, an example or drawing is shown.
- *Variations*. When the tool can have several different appearances or methods, the step-by-step procedure for each variation is written out. Often, examples are provided for the variation. Occasionally, separate "description," "when to use," or "considerations" sections are also necessary. In most cases, the variation has a unique name. Occasionally, it is simply called "variation."
- *Considerations*. This section includes tips, tricks, and warnings—notes to help you use the tool more easily, avoid problems, or add additional flair or sophistication. Thus, this section adds all the detail and color that were omitted from the basic procedure.

Example

Let's return to the example, with your team ready to spread a solution throughout the organization. What happens after using the Tool Matrix to narrow the list of tools to 13? Browse through those 13 tools, reading just the "Description" and "When to Use." When you flip to the *contingency diagram,* you will read, "The contingency diagram uses brainstorming and a negative thinking process to identify how process problems occur or what might go wrong in a plan. Then the negative thinking is reversed to generate solutions or preventive measures." When do you use this? "When planning implementation of a phase of a project, especially the solution," and "Before launching a change." That sounds like exactly what you need.

But you should continue browsing through all 13 tools. You will discover that *potential problem analysis* and the *process decision program chart* are designed for similar purposes and applications. Then, carefully read all sections for each of the three tools to decide which one is most appropriate for your team's situation.

GENERIC TOOLS

If you walked into a hardware store and asked for "a saw," the clerk would respond, "What *kind* of saw?" "Saw" is a name for a broad group of tools; there are many specific saws designed for particular purposes. Similarly, there are several generic kinds of quality tools that can be customized for particular purposes.

For example, "graph" is a general name for a generic tool. There are hundreds of types of graphs—line graphs, bar charts, pie charts, box plots, histograms, control charts, and so on—that have been developed over the years to respond to specific needs or uses for graphs. People have named and described these graph variations so others won't have to keep reinventing the wheel, or the graph, in this case.

Anyone familiar with the general definition of graph—"a visual display of numerical data to achieve deeper or quicker understanding of the meaning of the numbers"—might devise a new way of displaying data to suit a particular need. That type of graph might be used only once, or it might become another named graph that others with the same need could use.

Quality improvement practitioners are creative and inventive, so many tool variations have been devised. This book does not include many that are straightforward applications of the generic tool, which is especially common with check sheets, matrices, and tables. It does include ones that are in some way unique, where there was a creative or conceptual jump between the generic tool and the variation. Separate entries are allotted for tools that have complex procedures (such as the control chart) or a narrower application (such as the decision matrix). Otherwise, the variation is described under the generic tool's listing. Each of the generic tools has its own entry.

So what are these generic tools? Here is a list, with examples of unique variations:

Check sheet and checklist: defect concentration diagram, project charter checklist, guidance questions

Flowchart: deployment flowchart, macro flowchart, process mapping, top-down flowchart, workflow diagram

Graph: control chart, histogram, Pareto chart, run chart, scatter diagram

Matrix diagram: decision matrix, prioritization matrix, house of quality

Table: contingency table, check sheet, stakeholder analysis table, voice of the customer table

Tree diagram: decision tree, fault tree analysis, process decision program chart, why–why diagram

Two-dimensional chart: effective–achievable chart, Kano model, plan–results chart

Learn the generic tools first, and then the variations will be easier.

Once you are familiar with the generic tools, you too might improvise to develop a tool variation that fits a particular need. If it is widely applicable, share your new tool with others.

Now you know how to use this book to identify and learn the tools that are most useful in your specific situation. You might be wondering, "How do all these tools fit together to create improvements?" The next chapter, "Mega-Tools: Quality Management Systems," discusses the organization-wide processes into which the tools fit. Chapter 3, "The Quality Improvement Process," outlines the improvement model and types of tools used each step of the way, and Chapter 4, "Quality Improvement Stories," tells how five companies used the tools to improve their work.

Endnote

1. Michael Agnes, ed., *Webster's New World College Dictionary,* 4th edition (Foster City, CA: IDG Books Worldwide, 2000).

Table 1.1 Tool matrix.

	Tool	E/F	1 Charter & Plans	2 Customer Needs	3 Current State	4 Oppor-tunities	5 Root Causes	6 Changes	7 Do It	8 Monitor	9 Standardize	10 Learnings
Project Planning and Implementing Tools	ACORN test	F	X									
	Arrow diagram	F	X					X	X		X	
	Balanced scorecard	F	X	X	X			X	X	X		
	Benefits and barriers exercise	E						X	X		X	X
	Checklist (generic)	F	X						X	X	X	
	Contingency diagram	E							X		X	
	Continuum of team goals	F	X							X		X
	Control plan	F							X	X	X	
	Five hows	E						X	X		X	
	Flowchart (generic)	E/F	X	X	X	X	X	X	X	X	X	X
	Force-field analysis	E						X	X		X	X
	Gantt chart	F	X					X	X		X	
	Matrix diagram (generic)	F	X	X				X	X		X	X
	Meeting evaluation	F	X	X	X	X	X	X	X	X	X	X
	Mind map	E	X	X	X	X	X	X	X		X	X
	Operational definitions	F	X	X	X	X	X	X	X	X	X	X
	Perkin tracker	F						X				
	Plan–do–check–act (PDCA) cycle	F	X	X	X	X	X	X	X	X	X	X
	Plan–results chart	F								X	X	X
	Potential problem analysis	E/F						X	X		X	
	Presentation	F	X	X	X		X		X	X	X	X
	Process decision program chart	E/F						X	X		X	

Continued

Table 1.1 Tool matrix.

	Tool	E/F	1 Charter & Plans	2 Customer Needs	3 Current State	4 Oppor-tunities	5 Root Causes	6 Changes	7 Do It	8 Monitor	9 Standardize	10 Learnings
Project Planning and Implementing Tools	Project charter	F	X	X	X	X	X	X	X	X	X	X
	Project charter checklist	F	X									
	RASCI	F	X					X	X		X	
	Relations diagram	E/F	X	X		X		X			X	
	SMART goals	F	X									
	Stakeholder analysis	E/F	X	X				X	X		X	
	Storyboard	E/F	X	X	X	X	X	X	X	X	X	X
	Table (generic)	E/F	X	X	X	X	X	X	X	X	X	X
	Tree diagram (generic)	E	X	X	X	X	X	X	X	X	X	X
	Two-dimensional chart (generic)	F	X	X	X	X		X	X	X	X	X
	Wordsmithing	E/F	X	X	X		X	X			X	X
Idea Creation Tools	Affinity diagram	E/F	X	X	X	X	X	X			X	X
	Benchmarking	E/F	X			X		X				
	Brainstorming	E	X	X		X	X	X			X	X
	Brainwriting	E	X	X		X	X	X			X	X
	Desired-result fishbone	E						X				
	5W2H	E	X					X		X	X	X
	Mind map	E	X	X	X	X	X	X	X		X	X
	NGT	E	X	X		X	X	X			X	X
	Nine windows	E	X			X		X				
	Relations diagram	E/F	X	X	X	X	X	X			X	X
	Storyboard	E/F	X	X	X	X	X	X			X	X

Continued

Table 1.1 Tool matrix.

	Tool	E/F	1 Charter & Plans	2 Customer Needs	3 Current State	4 Oppor-tunities	5 Root Causes	6 Changes	7 Do It	8 Monitor	9 Standardize	10 Learnings
Process Analysis Tools	Benchmarking	E/F	X			X		X				
	Boundary diagram	E			X	X						
	Cause-and-effect matrix	F	X	X								
	Cost-of-poor-quality analysis	E			X	X	X					
	Critical-to-quality analysis	E		X	X	X	X					
	Critical-to-quality tree	F		X	X	X						
	5W2H	E			X	X					X	
	Flowchart (generic)	E/F	X	X	X	X	X	X	X	X	X	
	FMEA	E/F				X	X				X	
	House of quality	F		X	X	X						
	Matrix diagram (generic)	F		X	X	X			X	X	X	X
	Mistake-proofing	F						X	X		X	X
	Parameter diagram	E		X	X	X						
	Relations diagram	E/F	X	X	X	X	X	X			X	
	Requirements table	E		X	X	X				X	X	
	Requirements-and-measures tree	E		X	X	X				X	X	
	SIPOC diagram	E/F		X	X							
	Spaghetti diagram	E/F			X	X	X	X	X		X	
	Storyboard	E/F		X	X			X	X		X	X
	Tree diagram (generic)	E/F		X	X	X		X	X		X	X
	Value-added analysis	E			X	X	X					

Continued

Table 1.1 Tool matrix.

	Tool	E/F	1 Charter & Plans	2 Customer Needs	3 Current State	4 Oppor-tunities	5 Root Causes	6 Changes	7 Do It	8 Monitor	9 Standardize	10 Learnings
Data Collection and Analysis Tools	Balanced scorecard	F	X	X	X			X	X	X		
	Benchmarking	E/F	X			X		X				
	Box plot	F			X	X	X	X	X	X	X	
	Check sheet (generic)	F			X	X	X		X	X	X	
	Contingency table	F			X	X	X			X		
	Control chart	F			X	X	X		X	X	X	
	Correlation analysis	F			X	X	X			X		
	Cycle time chart	F			X	X	X			X		
	Design of experiments	F					X	X				
	Graph (generic)	F	X	X	X	X	X	X	X	X	X	X
	Histogram	F			X	X	X	X	X	X	X	
	Hypothesis testing	F			X	X	X	X		X		
	Importance–performance analysis	F		X	X	X				X	X	
	KPIs	F	X		X	X				X	X	
	Measurement system analysis	F			X	X	X		X	X	X	
	Normal probability plot	F			X	X	X		X	X	X	
	Operational definitions	F		X	X	X	X	X	X	X	X	
	Pareto chart	F		X	X	X	X			X	X	
	Performance index	F	X		X	X				X	X	
	PGCV index	F		X	X	X				X	X	
	Process capability study	F			X	X				X	X	
	Radar chart	F			X	X			X	X	X	
	Regression analysis	F					X	X		X	X	

Continued

Table 1.1 Tool matrix.

	Tool	E/F	1 Charter & Plans	2 Customer Needs	3 Current State	4 Oppor-tunities	5 Root Causes	6 Changes	7 Do It	8 Monitor	9 Standardize	10 Learnings
Data Collection and Analysis Tools	Run chart	F			X	X	X		X	X	X	
	Sampling	F		X	X	X	X		X	X	X	
	Scatter diagram	F				X	X			X		
	Stratification	F	X	X	X	X	X	X		X	X	
	Survey	E/F	X	X	X	X	X	X		X	X	
	Table (generic)	E/F	X	X	X	X	X	X	X	X	X	X
	Voice of the customer table	E		X	X							
Cause Analysis Tools ?	Contingency diagram	E					X	X				
	Fault tree analysis	E					X					
	Fishbone diagram	E					X					
	Five whys	E					X					
	FMEA	E/F					X	X				
	Force-field analysis	E					X	X				
	Kepner-Tregoe problem specification	F					X					
	Matrix diagram (generic)	F					X	X				
	Pareto chart	F					X					
	Perkin tracker	F					X					
	Relations diagram	E/F					X	X				
	Scatter plot	F					X					
	Stratification	F					X					
	Tree diagram (generic)	E					X	X				

Continued

Table 1.1 Tool matrix.

	Tool	E/F	1 Charter & Plans	2 Customer Needs	3 Current State	4 Opportunities	5 Root Causes	6 Changes	7 Do It	8 Monitor	9 Standardize	10 Learnings
Evaluation and Decision Making Tools	Criteria filtering	F	X	X		X		X				
	Decision matrix	F	X			X		X				
	Decision tree	F			X	X		X	X		X	
	Effective–achievable chart	F	X			X		X				
	List reduction	F	X	X		X		X				
	Matrix diagram (generic)	F	X	X				X			X	X
	Multivoting	F	X	X		X		X				
	Paired comparisons	F	X	X		X		X				
	PMI	F	X			X		X			X	
	Prioritization matrix	F	X	X		X		X				
	Reverse fishbone diagram	F						X				
	Tree diagram (generic)	F	X	X	X	X		X	X	X	X	
	Two-dimensional chart (generic)	F	X	X	X	X		X	X	X	X	X

2

Mega-Tools: Quality Management Systems

Discussions of quality tools often include huge mechanisms with cryptic names such as QFD, ISO, Six Sigma, and lean. Although sometimes called "tools," these are really systems for organizing and managing improvement across an organization. They involve philosophical concepts and methodologies as well as collections of smaller tools.

While a blueprint might be called a tool, a carpenter would consider it in a different category from screwdrivers and hammers. Similarly, these quality mega-tools are different from the specific tools that are the primary focus of this book. This chapter will provide overviews of major quality improvement systems to help clarify what they are and how the tools of this book are used within them. First, however, we must set the context with a brief history of quality improvement.

THE EVOLUTION OF QUALITY

In the 1920s, Walter A. Shewhart, a statistician with Western Electric, developed control charts and the principles of modern statistical process control. Shewhart's statistical principles spread in the 1930s and during World War II, but lost favor after the war as the booming market gave American manufacturing easy primacy.

Dr. W. Edwards Deming, a statistician who worked for the USDA and the Census Bureau, learned statistical process control from Shewhart and taught it to engineers and statisticians in the early 1940s. He became frustrated that managers did not understand the benefits of these methods and therefore did not support them. After World War II, he went to Japan to advise on census issues and in the early 1950s was invited to lecture to the Union of Japanese Scientists and Engineers (JUSE) on quality control. At the time, "Made in Japan" was a synonym for low-quality junk. Deming taught statistical and managerial concepts to Japanese industrialists and told them that by applying these concepts, they could have the world asking for their products.

Dr. Joseph M. Juran was an electrical engineer trained in industrial statistics at Western Electric. Like Deming, he applied his knowledge in Washington, D.C., during World War II. Like Deming, he was invited to lecture to the JUSE, focusing on planning and management's responsibilities for quality. Drs. Deming and Juran were both decorated by Emperor Hirohito.

Deming had been right. By the 1970s, American auto and electronics industries were reeling from Japanese high-quality competition. In 1980, a TV documentary titled, "If Japan Can, Why Can't We?" got the attention of American companies. Teams went to Japan to study what Toyota, Mitsubishi, Nissan, and others were doing, and Drs. Deming and Juran were suddenly in demand as consultants to American CEOs. Major corporations, including the Big Three automakers at that time—Ford, General Motors, and Chrysler—began programs of quality management and statistical quality control. The new quality philosophy taught that the quality of incoming materials was important, so these companies pressed their suppliers to begin quality efforts as well. Those suppliers turned to their suppliers, and quality programs cascaded through American industry.

TOTAL QUALITY MANAGEMENT

Total quality management (TQM) is any quality management system that addresses all areas of an organization, emphasizes customer satisfaction, and uses continuous improvement methods and tools. TQM is based on the concepts taught by quality management gurus Deming, Juran, Crosby, Ishikawa, and others.

Listening to Deming and Juran and observing the methods that had yielded such success in Japan, American quality programs emphasized far more than just statistics. Approaches that embraced the entire organization, not just the production area, and that included a change in management style, not just statistical tools, came to be called total quality management (TQM).

TQM was the name used in 1985 by the U.S. Naval Air Systems Command for its program. Since then, the term has been widely adopted and does not refer to a specific program or system. Practitioners of TQM might follow a program based primarily on Deming's 14 management points, the Juran Trilogy (quality planning, quality control, and quality improvement), Philip Crosby's Four Absolutes of Quality Management, or some customized composite. Regardless of the flavor, TQM programs include three components: management philosophy, an improvement process or model, and a set of tools that includes the seven quality control (QC) tools.

All the quality gurus agreed that a fundamental cause of quality problems in any organization is management. The leaders of organizations adopting TQM usually need to make fundamental changes in their management philosophy and methods. Common elements of any TQM program include senior management leadership of quality, employee involvement and empowerment, customer-defined quality and a focus on customer satisfaction, a view of work as process, and continuous improvement.

An improvement process or model provides the "how to" for specific improvements. It is a framework for teams or individuals to follow each time they tackle a specific issue.

Chapter 3 discusses improvement processes and defines the generic 10-step model used in this book.

Tools are the means for action, as discussed in Chapter 1. The most fundamental tools and the first ones that were developed are the seven quality control (QC) tools.

Tools: The Seven QC Tools and the Seven MP Tools

The seven QC tools were first emphasized by Kaoru Ishikawa, professor of engineering at Tokyo University and father of quality circles. His original seven tools were: cause-and-effect diagram (also called *Ishikawa* or fishbone chart), check sheet, Shewhart's control charts, histogram, Pareto chart, scatter diagram, and stratification. Some lists replace stratification with flowchart or run chart. They are variously called the seven quality control tools, the seven basic tools, or the seven old tools. Regardless of the name, a set of seven simple, yet powerful, tools are used in every system of quality improvement.

In 1976, the JUSE saw the need for tools to promote innovation, communicate information, and successfully plan major projects. A team researched and developed the seven new QC tools, often called the seven management and planning (MP) tools or simply the seven management tools. Not all the tools were new, but their collection and promotion were. The seven MP tools are: affinity diagram, relations diagram, tree diagram, matrix diagram, matrix data analysis, arrow diagram, and process decision program chart (PDPC). The order listed moves from abstract analysis to detailed planning. All of the old and new tools are included in this book, with the exception of matrix data analysis. That tool, a complex mathematical technique for analyzing matrices, is often replaced in the list by the similar prioritization matrix, which is included here. The seven new tools were introduced in the United States in the mid-1980s with *hoshin planning*, a breakthrough strategic planning process that links visionary goals to work plans.

Throughout the 1980s and 1990s, many people provided innovative additions to the concepts, methods, and tools of quality improvement. Genichi Taguchi developed new methods of applying experimental design to quality control. Masaaki Imai popularized the term and concept *kaizen*, which means small, continuous improvements, often using the plan-do-check-act (PDCA) cycle, also known as the plan-do-study-act (PDSA) cycle. Quality function deployment (QFD), benchmarking, ISO 9001 and ISO 14000, Baldrige, Six Sigma, lean, and agile are all either further developments or revitalization and repackaging of prior concepts and methods.

Problems and Benefits

TQM doesn't always generate the hoped-for results. Applying any system of quality management requires such tremendous change to an organization's culture that it is very difficult to accomplish. Picking out just the pieces that are appealing or easy won't work. Imitating successful organizations won't work either, because their starting points and their organization are different than yours. Quality management can only be successful with a great deal of learning, intense analysis, hard work, and focused attention over an extended period.

The next sections describe subsequent innovations to quality management. These systems are the mega-tools we discussed at the beginning of this chapter. Each is an evolutionary step beyond the foundations laid by Deming, Juran, and the early Japanese practitioners of quality.

QUALITY FUNCTION DEPLOYMENT

Quality function deployment (QFD) is a structured process for planning the design of a new product or service or for redesigning an existing one. QFD first emphasizes thoroughly understanding what the customer wants or needs. Then those customer wants are translated into characteristics of the product or service. Finally, those characteristics are translated into details about the processes within the organization that will generate the product or service.

History and Applications

QFD was developed by Dr. Yoji Akao for Japanese tire and ship manufacturing in the late 1960s and early 1970s. Previous quality methods had addressed only problems that arose during production. With QFD, customer satisfaction dictates product and process design, so customers are happy with the first and every product rolling out of production.

QFD was introduced to the United States in 1983 and has since spread around the world. Originally applied to manufacturing, it has been used to design services as diverse as police work, healthcare, law, kindergarten and college curricula, and a realistic, interactive dinosaur for a theme park.

Benefits and Problems

QFD shortens the design time and reduces the costs of achieving product or service introduction. The planning stage may take longer than without QFD, but expensive corrections and redesigns are eliminated. Eventually, fewer customer complaints, greater customer satisfaction, increased market share, and higher profits are achieved.

QFD requires cross-functional teams. It establishes a focus on the customer throughout the organization. And in its final steps, quality control measures are generated to ensure customer satisfaction after process start-up. As a result, QFD can be much more than a tool or planning process. It can be a key element of an organization's quality system.

Because of the emphasis on cross-functional teams and customer focus, introducing QFD into an organization may clash with the existing culture. This is a double-edged sword. Done thoughtfully, QFD can lead to the additional benefits of increased teamwork and customer focus. Done without considering the cultural conflicts, QFD can fail.

Before introducing QFD into your organization, learn more through reading and training, and enlist experienced assistance. Like any large-scale endeavor using new methods and requiring cultural change, the first efforts must be carefully planned and will benefit greatly from the insights of someone who has "been there, done that." QFD can be a powerful system to take an organization beyond preventing problems to truly pleasing the customer.

Tools and Methods

The house of quality is a key tool in QFD. The house of quality starts with customer requirements, stated in the voice of the customer, and relates them to quality characteristics of the product or service. From the house, decisions are made about which characteristics to emphasize and specific numerical targets to aim for in their design. See *house of quality* in Chapter 5 for more information about this tool.

Sometimes the house of quality is considered synonymous with QFD. But QFD is much more than one diagram. In the full QFD process, after you determine targets for critical characteristics, those characteristics must be translated into details about parts or components (for manufacturing applications) or functions (for service applications). In turn, those details must be translated into process designs and finally into specific task descriptions and procedures. Diagrams structured like the house of quality are typically used for those steps. Other tools, such as matrices, tables, and tree diagrams, are used within the QFD process to analyze customers, reliability, safety, or cost and to deploy the plans into action.

Satisfying Customers and the Kano Model

Customer satisfaction is the primary goal in QFD. Noriaki Kano's model of customer satisfaction, often used with QFD, says that customer requirements fall into three groups: satisfiers, dissatisfiers, and delighters (or exciters). Kano's model is drawn as a two-dimensional chart (Figure 2.1).

Satisfiers are requirements customers usually state if asked about their requirements. As satisfiers increase, customer satisfaction increases, following the straight line through the intersection of the two axes. Satisfaction increases linearly as more or better satisfiers are provided. An example might be a computer's memory capacity or speed.

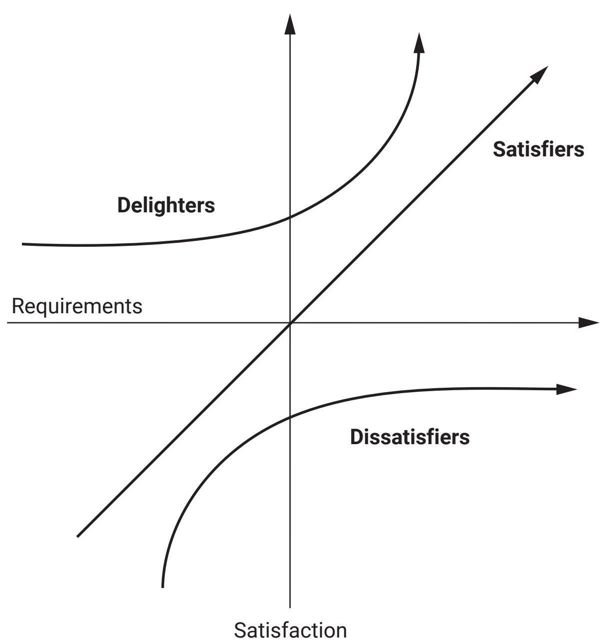


Figure 2.1 Kano model.

Dissatisfiers are requirements customers don't even think to mention, yet without them they would be very upset. They're expected or taken for granted. For example, a power cord for a computer is a dissatisfier, because that unstated requirement has the potential to create great customer dissatisfaction if it is not met. Dissatisfiers follow the curved line at the bottom of the graph. When dissatisfiers are missing, satisfaction plummets. As dissatisfiers are added, satisfaction stabilizes.

Delighters or exciters are extras customers haven't even imagined, yet if they were offered, the customer would be thrilled. Delighters follow the curved line at the top of the graph. Without the delighter, the customer isn't dissatisfied. After all, the customer has never even dreamed of that feature! But when it is provided, the customer's satisfaction increases dramatically.

One unusual feature of delighters is that today's delighter becomes tomorrow's satisfier or dissatisfier. USB ports in computers were delighters when first introduced. Now they're expected to be present, and their features, as well as their numbers and placement, are satisfiers.

How does the Kano model affect QFD? When you are gathering customer requirements, find creative ways to gather delighters and dissatisfiers, which customers will not normally mention. Also, the numerical methods applied in the house of quality should be modified if the requirements are delighters or dissatisfiers, which do not follow linear relationships with satisfaction. Various methods to do this can be found in books and papers on QFD.

ISO 9001

ISO 9001 is an international standard for quality management. Organizations are audited and certified against the requirements of the standard. It includes elements that are considered important in a quality management system, from senior management responsibility to documentation to continuous improvement.

History and Applications

Quality standards have their roots in the twelfth century practice of hallmarking silver. To protect customers, an item was tested at an assay office, and if it met minimum standards of silver content, it was stamped with a hallmark.

Starting in 1959, the US and UK defense departments issued standards for quality control to ensure that materials, parts, and equipment provided by suppliers were of suitable quality. No one wanted bombs that wouldn't explode—or exploded prematurely! Government inspectors visited suppliers to ensure compliance with the standards. Other standards proliferated throughout the 1960s: by NASA's space program, NATO, Canadian and British electrical utilities, the UK's Ministry of Defence. All these standards were based on a philosophy of inspecting the product for quality after production and required auditing by the customer's inspectors. In Britain alone, 17,000 inspectors were employed by the government.

During the 1970s, the approach changed from customers' inspection of their suppliers to independent, third-party inspectors performing this function. The term "quality assurance" also became prevalent, rather than "quality control." In 1979, the British standards office issued BS 5750, covering quality assurance in nonmilitary applications. Other countries followed suit. Finally, in 1987, the International Organization for Standardization (known as ISO, from the Greek word meaning "equal"), an alliance of the standards bodies of 91 countries worldwide, issued the ISO 9000 family of standards to facilitate international trade. It was essentially identical to BS 5750.

Use of the ISO 9000 series spread rapidly, as customers required it of their suppliers to be assured of a minimum level of quality practice. Revisions in 1994, 2000, 2008, and 2015 emphasized current concepts for managing quality, accommodated the expanded use of the standard in nonmanufacturing situations, and made it easier to integrate with other management system standards such as environmental and energy. Additional sector-specific guidelines and requirements have been issued in areas as diverse as computer software, government, and railways.

As of the end of 2021, more than a million organizations had been certified worldwide.

What ISO 9001 Requires

The ISO 9000 series consists of three documents: *Fundamentals and vocabulary* (ISO 9000), *Requirements* (ISO 9001), and *Guidelines to achieve sustained success* (ISO 9004). There are other supplemental documents in the ISO 9000 family. ISO 9001 is the standard to which organizations can be certified. Its major sections are: context of the organization, leadership, planning, support, operation, performance evaluation, and improvement.

Organizations that wish to be certified study the standard, assess where they are complying and where practices are lacking, and then make changes to their quality management systems. Training, standardization of procedures, documentation, and internal auditing are usually required. Then accredited third-party auditors are hired to audit the organization, and if the organization passes, it is certified for three years. Annual surveillance audits are required to maintain certification.

Problems and Potential

ISO 9001 in its early versions was criticized for an emphasis on inspection, control of nonconforming product, and documentation, reflecting a quality control approach of "inspect-in quality." It could work with modern TQM concepts, if creatively applied by people who had learned elsewhere the principles of TQM. By itself, it led to an outmoded management system.

The changes of 2000 and 2015 incorporated current quality management principles. Changes included greater emphasis on processes, customer satisfaction, the role of top management, data analysis, continual improvement, the plan-do-check-act (PDCA) cycle, and risk-based thinking. Seven quality management principles are included: customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision making, and relationship management.

More than three decades of experience and many research studies have shown benefits from the successful implementation of ISO 9001, such as increased productivity and efficiency, reduced costs and waste, improved product quality, greater customer satisfaction, and increased sales and profits. However, studies that have looked for problems have found them too, including bureaucracy, the burden of documentation, cost, and internal resistance.

In many cases today, certification is not a choice but a requirement for access to desired markets and even for corporate survival. Organizations that rush a superficial implementation and become certified without fundamentally changing anything will not see benefits. However, ISO 9001 is an outline of best practices for managing quality, and by thoughtfully implementing it, an organization can achieve the benefits and avoid the pitfalls. Whether the process of implementing ISO 9001 adds value to the organization or is a symbolic exercise to achieve a certificate seems to depend entirely on which outcome the organization wants.

EXCELLENCE MODELS AND AWARDS

Around the world, foundations and governments have established programs to help organizations achieve performance excellence and improve their global competitiveness. The Baldrige Performance Excellence Program in the United States, the European Foundation for Quality Management (EFQM), the Japan Quality Award, and many others develop and disseminate excellence models and administer programs of organizational training, assessment, and recognition.

History and Applications

In 1950, the JUSE instituted the annual Deming Prize to reward companies showing excellence in product quality. The prize and its criteria, based on Dr. Deming's teachings, are believed to be a significant motivating factor in the "Japanese miracle"—the transformation of the Japanese economy following World War II.

In 1987, when such a transformation was desired for American businesses, the Malcolm Baldrige National Quality Award was established by an act of Congress, named after a former Secretary of Commerce who believed strongly in the importance of quality management to America's prosperity and strength. The award criteria provide a guide for developing management systems that can achieve high levels of quality, productivity, customer satisfaction, and market success. The rigorous award process includes a two-part application package, virtual interviews, on-site review, and feedback. The National Institute of Standards and Technology (NIST) administers the Baldrige Performance Excellence Program with the American Society for Quality (ASQ).

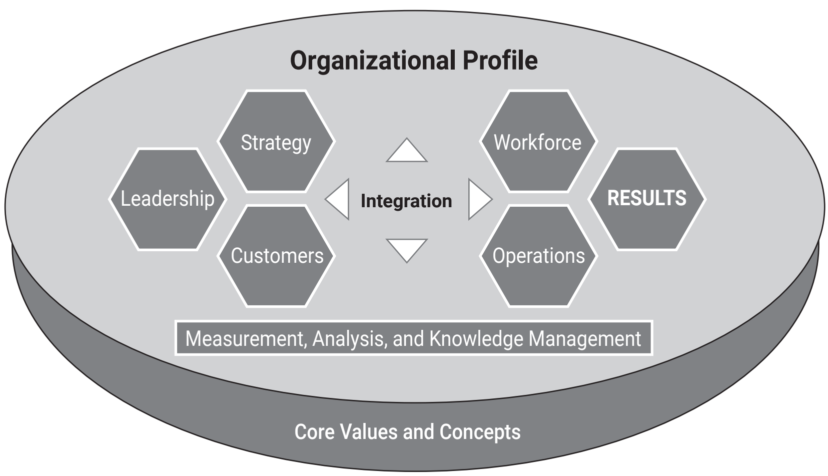
In 1989, CEOs from 67 European companies formed the European Foundation for Quality Management (EFQM). A team of experts developed the EFQM Model to support organizations in managing change and improving performance. Thousands of companies in more than 40 countries have used the model to increase their effectiveness and competitiveness. In its award process, EFQM recognizes top-performing companies after a rigorous, week-long assessment process. Four recognition categories are topped by the European Quality Award, first given in 1992.

Japan created a new award in 1996—the Japan Quality Award—that is similar to the Baldrige Award. Many other excellence programs and quality awards—local, state, and in many countries—have been established with similar goals.

While recognition and role models are important, the more significant value of the award programs has become the guidance they provide on the importance of performance excellence, what it looks like in an organization, and how to achieve it.

Excellence Models, Uses, and Benefits

The Baldrige Excellence Framework (Figure 2.2) organizes criteria into seven categories, based on key organizational processes. Leaders drive the organization through leadership, strategy, and engaging customers. The purpose of the organization is accomplished through the workforce and operations. All these processes are supported by measurement, analysis, and knowledge management. Results show the outcomes of the other processes and provide information for evaluating and improving all systems. Underpinning the criteria are core values and concepts shared by high-performing organizations.



From Baldrige Performance Excellence Program. *2021. 2011-2011 Baldrige face/Jenee framework: Proven Leadership and Management Practices for High Performance.* Gaithersburg. MD: U.S. Department of Commerce, National Institute of Standards and Technology. https://www.nist.gov/baldrige.

Figure 2.2 Baldrige excellence framework.

The EFQM Model also has seven criteria, grouped into three broad headings: direction, execution, and results. Direction summarizes the question, "Why does this organization exist?" which is answered by criteria one—purpose, vision, and strategy, and criteria two—organizational culture and leadership. Execution refers to the question, "How does it intend to deliver on its purpose and strategy?" Three criteria answer that question: engaging stakeholders, creating sustainable value, and driving performance