CHAPTER

11

Six Sigma for Service Process Improvement

LEARNING OBJECTIVES *The material in this chapter prepares students to:*

- Describe the history and importance of Six Sigma.
- Describe the importance of variation to managers and executives.
- Explain the core concepts of Six Sigma.
- Explain whether Six Sigma is a fad, and whether it matters if it is a fad.
- Understand and use the tools included in the Supplementary CD.

Saying "Six Sigma" to an executive always elicits a powerfully emotional response. Some executives will swear that Six Sigma is the only reason their company is successful, while others will swear with equal passion that Six Sigma would be the death of their company if they were to adopt it. If a person talked to a hundred executives, they would be convinced that Six Sigma was the best thing that ever killed a company. Until relatively recently, service companies were insulated from this paradox because many people thought that Six Sigma could only be used in manufacturing companies. Recent history, though, has shown that this point of view is just wrong (companies like The Home Depot, Delta Air Lines, Bank of America, Wells Fargo, Wipro Technologies, Quest Diagnostics and others have adopted Six Sigma). This chapter will explain where many quality problems come from, what Six Sigma is, its history, whether it is a fad, and how it has been applied to service companies of all kinds. The chapter does not go into detail on the tools of Six Sigma, but the supplemental material included on the CD specifically explains and demonstrates these tools.

What Causes Most Quality Problems?

Chapter 10 explained service quality, SERVQUAL, and service recoveries. But it left open the question of what causes quality problems and how to keep these problems from happening in the first place. Equally important, why do managers and executives have such a hard time spotting quality problems until they become plain silly? (Remember the examples presented in Chapter 9 of the NYPD changing tires or the New York City arrest-to-arraignment process?) Chapter 9 pointed out one reason:

processes evolve over time; assumptions become embedded in the process; and managers stand so close to the process that they don't think to question these assumptions. One company we have worked with had an insurance policy approval process that required a manager to sign off on every policy before it went into force. Of course, the managers were so busy that getting a signature often added days to the cycle time to complete a policy request. A manager once explained that they required the manager's signature because "it has always been done that way." After doing a little analysis, the company discovered that when they first began selling this particular type of insurance, the only people that sold it happened to be managers, so every request was signed by a manager because of a quirk in staffing (not a policy decision).

A second reason why managers do such a bad job of recognizing quality problems before they get to be silly is that every person suffers from a predictable set of mental "biases" that makes it hard to process new information. Table 11.1 shows a few of these biases. Consider one classic experiment where people were asked about brands of pasta. They were asked things like "Have you seen advertisements for this brand?," "Have you bought this brand?," "Did you enjoy it?" The trouble was that some of the brands were made up, but still some respondents clearly remembered having these imaginary pastas for dinner, and liking them very much. But there is another, more compelling reason why managers have such a hard time spotting the source of quality problems.

Kirk Kirkpatrick, a Senior Vice President at Bank of America, says, "Managers are trained to manage based on the average, but our customers feel variation and they hate it." The implications of this statement are profound. Managers evaluate employee performance and award bonuses for achievements that are virtually always described as averages (average ticket size, average time on hold, average utilization, average airplane load, and the list goes on). But by definition an average distills a set of customers into a single number, the expected value for some arbitrary next customer. Customers, on the other hand, simply don't care what the

TABLE 11.1: *Mental Biases*

Bias Name	Explanation
Halo effect	If a person is good at one thing, he or she must be good at another. Studies have shown that attractive people are more likely to get promoted than ugly people.
Availability	Because I have seen it, it must happen a lot. When surveyed, people generally respond incorrectly that tornados kill more people than lightning because they see the devastated mobile home parks on the news.
Spurious awareness	I think I know things that really are not so. The pasta example described in the chapter.
Anchoring	People are very suggestible; they latch onto information early (anchor on a fact), then fail to update when new information is available.
Recency	People tend to pay more attention to what has happened recently, even if it is not representative of what usually happens.
Selective perception	People tend to give credence to what confirms their beliefs and discount things that contradict their beliefs.
Memory/hindsight	People remember things differently than they actually happened. Everyone has a friend that says after a big upset, "I knew they would win!"
Confirming evidence	When given information, people tend to see things that support their positions, while discounting things that conflict with their positions.

average number of people bumped from a flight is, they care whether they get bumped and how long they have to wait for the next flight.

Consider a specific example: "time to answer" is a widely used metric for call centers. A call center might have an average time to answer of 40 seconds, and for now let's assume that the target time to answer is also 40 seconds. But again, the customer doesn't see himself as an arbitrary next caller. He sees himself, rightly, as an individual needing service from our call center. Table 11.2 shows two different scenarios, each with an average time to answer of 40 seconds, but with wildly different customer service impacts. In Scenario 1, all of our customers are happy with our service. They don't love it, but they don't hate it. On the other hand, in Scenario 2, three people love us, one thinks we're ok, and two people despise us. But because both have an average time to answer of 40 seconds, right on target, management would view these two scenarios as the same. They would award the same bonus to the two managers even though one has lost the company a third of the customers who used the service. At the same time, the company would probably be fretting over the poor customer retention numbers, but have no clue what was driving the loss of customers.

So, quality problems come from the fact that managers don't understand variation well, they are distracted by their own, often unfounded, assumptions, and they are susceptible to an array of mental biases that cause them to overvalue what they think they know. So managers need a structured way to think about their business that pinpoints the impact of variation, allows them to bring assumptions to the surface so they can be evaluated, and forces them to step beyond the mental biases every person faces. The quality movement as it has developed over the past nearly 70 years provides these tools. The latest approach in the quality movement is Six Sigma as a method to reduce variation.

Variation

Every day we deal with variation, often without even realizing it. Those days that you are late to class because all of the stoplights conspired against you, and then there was no parking available is an example of two different instances of variation. You could talk about the average amount of time spent waiting at stoplights on the ride to class, but you know each day will be different (variation). Or you could talk about the average number of open parking places at 10:00 A.M. when you get to campus, but again you know it will be different every day. Stated directly, nearly every phenomenon has an average value that can be thought of as describing the "central tendency" of the phenomenon, and variation is the idea that any individual probably doesn't fall on that measure of the center, but has some "dispersion around the mean."

TABLE 11.2: *Two Different "Time to Answer" Scenarios*

Time to Answer in Seconds, Scenario 1	Time to Answer in Seconds, Scenario 2
40	80
40	10
40	20
40	90
40	10
40	30
Average: 40	Average: 40
Standard Deviation: 0	Standard Deviation: 35.77

Figure 11.1 graphically shows the distribution of the call center data from Table 11.2; the distance between each phone call and the mean represents the variation. In Scenario 1, the central tendency is obviously 40 seconds, and there is no dispersion around that number (i.e., every caller waited exactly 40 seconds before being connected with a customer service representative). But look at Scenario 2. Again the mean time to answer is 40 seconds, but not a single customer waited 40 seconds. Table 11.3 presents the deviations each customer felt. Mathematically, each deviation is found by subtracting the mean $\overline{X}$ from each individual observation (each one is called an X_i, with i ranging from 1 for the first caller up to 6 for the last), or:

$$X_i - \overline{X} \text{ for } i = 1 \text{ to } 6$$

Unfortunately, if one wanted to find the average deviation, it would be zero because the sum of the deviations around the mean by definition is zero. To keep the deviations from canceling each other out, square each deviation before adding them. For rather arcane statistical reasons, divide by 5 instead of 6 to get the average. In general, divide by (n – 1); the reasons for this are beyond the scope of this book, but trust us—it works to make the average of the squared deviations a better estimate of what we want to know. But now when the squared deviations are averaged, they are in a completely different scale than the original data (40 seconds for the average, 1280 seconds^2 for the average squared deviations). In order to get the average deviation back into the correct scale, take the square root of 1280 seconds^2, which turns out to be 35.77 seconds, and is called the "standard deviation," the most common and useful of the measures of variation. The Greek character "sigma" (σ) is used to represent standard deviation, which is calculated as:

FIGURE 11.1: *Service Design Process with Customer Utility Model*

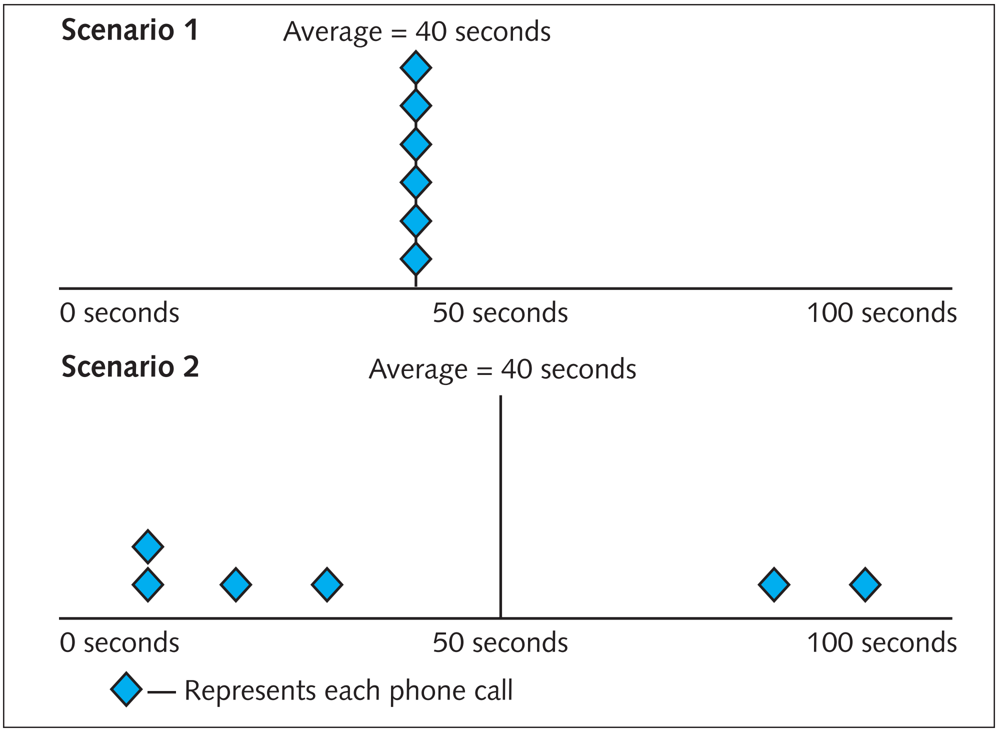


TABLE 11.3: *Deviations from Time to Answer*

Time to Answer in Seconds, Scenario 2	Deviation from the Mean (observation minus the mean)	Squared Deviations
80	80 – 40 = 40	1600
10	10 – 40 = –30	900
20	20 – 40 = –20	400
90	90 – 40 = 50	2500
10	10 – 40 = –30	900
30	30 – 40 = –10	100
Average: 40	Sum of the deviations = 0	Sum of squared deviations = 6400

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}\left(X_i - \overline{X}^2\right)}{n-1}}$$

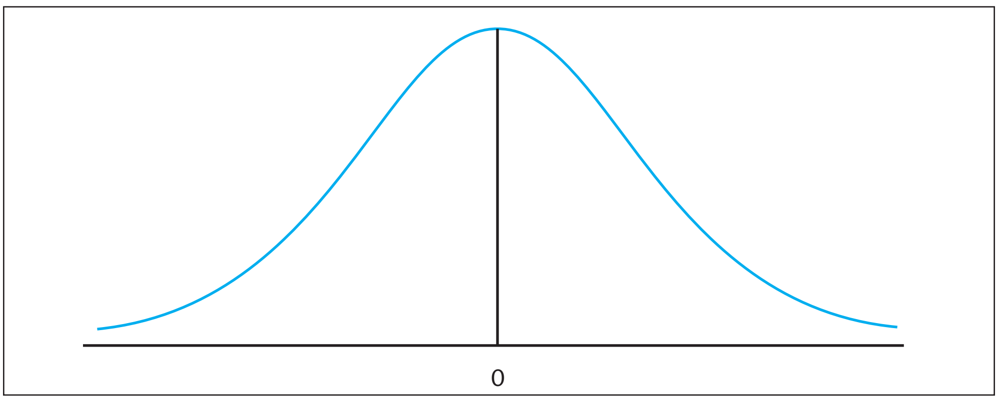
Many different "distributions" exist, but the most commonly used distribution is the normal distribution, or the bell curve. The next section serves as a refresher for those who have previously studied the normal distribution. If you have never studied the normal distribution, you may need to consult a statistics book for more details. If you are quite familiar with the normal distribution, feel free to skip the next section.

The Normal Distribution

The normal distribution is shown on the back leaf of this book, and the picture of the distribution is recreated in Figure 11.2. While we commonly say "the normal distribution," implying that there is only one of them, there are in fact lots. The normal distribution is really a family of distributions, the particular member of the family determined by two pieces of information, the mean and the standard deviation. For every normal distribution, the mean defines the center point of the distribution. For the specific normal distribution shown in Figure 11.2, the mean is zero. Then the standard deviation determines the width of the normal distribution. A higher standard deviation (i.e., more dispersion from the mean) would lead to a wider and flatter normal curve, while a lower standard deviation would lead to a thinner and taller curve. But what does the normal curve tell us?

All probability distributions describe the chance of things happening, and the way the normal curve does this is by the "area under the curve." Take the easiest example;

FIGURE 11.2: *The Normal Distribution*



what is the chance you are below average? The mean of the normal distribution defines the middle point, so by definition half of all observations will be above the mean and half will be below. Put another way, the probability of being below the mean is 50%. Since the total area under the curve of the normal distribution is 1, or 100%, and the mean cuts the distribution precisely in half, the chance of being below average is precisely 50%.

The normal distribution is far more powerful than this simple example implies though. Most people have referred to the table on the back leaf of the book as a *z*-table without really understanding what *z* means, what to do with it after we find it, and why it is so helpful. These three points are critical. Recall that we calculate *z* as:

$$z = \frac{x - \overline{X}}{\sigma}$$

But again, what does it mean? Think about the numerator; it tells how far an individual observation is from the mean, in whatever units the original data are in. Using the call center data again, what if we wanted to know how strange it was that someone had to wait up to 60 seconds to be helped. The numerator would yield (60 minus 40) 20 seconds. This is to say; the thing that we are interested in is 20 seconds above the mean. Now consider what happens when we divide this result of 20 seconds by the standard deviation. We end up with a ratio that tells us how many standard deviations from the mean that 20 seconds is (20 divided by 35.77), 0.56 standard deviations. In other words, the 60-second cutoff we are interested in is 0.56 standard deviations above the mean of 40 seconds. *z* always tells us the number of standard deviations the thing of interest is away from the mean. Table 11.4 shows six more calculations of the number of standard deviations that some point of interest is from the mean.

The second point people often miss is what do we do with *z* when we find it? *z* is the linchpin to the normal table (a portion of which is recreated in Table 11.5). To find out how unusual it is that someone waits up to 60 seconds when she calls our call center, we need to find the probability that someone waits less than 60 seconds; the notation for this is $P(X < 60)$. The same question can be stated in terms of number of standard deviations. We have calculated that 60 is 0.56 standard deviations above the mean, so we can write the question as $P(z < 0.56)$. We will use the *z* table to find this probability. Look at the picture of the normal curve on the back leaf. The gray bar on the normal curve tells us that the table gives the area from the mean up to whatever *z* value we look up. For our example this would be, in words, the chance that someone waits between 40 and 60 seconds, in notation $P(40 < X < 60)$ or in terms of number of standard deviations $P(0 < z < 0.56)$. To use the table, find the first two digits in the column marked *z* (so find 0.5). Next, find the hundredths place digit in the row across the table (so find 0.06). Read to the intersection of this column

TABLE 11.4: *A Few Examples of Calculating z*

Point of Interest	Mean	Numerator	Standard Deviation	z
15	30	–15	5	–3
15	30	–15	10	–1.5
15	30	–15	20	–0.75
200	100	100	20	5
200	100	100	100	1
200	100	100	200	0.5

TABLE 11.5: *A Portion of the Normal Table Applied to the Call Center*

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2518	0.2549
0.7	0.2580	0.2612	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389

and row to find the probability. In this case it is 0.2123, which means the chance that someone waits between 40 and 60 seconds is 21.23%.

This doesn't answer the original question though. What is the chance someone waits no more than 60 seconds? We have both pieces calculated; we just need to put them together. We found the chance of being below the mean is always 50% by recognizing that the normal distribution is symmetric about the mean, in the notation of our example, $P(X < 40) = 0.5000$. We found the chance of the wait being between 40 and 60 seconds to be 21.23% by using the *z* table, in notation $P(40 < X < 60) = 0.2113$. If we add these together we have the chance of being either below 40 seconds or between 40 and 60 seconds. Which, of course, is the same as being below 60 seconds. So, $P(X < 60) = 0.5000 + 0.2123 = 0.7123$, or 71.23%. Table 11.6 presents a few more examples of using *z* scores to find probabilities.

Now why is this helpful? Being able to transform any question about a normal distribution into a standard measure like number of standard deviations away from the mean allows us to apply a single method for dealing with normal distributions to any normal distribution we might come across. The process of finding *z*, or transforming a normal variable into the standard normal (which by definition has a mean of zero and a standard deviation of one), allows us to use the normal table regardless of the context we find ourselves in.

Consider a different service example. Virtually all retailers track the amount spent by a shopper in an individual visit to the store, or "average ticket." The Home Depot recently announced that for the first quarter of 2004 the average ticket was

TABLE 11.6: *More Examples of Using the z Table*

Mean	Standard Deviation	Find...	z Values	z Notation	How to Find Probabilities	Probabilities
50	10	$P(50 < X < 75)$	0 and 2.5	$P(0 < z < 2.5)$	Directly from z Table	0.4938
100	18	$P(87 < X < 105)$	−0.72 and 0.28	$P(-0.72 < z < 0.28)$	$P(0 < z < 0.72) = 0.2642$, so by symmetry $P(-0.72 < z < 0) = 0.2642$ $P(0 < z < 0.28) = 0.1103$	0.3745
20	4	$P(X < 11)$	−2.25	$P(z < -2.25)$	$P(0 < z < 2.25) = 0.4878$ so by symmetry $P(-2.25 < z < 0) = 0.4878$ so, $P(z < -2.25) = 0.5 - 0.4878 = 0122$	0.0122

$55 dollars. They did not announce the standard deviation so for this example let's assume a standard deviation of $15 dollars. What percentage of customers who buy from The Home Depot will spend between $40 and $70? In notation, we want to find $P(40 < X < 70)$. We can translate each of these two points of interest into z values:

$$z = \frac{40 - 55}{15} = -1 \qquad \text{and} \qquad z = \frac{70 - 55}{15} = 1$$

So in terms of z we want to find $P(-1.00 < z < 1.00)$. Looking in the z table in the back of the book, in the row marked 1.0 and the column marked 0.00, we find a z value of 0.3413. Remember that based on the structure of the table this is the probability of being between the mean and 1.00, or $P(0 < z < 1.00)$. Because the normal distribution is symmetric about the mean, the probability of being between −1.00 and 0 is exactly the same, 0.3413. So the chance of being between −1.00 and + 1.00 standard deviations from the mean is $0.3413 + 0.3413 = 0.6826$. Translating this result back into the language of retail sales, there is a 68.26% chance that a customer that buys from The Home Depot will spend between $40 and $70.

Common Cause and Special Cause Variation

One additional distinction concerning variation is critical from a business practice point of view. That distinction is between common cause and special cause variation. Conceptually, common cause variation is the variation we expect in a process, and special cause variation is the unexpected variation. For example, when ordering a pizza at midnight, let's say it usually takes between 35 and 45 minutes to be delivered, so we're not surprised if tonight's pizza takes 38 minutes. That's just the way it usually is; that's what is common. Hence the name common cause variation. On the other hand, it rarely takes 2 hours for the pizza to arrive. That would be unexpected, something special must have happened. Hence the name special cause variation.

From a business perspective, common cause variation reflects the choices management has made in terms of people, processes, technology, training, staffing, etc. Think back to our comparison of Delta Air Lines with Southwest Airlines in Chapter 2. Southwest is able to turn their aircraft in about 16 minutes. One description has it that two-thirds of the flights turn in 15 minutes and the remainder turn in 20 minutes (Heskett and Hallowell). Because of the decisions made by management, the variation in Southwest's turn time is quite small. They would consider the variation in turning a plane to be routine if the plane turned anywhere between 15 and 20 minutes. On the other hand, if the plane turned in the industry average 55 minutes, Southwest would be unpleasantly surprised and feel like its service system had failed. In this instance, common cause variation would be reflected in any aircraft turn that took place between 15 and 20 minutes, and special cause variation would be any flight that turned in under 15 minutes (special cause variation helped in this instance) or over 20 minutes (special cause variation hurt here).

So which type of variation is more important for managers to get rid of? Because special cause variation is in a sense an accident, management's first job is to get rid of special cause variation. This is analogous to a doctor in an emergency room stopping a patient's bleeding. It doesn't fix the underlying problem, but it stabilizes a patient's condition enough that the doctor can begin to find and fix the main problem. Once the process is "in control" (i.e., special cause variation is taken care of), the only way to improve the performance of the process is to reduce the common cause variation. Remember that common cause variation is what it is because of the decisions management has made, so reducing common cause variation can be done by changing the people, processes, technology, etc. that management has put in place.

One Really Important Property of Standard Deviation

The preceding work with *z* and the discussion of common versus special cause variation should have emphasized an unexpected but extremely important property of standard deviation to you. That is, while standard deviation by definition measures dispersion around the mean, or the effect of randomness on an individual observation, it is surprisingly predictable in how it behaves. As we just demonstrated, in every instance with the normal distribution, 68.26% of all occurrences take place between the mean $\pm 1\sigma$ (calls that are answered between 5 and 75 seconds, retail purchases between \$40 and \$70). If we make the not at all unreasonable assumption that we want to define a performance standard for our business, choosing to accept $\pm 1\sigma$ as our standard means that 68% of our service encounters will meet our standard, while $1 - 0.6826 = 0.3174$ or 32% of our service encounters will not. Setting our performance standards at $\pm 2\sigma$ (look up 2.0 in the first column in the *z* table, find 0.00 in the top row, read to the intersection of the row and column to find 0.4772, then double this because the normal distribution is symmetric) yields a success rate of about 95% and a failure rate of 5%. What happens at $\pm 3\sigma$? 4σ? 5σ? Wait for it . . . 6σ?

Six Sigma

Six Sigma was developed at Motorola in the late 1970s and early 1980s. Mikel Harry and Richard Schroeder describe how an executive stood up in a meeting in 1979 and declared, "the real problem at Motorola is that our quality stinks." In the time spent developing the approach, they estimated that there was an opportunity to return over \$800 million per year to the bottom line by improving quality. This represented the amount being spent to correct quality problems. Harry and Schroeder claim that within 4 years of implementation, Six Sigma had saved Motorola \$2.2 billion. Since then it has spread to other big manufacturing companies like General Electric (a total of \$900 million saved in the two years of 1997 and 1998), and AlliedSignal (\$2 billion saved in direct cost from 1994 to 2000), Polaroid (adds 6% to the bottom line each year) (Harry and Schroeder, 2000). And now a second wave of companies is adopting Six Sigma, many of them service companies. Interestingly, some manufacturing companies are aiming Six Sigma's methods at service processes inside their company, like information technology services.

Though it was formalized at Motorola, Six Sigma is in fact the culmination of years of development and evolution in the area of quality. In a nutshell, Six Sigma is a strategic approach to improving business performance by deploying a structured methodology to reduce process variation. It is comprised of several key components. Table 11.7 presents these components with explanations.

One characteristic of Six Sigma, how processes behave and process variation, can be traced back to Walter Shewart's work in the late 1930s. Many of the ideas associated with the strategic nature of quality and applying a structured approach to improvement can be traced back to the 1950s and the work of Deming and Juran. Ishikawa deployed many of the tools used in Six Sigma in the mid-1970s. Six Sigma's view of the cost of poor quality derives in part from Crosby's work in the late 1970s. But when taken all together, and with one or two evolutionary additions, Six Sigma embodies an approach that can dramatically improve business performance. The next sections explain the key ideas of Six Sigma.

TABLE 11.7: *Key Components of Six Sigma*

Component	Explanation
Management support	The approach is resource intensive, requiring training and time away from a person's normal job to execute
Project based	Teams select a problem to fix, then use a project-based approach to devise the solution
Metrics	Metrics define what matters to an organization, provide a baseline of current performance and allow for benchmarking of targeted performance
Structured approach	Teams follow "D-M-A-I-C" methodology for problem solving
Tools oriented	Teams use tools like flow charts and histograms as needed

Process Capability

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But why is it called Six Sigma? The short answer to the question is that when we go ±6s from the mean, the chance of making a defect is 3.4 per million opportunities. But to understand this in practice requires an understanding of "process capability," which in effect describes the likelihood of a process making a product or service that does not meet the specifications set by management. Go back to our call center that had a mean time to answer of 40 seconds, with a standard deviation of 35 seconds. In that instance, the target value set by management was also 40 seconds. Assume that management has set a target margin of error for answering calls to be ± 10 seconds. In other words, management wants calls to be answered between 30 and 50 seconds (i.e., 40 ± 10 seconds). How will this process behave compared to what management wants of it? How likely is it that this process can meet management's expectations? What percentage of calls will be answered between 30 and 50 seconds? Applying the z table methodology, the question can be written as $P(30 < X < 50)$ or $P(-0.28 < z < 0.28)$. Finding $z = 0.28$ in the table returns a probability of 0.1103, so the probability of a call being answered between 30 and 50 seconds is 22%. Hence, 78% of calls will be outside the range set by management; this process is not capable of meeting management's requirements.

But management wouldn't necessarily care if the call was answered quickly, so the real question is what percentage of calls can be answered in less than 50 seconds [i.e., $P(X < 50)$ or $P(Z < 0.28)$]? The answer to this question is that 61% of all calls will be answered in less than 50 seconds (0.5000 for all calls below the average of 40 seconds + 0.1103 for the calls between 40 and 50 seconds). In the parlance of Six Sigma, this process would be capable at the 0.28σ level, and would generate 39 defects per hundred opportunities, or more commonly, 390,000 parts per million defective (PPM). This is pretty bad.

This 0.28σ capability level reflects the short-term capability, before time has a chance to really mess things up. In order to achieve the same level of performance in the long-term, the process has to be considerably better. In fact, research has shown that in order for a process to deliver 390,000 PPM in the long term, it must be better than the short-term capability by 1.5σ. In other words, for this call center to reliably provide time to answer service of less than 50 seconds in the long term, we need to be capable at the 1.78σ level!

But here is where it gets interesting. We have determined that for our current process, we are operating at a short-term 0.28σ capability, resulting in 390,000 PPM defective. And we have determined that we need to improve our capability to 1.78σ in order to deliver 390,000 PPM performance in the long term. Two questions need to be considered: What will be our short-term PPM performance if we achieve a 1.78σ capability, and how will we make such an improvement? The first question is statistical, and can be answered easily using the z table (look up 1.78 in the table and add 0.5000), 96.25% of calls will be answered within 50 seconds, yielding 37,500 PPM. The answer to the second question drives Six Sigma as a business practice: the only way to get this done is to find out why the standard deviation is so high (35.7 seconds), and find ways to reduce the standard deviation. Table 11.8 presents short- and long-term defect rates in PPM for various sigma levels of capability. Notice that in order to achieve comparable PPM performance in the long term as in the short term, a process' capability must be 1.5σ higher than its short-term capability.

The Cost of Poor Quality

Access your Student CD for tools for determining cost of poor quality.

One of the most compelling arguments in favor of a quality approach like Six Sigma is that the costs of poor quality are quite high, and that avoiding those costs would naturally improve business performance. Harry and Schroeder argue that in many companies that have not adopted a real quality approach, the cost of poor quality ranges between 20 and 30 percent of sales. To put this in context, salaries represent by far the largest single cost for the airline industry, often twice as much as the cost of fuel, which is the second largest cost. Salaries represent about 25 to 35 percent of sales in the airline industry. When GE began their Six Sigma initiative, they calculated that their cost of poor quality was about $5 billion per year (Harry and Schroeder, 2000).

But what comprises this cost of poor quality? There are two broad categories: failure costs and prevention/appraisal costs. Products that fail in front of the customers (i.e., external failures) incur costs for such things as warranties, returns, litigation, lost goodwill, and lost value of the brand. Products that fail internally incur costs such as scrap and rework. A common misconception is that service companies cannot suffer from scrapped products, or incur rework costs. Consider the service of processing a request for insurance coverage (a request for a quote). If the insurance company were to misplace the request, enter incorrect information into the policy quote, fail to get the driving record of the potential insured, or make any other of a host of "defects" one of two things will happen. First, customers will become so annoyed that they will withdraw their request. In this instance all of the time invested in generating the quote is lost, scrapped. The second possibility is that the company realizes the mistake and hurries to correct it, rework.

Prevention and appraisal costs are those spent to either avoid a defect or to find the defect after it happens. Prevention costs include employee training, supplier

TABLE 11.8: *Capability and PPM for the Short- and Long-Term*

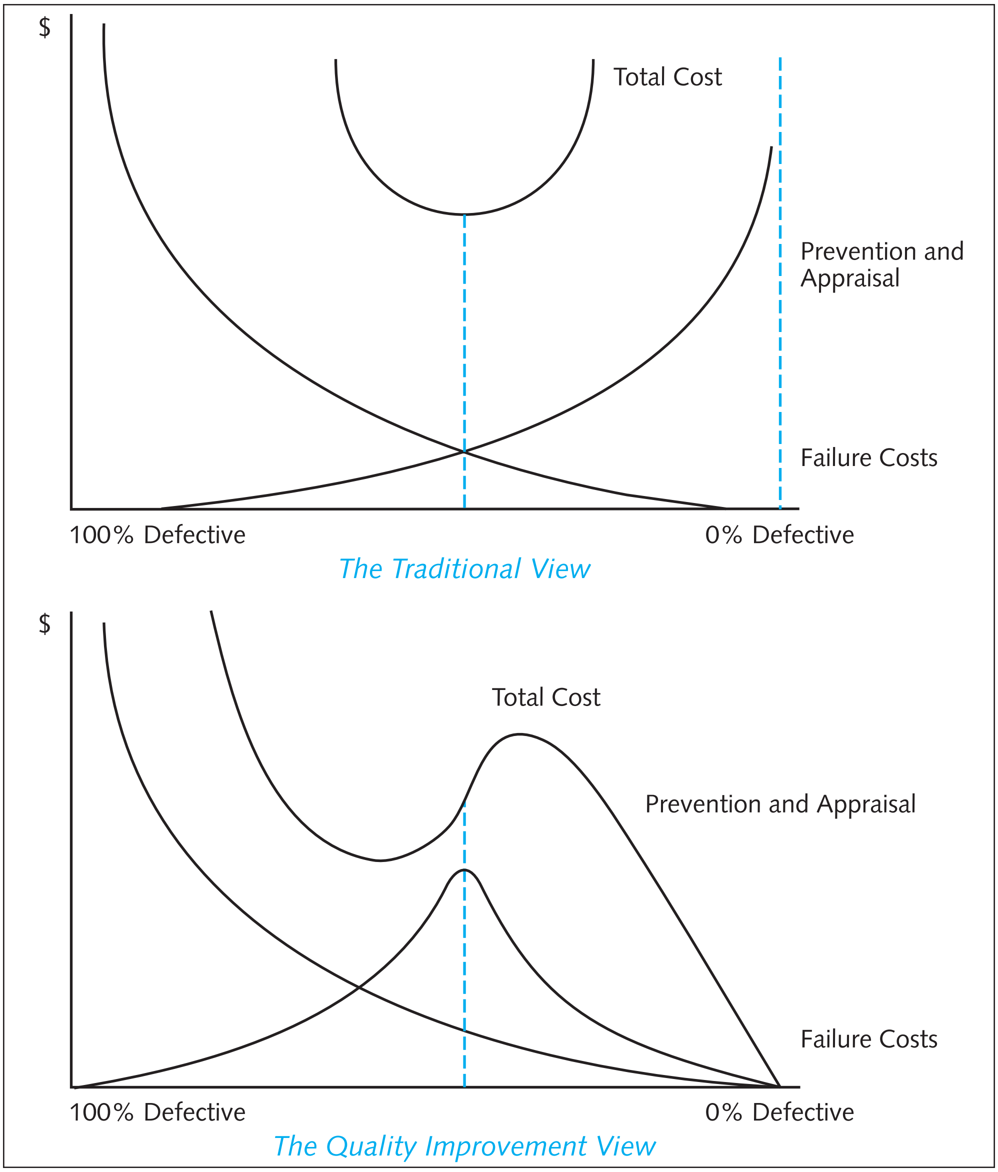
Sigma Level	Short Term % Acceptable	ST Parts Per Million Defective	Long Term % Acceptable	LT Parts Per Million Defective
1.000	0.8413	158655.3	0.3085	691462.5
1.500	0.9332	66807.2	0.5000	500000.0
2.000	0.9772	22750.1	0.6915	308537.5
2.500	0.9938	6209.7	0.8413	158655.3
3.000	0.9987	1350.0	0.9332	66807.2
3.500	0.9998	232.7	0.9772	22750.1
4.000	1.0000	31.7	0.9938	6209.7
4.500	1.0000	3.4	0.9987	1350.0
5.000	1.0000	0.3	0.9998	232.7
5.500	1.0000	0.0	1.0000	31.7
6.000	1.0000	0.0	1.0000	3.4

certification and management, and process improvement initiatives. Appraisal costs include all of the inspection costs, like hiring inspectors, designing sampling plans, etc.

Two competing views of the cost of poor quality are shown in Figure 11.3. In the traditional view, the company attempts to achieve a balance between failure costs and prevention/appraisal costs. The minimum total cost of poor quality is found at the place where the two curves intersect. This quality level represents the company's "acceptable quality level," or AQL, and it is by definition something other than perfect quality.

The second view of the cost of quality says that if we focus on removing the "root cause" of the defect then the cost of poor quality will eventually go down as we get rid of the big causes for defects. Under this view, a company would strive for improved quality because it is cheaper than having poor quality.

FIGURE 11.3: *Two Views of the Cost of Poor Quality*



Historically, companies have set AQL at 95% (i.e., the boundary of common cause variation was at $\pm 3\sigma$). That left the remaining 5% of variation to be special cause. From a customer's perspective, this meant that there would be 5 defects for every 100 opportunities to make a defect. The problem is that if you expect defects, you are going to get them. There is an apocryphal story about a computer manufacturer buying components from a Japanese semiconductor company. The American computer manufacturer sent the purchase order with all the usual information, including the quality limit of 5%; if more than 5% of the items in the lot were defective, the computer company would reject the entire lot. When the order arrived, there were two boxes, one big one full of chips and a small one full of chips. And there was a note that said, "We didn't know why you wanted 5% defective, but since you ordered them we set our machines to make them for you. We put them in the small box so you wouldn't confuse them with the good chips."

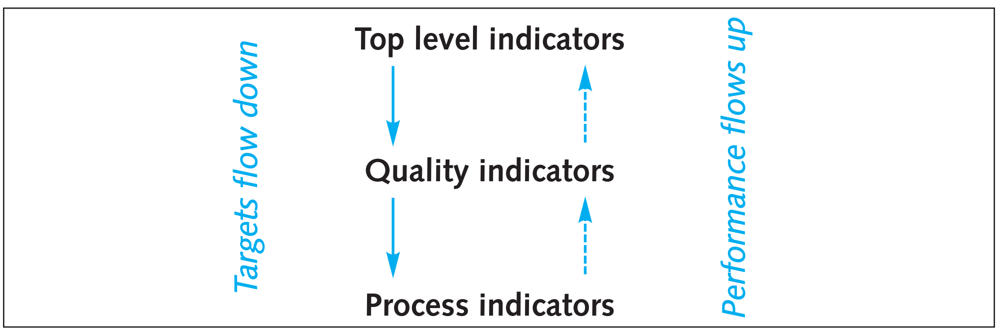
Metrics and Strategic Consistency

Chapter 2 described how strategic consistency is conceptually easy, but is difficult to do. Six Sigma uses metrics as its approach to ensure strategic consistency. This is accomplished through a series of linked metrics that start at the highest level of the company and flow down to the individual processes within the company. Figure 11.4 shows the measures used by Six Sigma and their relationship to one another.

Top level indicators (TLIs) are those measures that would be reported to the executive suite. An organization should define between 4 and 6 TLIs, 2 or 3 should reflect financial objectives, and the remaining should reflect customer service objectives. Examples of TLIs include earnings per share growth, return on investment, return on assets, net sales to budget and same store/same month sales growth ("comps"). Examples of customer service TLIs include customer retention rate, customer complaints, and service acceptance.

Where TLIs define what matters to the business as a whole, outcome measures define what matters to an individual process. So, for example, the aircraft turnaround process at Southwest might define the percentage of planes turned in under 20 minutes as an outcome measure. A call center might monitor percentage of calls answered in 50 seconds, or percentage of calls dropped as outcome measures. But both TLIs and outcome measures suffer from the problem that a company doesn't know how they are performing on the measure until it is too late to fix. Companies need something to monitor while the process is being executed to make sure they are on track to meet their objectives. These are called "process measures." Process measures are those things a business might monitor during the game, if you will. For the call center, it could monitor the time on hold for any individual call.

FIGURE 11.4: *The Measurement Structure of Six Sigma*



The Six Sigma measures ensure strategic consistency by requiring that the measures specifically relate to each other. The definition of any metric is driven by the measures above it. In other words, when a company decides on a process measure, it should be able to describe how succeeding on that process measure improves its outcome measures, and how being better at those outcome measures improves its top level indicators. With the measurement structure in place, the Six Sigma approach would require evaluating potential projects based on their ability to drive top level indicators. Some projects will be selected that drive almost exclusively at financial performance metrics, efficiency and cost-oriented projects. Other projects will drive at customer service metrics, effectiveness projects. Most will address both, so the challenge becomes selecting projects while balancing the sometimes conflicting goals of efficiency and effectiveness.

D-M-A-I-C

"DMAIC" (which has unfortunately been turned into a word, pronounced "duh-MAY-ick") is the acronym frequently used for the structured methodology Six Sigma uses to drive down common cause variation. The acronym stands for Define, Measure, Analyze, Improve, and Control. DMAIC provides the roadmap for how to execute a Six Sigma project. The purpose of this methodology is to provide a way to improve business level performance. In other words, DMAIC feeds into the measurement structure described in the previous section. Figure 11.5 graphically shows this relationship.

The Define step requires that the project team describe in detail what project they are considering. They must determine what process they intend to improve and determine how the current process works. This involves several steps. First the team must create a process map or flow chart that shows the main activities that take place to accomplish the process (all of the tools mentioned in this chapter are shown in detail in the supplementary materials included on the CD). Figure 11.6 presents an example process map. Second, the team defines the process and outcome metrics for the process, keeping in mind the link between these metrics and the TLIs. Third, the team has to define the project plan (schedule, resources, timelines, etc.) for the improvement project.

FIGURE 11.5: *DMAIC and the Measurement Structure*

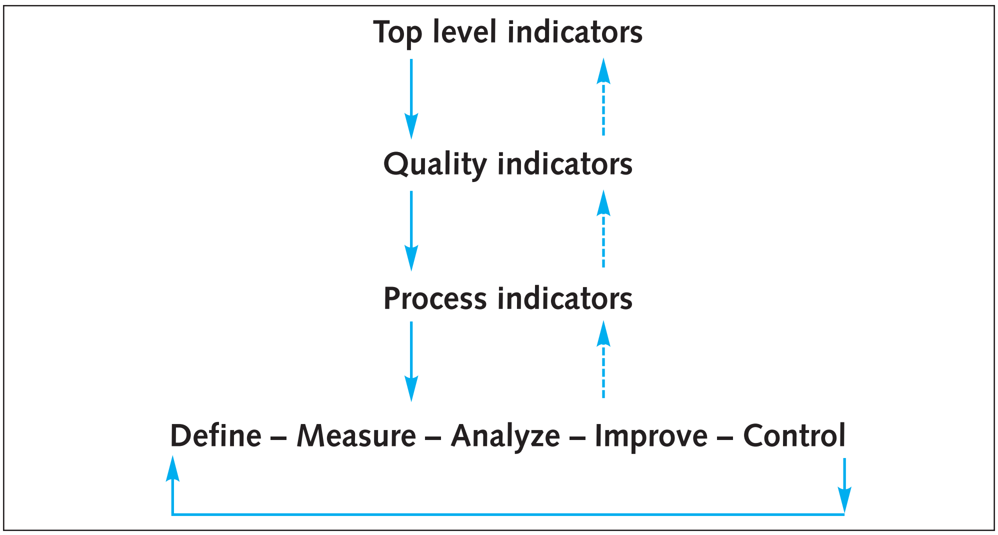
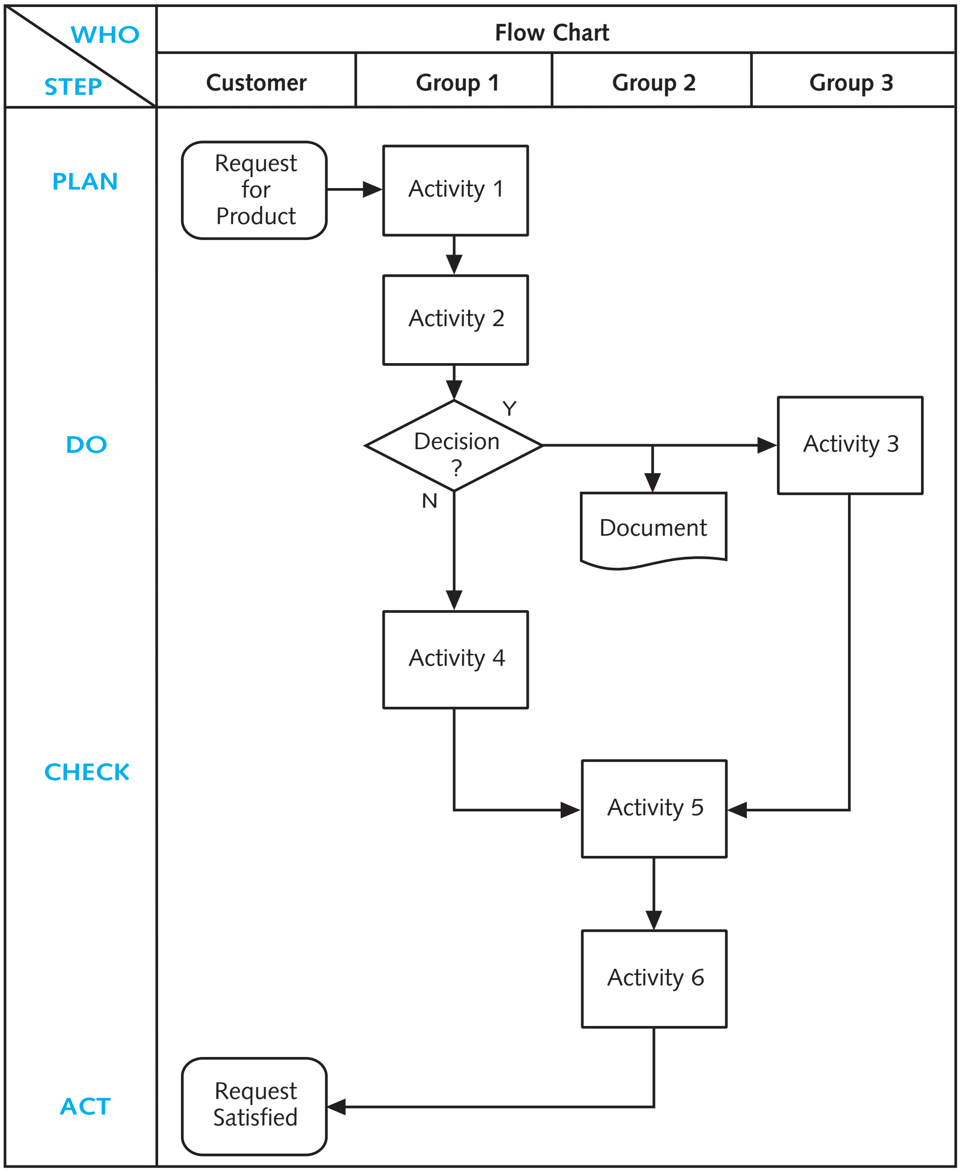


FIGURE 11.6: *An Example Process Map*



Note: Chart created using the QI Macros for Excel, available at http://www.qimacros.com.

Access your Student CD now for tools for constructing process maps.

The Measure step involves determining how the process currently performs on the outcome and process measures. The team must determine the baseline performance of the process. While this sounds easy, companies often run into the problem that they don't have the data. Companies have access to data that they have historically used to manage the process, but often find that after they have defined metrics that drive to the TLIs, they do not have data for these new metrics. Because of this, companies frequently have to gather new data to baseline their process. Next, the team determines how they want the process to perform after the improvement. Often through benchmarking against other companies or similar processes, the team will set a target performance level for the process. Third, the team measures the cost of poor quality. By identifying the types of failures that might occur and the costs associated with avoiding or mitigating these failures the team can estimate the cost of poor quality, which in turn helps team members estimate the business benefit associated with their project.

The Analyze step involves the work of determining the root cause of the problem. This work begins by analyzing the failure types identified in the Measure step. Generally, the failures identified are symptoms of a broader problem, so the first priority is to move past the obvious symptoms to get to the underlying "root cause." Fishbone analysis is one tool to help the team conduct this root cause analysis. This sort of analysis is also called "the 5 whys" because it requires the team to continue to ask "why does that happen" at least 5 times to drive past the obvious. Figure 11.7 shows a generic fishbone diagram.

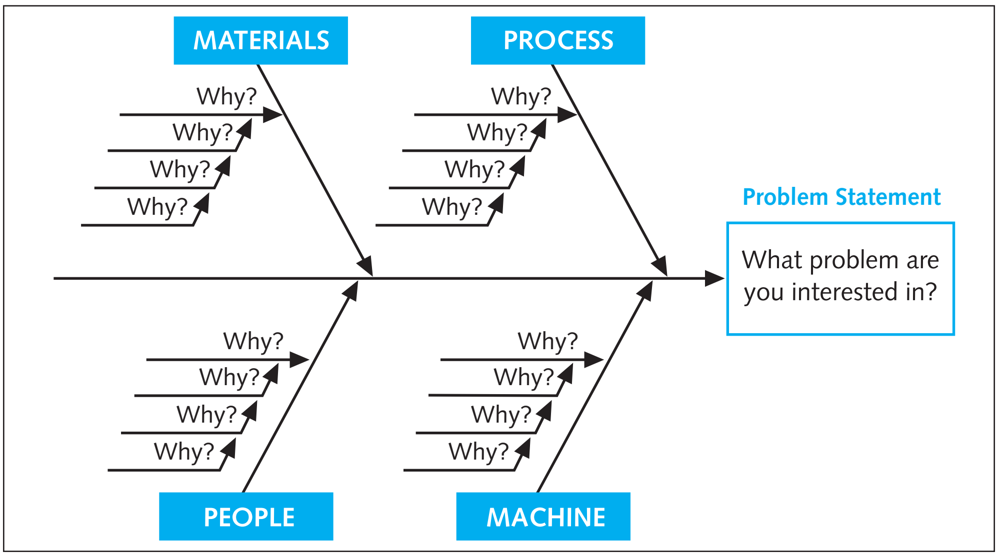
The fishbone diagram suggests possible things that might be causing the quality problem. The next step of the Analyze step is to formulate theories about why these causes exist and test those theories (very much like the scientific method of devising and testing hypotheses). Data must be used to test the theories.

Tools for constructing fishbone diagrams are included on your Student CD.

After developing, testing, rejecting, revising and retesting theories until one proves to be the root cause, the project moves to the Improve step. Improve involves devising ways to remedy the root cause. Usually there are multiple ways to get rid of the root cause, so the project team evaluates these alternatives to select the one most effective at removing the root cause. Much like the theory testing of the Analyze step, the Improve step is iterative. A solution is devised, and tested in a small scale pilot study. The results of the pilot study lead the solution to be refined until it works as needed. Then the solution is ready to be rolled out across the process.

But the work is not done. One of the most critical steps is to control the new process. This step is often not given the attention it deserves. The Control step is about devising the management control techniques that will ensure the process continues to perform to the new level achieved because of the Six Sigma project. This involves determining how the process will be monitored, who will be responsible for

FIGURE 11.7: *An Example Fishbone Diagram*



Note: Chart created using the QI Macros for Excel, available at http://www.qimacros.com.

monitoring and reporting process problems, what performance levels will be considered acceptable (common cause variation for the new process) and what will be considered out of control. Whenever possible the Control phase would include devising methods to foolproof the process so that it is as difficult as possible to get it wrong.

Six Sigma, then, is about process capability, the cost of poor quality, a hierarchy of metrics to drive strategic consistency, and DMAIC as a way to execute improvement projects. When we put all these pieces together we end up with a very powerful approach to improving process quality, and hence business level performance.

So, Is Six Sigma a Fad?

Why is it that some companies are dead-set against Six Sigma if it is as logical as the preceding discussion suggests? In fact one of the companies we have worked with forbade us from using the phrase "Six Sigma" when we met with a group of their managers. The main reason why is that many companies are convinced that Six Sigma is just another in a long string of management fads. The list of fads these managers have lived through is extensive (zero defects, TQM, ERP, CRM, 360 evaluations, self-directed work teams, etc.). And each time a company goes through a fad, it instills significant cynicism in the organization. Which then begs the question, is Six Sigma a fad?

There are two schools of thought. One side would argue that it is a fad. Companies are adopting Six Sigma without knowing what they are getting into. They are hiring consultants, going through a flurry of training, then abandoning the approach when it doesn't yield results in the first 30 days. Consultants are suggesting that Six Sigma is right for every company and that everyone should implement it in more or less the same way. Any time an approach is seen as a one-size-fits-all, quick fix to all that ails you, it has become a fad.

The other side would argue that Six Sigma really has delivered tremendous benefits to many companies, and if some companies implement it badly, then that's not Six Sigma's fault. But this is not convincing.

The fact of the matter is that it does not matter at all whether Six Sigma is a fad or not. Because the tools and approaches have proven effective over decades of use, the tools and mindset cannot be a fad. What might be a fad is the use of terminology like greenbelt (one who has received basic training in Six Sigma), blackbelt (one with more training who manages greenbelts) or master blackbelt (one who has more training still, and manages blackbelts). It might be a fad to use DMAIC as a word, but that doesn't minimize the strength of the approach.

Summary

This chapter presented an overview of variation and the impact that variation can have on process performance. The chapter describes the main points of Six Sigma: process capability, the cost of poor quality, a hierarchy of metrics to drive strategic consistency, and DMAIC as a way to execute improvement projects. It also addressed the issue of whether Six Sigma is a fad, and argued that it doesn't really matter whether it is a fad or not. The tools are so well proven and the approach so sound that it deserves attention even if it might be a fad. Many of these tools are explained in detail in the supplemental materials on the CD ROM.

Review Questions

1. An upscale hotel has been measuring the frequency with which customers try to check in to the hotel but find that their reserved rooms are unavailable. The hotel has gathered data and found that on average 18 guests are unable to check in because their rooms are not ready (with a standard deviation of 4 guests). What is the chance that more than 24 guests will be unable to check in for this reason? If management is willing to tolerate 15 guests per night as the maximum number of guests inconvenienced in this way, what is the capability of this process?
2. For the hotel described in question #1, what are some examples of the cost of poor quality?
3. Explain the difference between common cause and special cause variation.
4. Diagram the relationship between top level indicators, outcome measures and process measures. Explain how this relationship enforces strategic consistency.
5. In your opinion, is Six Sigma a fad? How might a manager mitigate the impression in a company that Six Sigma is a fad?
6. Explain the DMAIC approach.

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CASE STUDY

ZC Sterling and Six Sigma in Financial Services

Every year for a decade, ZC Sterling, a part of the Zurich Financial Group, has held a conference for its major clients at a nice resort. In 2003, the Viewpoints conference was held at the Montage Resort and Spa in Laguna Beach, California. Bill Krochalis, a co-founder of the company and its current CEO, was preparing for a presentation in which he was going to pitch ZC Sterling's commitment to "an approach based on Six Sigma principles." Krochalis was not sure how the audience would respond. While Bank of America and ABN AMRO were represented in the audience (two companies that were actively engaged in Six Sigma), other participants were much less sure about what Six Sigma might mean for their company.

About ZC Sterling's Business

ZC Sterling is a service provider to the mortgage industry. In its words:

> *We were the industry's first provider of hazard insurance outsourcing services. Since then, the organization has grown to become one of the largest hazard insurance outsourcers. And now, as a member of the Zurich Financial Services Group, ZC Sterling leads the field in providing outsourced insurance, real estate tax, and customer care solutions for the mortgage industry . . . ZC Sterling achieved this growth with a winning philosophy and an innovative, collaborative approach that keeps its customers first in mind—and first in the minds of their customers. President and CEO of ZC Sterling, Bill Krochalis explains, "Our client partners are first in every way. Their business strategies, goals, and needs shape the way we do business—every day. It's as simple as that" (from the company Web site, http://www.zcsterling.com).*

This focus on their customers coincided nicely with the underlying vision of Six Sigma, with its top level indicators focused at both financial and customer service performance.

Preparing for the Viewpoints Presentation

As Krochalis prepared himself for the presentation, he was "worried about what I am about to get myself into. I know we have a great message and we have great people, but how will it be received by our clients?" Some clients had already approached ZC Sterling about partnering for specific projects. One client, ABN AMRO, actually included ZC people in one of their Six Sigma projects. This partnership with ABN AMRO helped keep ZC Sterling on track as they learned more about Six Sigma.

But for every company like ABN AMRO or Bank of America, there were quite a few companies that held a different view of Six Sigma. A significant number of people believed that Six Sigma didn't apply to service companies. Since it came from

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manufacturing, they were unsure how it would help their business. Others knew how expensive it was to implement; the newspapers are full of stories about General Electric spending over $200 million to train their employees. The overriding concern was that Six Sigma was a fad, and like every other fad before it, after a little while it would be forgotten so any effort spent doing Six Sigma would be wasted.

All of these things worried Krochalis. Before he could pitch Six Sigma as an initiative to his clients, he had to have the capabilities in his company to support it. That meant adopting Six Sigma or something like it at ZC Sterling. But in the history of the company, ZC Sterling had never fallen for a fad. A great deal was at risk if Krochalis really pressed the issue for Six Sigma and it turned out to be a fad that didn't last. The over 1,000 employees had a great deal of trust in senior management because they had never taken the company down the blind alley of "management by fad." Krochalis knew that this trust was critical to the success of ZC Sterling, wasn't to be taken lightly, and had to be reciprocated, "You wouldn't make the bets we make on people unless you have a lot of trust in training and empowerment."

Krochalis saw quite a few significant risks in adopting Six Sigma, aside from the time and cost required to train people in the Six Sigma approach. First, by definition Six Sigma is a distraction and a disruption of what the company does. It has to be this way because Six Sigma focuses on changing processes, but that doesn't make the change easy to do. Second, there is an implied criticism of operations when you take on process improvement. It is as if the company is saying to operations, "You haven't really been getting it right, so now we're going to come fix things for you." Third, the employees might perceive Six Sigma as "additive," in other words the work required of the employee will increase but no work or responsibility will be taken away to offset for the new work. Some call it "mission creep." In Krochalis' words, "This is something that is hard for Operations to put into place on their own. You need someone above to keep a holistic view of the issue. Otherwise, you'll get malicious compliance." He feared all the ways that people could obey the letter of the Six Sigma law, so to speak, while completely violating the spirit of the process.

But there was a significant upside as well. The partnership with ABN AMRO was a great nudge toward acquiring the skills of Six Sigma. It helped ZC Sterling learn a common language and approach that ABN AMRO and other big clients used routinely. Also, this could be a way to differentiate ZC Sterling further. For their big clients, ZC could partner for Six Sigma projects. For the smaller clients, ZC could bring their Six Sigma skills to bear on a client problem to devise a customer-driven solution.

By the time Krochalis was preparing for Viewpoints, ZC Sterling had adopted an approach based on Six Sigma principles. Blair Schrum, one of the Product Line Executives, describes it as, "We chose to soften the message, not the approach. We use all of the steps of DMAIC, and we use the discipline to systematically attack process problems. But we did not want to be distracted by phrases like 'greenbelt' or 'blackbelt'." ZC Sterling applied the approach to their internal processes, which were at the time organized functionally. For example, the mail was sorted, routed, and opened in an assembly line fashion. The study found that this was not effective from

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the client's point of view because no one had ownership of the client's incoming mail. Based on its analysis, ZC Sterling chose to break the functional organization, and organize around business product lines. This led to redundant processes across the businesses, but the gain in client effectiveness more than offset the loss of efficiency. As well, there was growing excitement among the employees; people were beginning to ask, "I've heard about the Six Sigma training. Can I get plugged in?"

Time to Make the Presentation . . .

Everything had gone well so far at Viewpoints, but the time for the presentation was coming up fast. The panel discussion that was designed to help the participants understand Six Sigma in general was just wrapping up, and it was time for Krochalis to make the pitch. He felt like he needed to explain what it means to be doing Six Sigma, but this was potentially risky if the clients already thought Six Sigma was a fad. As he walked to the stage to start the presentation he had two other driving fears: would ZC Sterling end up more under the thumb of their larger clients if they partnered more closely with these big companies for Six Sigma projects, and would ZC Sterling be able to handle the requests for projects after he had announced the initiative?

Questions:

1. What do you see as the strengths of how ZC Sterling has chosen to position Six Sigma? What weaknesses do you see?
2. How would you resolve the tension between the needs and expectations between ZC Sterling's smaller clients and their larger clients?
3. If you were Krochalis, what would be your next steps for positioning Six Sigma to the employees at ZC Sterling? For positioning it to your clients?