Six Sigma

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Abstract
Although the term Six Sigma has become synonymous with highly efficient, customer-focused companies that have reduced costs while increasing customer satisfaction, at its most fundamental, Six Sigma is a measurement of quality. A process that operates at the Six Sigma level has so few defects that it is nearly perfect.

DEFINING SIX SIGMA
Six Sigma has its origins in statistics, and, in fact, the term is a statistical one. A statistician would explain that in addition to being the 18th letter of the Greek alphabet, sigma (σ) is the symbol for standard deviation. The same statistician would point out that a process that is at the Six Sigma level has six standard deviations between its process center and the upper and lower specification limits. In simpler terms, that process produces only 3.4 defects per million opportunities. If that sounds close to perfection, it is.

While there is no denying the statistical origin of Six Sigma or the fact that statistical analysis plays an important role in many companies’ implementation of Six Sigma, it has become more than a simple measurement of defects. The term is now used to encompass concepts and tools, all of which are designed to help achieve the goal of nearly perfect processes, in many cases without relying on heavy-duty statistics.

MORE THAN STATISTICS
Six Sigma is more than statistics. While its objectives are to reduce variation and prevent defects, it has also become a management philosophy that includes in its credo the need for fact-based decisions, customer focus, and teamwork.

If this sounds like déjà vu, yet another productivity program du jour that will be supplanted next year, the results Six Sigma companies have achieved should dispel the skepticism. While some previous quality and productivity initiatives promised great benefits but frequently failed to deliver them, Six Sigma delivers. Streamlined processes and less rework result in lower costs. Add them to improved customer satisfaction, and the effect on the bottom line can only be positive. This is the power of Six Sigma.

How great can the improvement be? To put Six Sigma in perspective, most companies operate between three and four sigma. As shown in Table 1, a four sigma process has greater than 99% accuracy. While that might appear acceptable, consider the third column in Table 1. Four sigma processes have 6210 defects per million, compared to 3.4 for Six Sigma. If it took only 1 minute to correct each defect, a four sigma company would spend 103 1/2 hours in error correction compared to less than 3 1/2 minutes. Even at minimum wage, the difference is significant. Most defects, of course, require far more than a minute to correct.

More significantly, many are never corrected but instead are found by customers. While not all customers will return a defective product and demand a replacement, it is a rare one that will ignore poor quality. For the company that permitted defective products to ship, the result may be thousands of dollars of lost future sales.

NOT JUST PRODUCTS
Although Six Sigma had its origin in manufacturing, it also applies to service industries. A defect is a defect. Whether a customer receives the wrong sized widget or an incorrect answer to an inquiry, the result is the same: dissatisfaction, increased costs to correct the error, and potential lost sales.

Six Sigma companies focus on far more than the measurement and elimination of defects. For them, Six Sigma is the way they do business. It permeates their corporate culture and becomes one of the things that defines them and differentiates them from their competition.
Six Sigma is built on a foundation that includes the following tenets:

- Prevent defects
- Reduce variation
- Focus on the customer
- Make decisions based on facts
- Encourage teamwork

DEFECT PREVENTION

One way in which Six Sigma differs from previous quality initiatives is in its insistence that the way to eliminate defects is through prevention rather than correction. This is an important distinction. While it may seem that the results—zero defect products—appear the same to the customer, there is a fundamental difference between the philosophies of correction and prevention, just as there is a fundamental difference between fire fighting and fire prevention. Classic quality control inspected products to find the defects, then corrected them. Six Sigma analyzes the process to determine what causes the defects then changes the process to prevent them. As shown in Table 2, the effect of prevention is widespread and permanent.

Although the difference may not be immediately apparent to the customer, prevention of defects has a positive effect on the company’s bottom line. That is because the cost of poor quality (COPQ) has been eliminated. Although some companies equate COPQ with warranty work and the cost of returned products, both of those are the result of customer-detected defects. Because the objective is to identify defects before they leave the factory, the COPQ should also include the following elements related to internal detection.

- Scrap or waste: the product or material that cannot be used or sold.
- Rework: the effort required to correct an error.
- Inspection: the cost of performing quality control.
- Reporting: the effort involved in developing and reviewing reports.

While many companies focus on the first two components, the cost of inspection and reporting can exceed scrap and rework, particularly in service processes. Sometimes whole organizations spring into existence to monitor quality. In other cases, employees develop informal methods of detecting and correcting defects before they reach quality control and can be reported. These processes are often referred to as “a hidden factory.”

The COPQ can be significant. The need to reduce it was, in fact, the impetus for Motorola’s initiating a Six Sigma program in 1979. For a four sigma company, the COPQ is estimated to be between 15% and 25% of sales; whereas for a six sigma company, it is less than 1% of sales. Reducing the COPQ can have a measurable effect on the bottom line. This is the reason Six Sigma companies place such a high emphasis on preventing rather than correcting defects. By “mistake-proofing” a process, defects are eliminated, and the COPQ is greatly reduced.

REDUCED VARIATION

The second Six Sigma tenet is to reduce variation, or—to explain it in another way—to increase consistency. This is one way to prevent defects. Consistency is important because it is predictable. And what is predictable can be perfected. As shown on Fig. 1, although it might appear that the dart player on the left is the better one, because they hit the bull’s eye once, a Six Sigma company would prefer the consistency of the player on the right. Although they have never hit the bull’s eye, and in fact have never even come close, this player’s aim is consistent. Whatever they are doing wrong that keeps them from hitting the bull’s eye is unvarying. As such, it can be corrected.

<table>
<thead>
<tr>
<th>Action taken</th>
<th>Action is on</th>
<th>Effect is</th>
<th>Effect is on</th>
<th>Need to repeat</th>
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<tbody>
<tr>
<td>Quality control</td>
<td>Inspect</td>
<td>Product</td>
<td>Correction of error</td>
<td>One product</td>
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<tr>
<td>Six Sigma</td>
<td>Analyze</td>
<td>Process</td>
<td>Prevention of defect</td>
<td>All products</td>
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Consistent, on-target results are the goal of every company. Six Sigma helps them get there.

CUSTOMER FOCUS

Six Sigma companies spend a lot of time talking about—and to—customers. Whether they are external customers, the ones who buy the products or services the company sells, or internal ones, such as a department that uses a service another department provides, customers are the focal point of all activities. This is in direct contrast to many companies’ focus on the bottom line. Six Sigma companies know that satisfying customers and increasing profits are not mutually exclusive but, rather, that increased profits are a direct result of having a strong customer focus. That is one of the reasons why eliminating defects is so important. Customers want—and deserve—perfect products and services.

Six Sigma projects begin by listening to the voice of the customer. That means learning what customers need and which of those requirements are most important to them. But concern for the customer does not end when requirements are identified and the project is initiated. The entire project life cycle is characterized by constant communication, and it is much more than delivering periodic status reports. This is genuine two-way communication, ensuring that customers are a part of the process and that the results will satisfy their requirements.

The reason for such a high level of customer focus is simple: without the customer, there is no need for the company itself to exist.

FACT-BASED DECISIONS

One of the hallmarks of a Six Sigma company is its insistence that decisions are based on facts. Although a project may be initiated because someone says, “I think we could improve our process by doing....” no action would be taken until the project team can state, “We know that our process will be improved if we....” Intuition and gut feel are second to incontrovertible facts. As detailed in “More than Statistics,” getting from I think to we know requires an analysis of both the current process and the reason why the change is necessary or desirable. Although these analyses can be performed concurrently, neither can be neglected.

It is important to understand exactly how a process is operating before making any changes. That may sound basic, and it is, but all too often in the rush to show progress in solving a problem, companies fail to understand exactly what it is that they are changing before they begin to implement the modification. The result of this failure can be unexpected side effects or, in Six Sigma terms, defects.

Consider the Monster Cracker Manufacturer. When its best-selling crackers emerged from the oven apparently undercooked, the intuitive response would have been to raise the temperature of the oven. Instead, the company analyzed the entire cracker-making process and discovered that the problem was caused by excess humidity in the mixing room. Had the oven been adjusted rather than reducing the amount of liquid in the batter, the result would have been crackers that still did not meet the company’s—or the customer’s—standards.
Similarly, it is important to ensure that the change being made is the right one. This is a corollary to focusing on the customer. Before beginning any process changes, a Six Sigma company knows that it is essential to understand what the customer really wants, not simply the project team’s perception of the customer’s needs. A defect-free product is of no value if it is not one the customer will buy.

Like customer focus, the reason for insisting on fact-based decisions is simple. By having all the facts before making any change, a Six Sigma company eliminates the rework and waste caused by solving the wrong problem.

TEAMWORK

It is not insignificant that the previous paragraphs described the process of moving from I think to we know, because teamwork is one of the characteristics of Six Sigma companies. Just as they recognize the importance of working on the right projects, these companies realize that the ability to understand what is currently happening, to determine what is causing the variation, and to develop methods of preventing defects requires having the right people working together to solve the problem. Individual heroics are much less important than the work that is accomplished by having the right group of people working together, sharing knowledge and expertise.

Although the corporate hierarchy does not disappear in a Six Sigma company, it is of little importance when a team is formed. This is why many meetings begin with the admonition to check titles at the door. Team members are selected and valued because of their knowledge and expertise, not their position on an org chart.

Similarly, departmental rivalries and functional silos that discourage sharing of information have no place in a Six Sigma company. Because most processes span departmental boundaries, with one department providing input to a process and another using the output, teams are almost always cross-functional. The objective is to assemble the right group of people so that decisions are indeed fact based rather than being dependent on incomplete knowledge or assumptions.

Teams are, quite simply, the mechanism Six Sigma companies use to eliminate defects.

TOOLS AND TRAINING

Because one of their primary goals is to reduce variation, it is logical that Six Sigma projects would use a standard process and set of tools, rather than relying on each team to develop its own problem-solving techniques. Not only does this increase consistency, but it also reduces the time—and cost—of teams’ reinventing processes.

Six Sigma projects are divided into five phases, with recommended tools for each phase. “More than Statistics” describes the phases, tools, and overall process in detail.

Because Six Sigma companies recognize that training is a necessity rather than a luxury if their employees are to understand both the philosophy of Six Sigma and the best ways to implement that philosophy,

there are three levels of formal training programs: 1) Green Belt; 2) Black Belt; and 3) Master Black Belt.
Green Belt courses, which consist of up to 2 weeks of training, provide basic knowledge of the concepts and tools. Black Belts are given in-depth training, normally an additional 4 weeks, with more emphasis on the statistical analysis tools, while Master Black Belts receive specialized training in the statistical tools, enabling them to guide and mentor Black Belts on their projects.

Unlike many corporate training programs, these culminate in employee certification. Typically, participants may not attend training unless they are part of a team with an approved project. The reason for this stipulation is the understanding that learning is more effective when it includes applying concepts to real-world problems rather than simply using classroom examples. Having a project turns theory into practice. This approach has the added benefit of getting projects completed, because certification occurs only after the project is finished and the students can demonstrate both knowledge of the Six Sigma problem-solving process and that they used the tools in their project.

A STRATEGY, NOT AN INITIATIVE

Six Sigma is often described as a strategy rather than an initiative. Although that may seem like semantics, it is not. Webster defines an initiative as an “introductory step,” while a strategy is a “careful plan or method.” The distinction is an important one. Six Sigma is more than a beginning or a first step. With its emphasis on analysis and fact-based decisions, it provides a method for improving a company.

To do that, three things must be right: the right people must be working on the right problem in the right way.

DESIGN FOR SIX SIGMA (DFSS): THE LOGICAL EXTENSION TO SIX SIGMA

Six Sigma is a strategy and a highly effective one. It does, however, have limitations. Even when applied rigorously,
companies have discovered that they are not reaching their goal of having six sigma processes, but in fact rarely exceed a sigma level of 4.5. This represents 1350 defects per million opportunities, a number that is still too high for most companies. The reason for this shortfall is that traditional Six Sigma focuses on improving existing processes. While there is no denying the benefit to be derived from reducing variation and eliminating defects in existing processes, this may not be enough.

Classic Six Sigma assumes that the fundamental design of the process being optimized is a good one. It may not be. As Chowdhury states, “80 percent of quality problems are unwittingly designed into the product.” In that case, because the Six Sigma process begins after design is complete, it may be impossible to correct all of the problems and achieve the company’s goal of near-perfection.

DFSS tackles this problem by starting earlier in the process. As its name implies, it focuses on the design of the product or service. Using statistical methodologies and tools, DFSS has as its goal ensuring that the design fully meets the customers’ requirements and results in a product that can be manufactured at the six sigma level.

Information technology (IT) professionals are familiar with the Five Ps (prior planning prevents poor performance). DFSS is the ultimate embodiment of those Five Ps. Table 3 illustrates the difference between classic Six Sigma and DFSS.

Although DFSS is a powerful methodology, it should be noted that it is not applicable to all situations. There are many projects that are better suited to classic Six Sigma. The strengths of DFSS are best applied to the development of new products or the major reengineering of existing ones. Classic Six Sigma and DFSS are complementary strategies. A successful company will employ both.

### APPLYING SIX SIGMA TO SYSTEM DEVELOPMENT

Although it is doubtful that any IT manager would deny the importance of reducing defects, increasing customer satisfaction, and operating more efficiently, many IT departments have not adopted Six Sigma. While there are a number of reasons, there are also two misconceptions that are frequently associated with Six Sigma and system development. The first is that, because Six Sigma has its basis in statistical analysis, it can be applied only to manufacturing or engineering processes and that it has little or no relevance to the system development life cycle and the IT department in general. The second is that it cannot use Six Sigma techniques unless the entire company has adopted the Six Sigma philosophy. Both ideas should be debunked.

### NO RELEVANCE TO IT

There is some irony to the belief that Six Sigma applies to engineering processes but not to IT, because system development is sometimes referred to as software engineering. The truth is that the use of Six Sigma’s disciplined approach and tools benefits service organizations as well as manufacturing processes. Both the tools and the techniques can increase the probability of successful system development by ensuring that the “three rights” are in place.

1. **The right people are involved.** Too often, projects fail either because all stakeholders are not represented or because they join the team too late to participate in the definition of requirements. With its emphasis on teamwork and the clear identification of customers, Six Sigma mitigates this problem. As explained in “More than Statistics,” the definition of **customer** is broad and can include everyone who touches a product or process. Having these groups as active participants means that the right people are involved and helps to ensure the next right.

2. **The right problem is solved.** Although meant as a joke, there is some truth to the classic cartoon that shows an IT manager speaking to his staff. “You start coding,” he says, “I’ll find out what they want.” Six Sigma tools provide a clear way to identify not just the customer’s requirements, but also...
the impact that a proposed solution will have on those requirements. Stringent use of the tools will help the team focus on the system components with the greatest value and will assist in separating nice-to-have features from those that are essential. In manufacturing terms, IT will produce the right product.

3. The right method is employed. Just as they can for a process on the manufacturing shop floor, Six Sigma tools can be used to assist the IT department in evaluating its processes and procedures to determine where there is variation, why defects occur, and how to prevent them. If, for example, projects are consistently over budget, the use of Six Sigma techniques will help IT uncover the root cause and correct it. Following Six Sigma principles will ensure that decisions are fact based and risks such as modifying the wrong part of the process are avoided.

ALL OR NOTHING

The second misconception is that IT cannot benefit unless the entire company has adopted Six Sigma. While there is no denying that it is easier for IT to implement Six Sigma processes if the remainder of the company has embraced the philosophy, there are benefits to be derived from employing the tools and incorporating the process into system development, even if the corporation as a whole is not a Six Sigma company. This entry describes ways in which Six Sigma tools can improve various aspects of system development. These tools are designed to be used in any IT department.

Six Sigma has applicability in software engineering. The techniques for ensuring that customer requirements are understood, that the impact of proposed changes is measured and evaluated, and that the development process is made more reliable will benefit all IT departments. The reasons for adopting these techniques are clear. Fewer defects, faster delivery, and increased customer satisfaction will result in a more effective IT department, one with enhanced value to the corporation.

REFERENCE

1. Subir, C. Design for Six Sigma; Dearborn Trade: Chicago, IL, 2005; p. 9.