Common Myths about Six Sigma

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Abstract

Although Six Sigma initiatives have grown in popularity due to success, the methodologies are not a panacea for all organizational ills. In fact, as the initiatives propagate, certain myths are encountered more and more frequently. In this paper, the authors share some misconceptions that are faced regularly in their communications with managers of various organizations. They provide insights to counter these misconceptions by contrasting various Six Sigma beliefs with those of proven quality experts and statisticians.

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Introduction

Six Sigma initiatives are the latest version of consulting themes and organizational initiatives based primarily on quality and statistical tools. Although Six Sigma initiatives have grown in popularity due to the many reports of success, the methodologies are not the panacea that some insist. In fact, as the initiatives propagate, certain myths are encountered more and more frequently. These myths are listed in Table 1. These misconceptions are widely held among managers in many organizations. Many of these misconceptions are the result of the marketing efforts of Six Sigma training and consulting organizations. Others are inherent characteristics of most Six Sigma initiatives. Whatever the source, these myths are in direct conflict with the wisdom and principles of many famous and proven quality and statistical experts.

TABLE 1. Common Myths Associated with Six Sigma

Common Myths About Six Sigma
1. *Six Sigma approaches are the quickest way to solve critical issues.*
2. *The important measures of Six Sigma implementation are sigma levels, defects per unit (dpu's), rolled throughput yield (RTY), etc.*
3. *All critical performance characteristics must be measured in order to manage or improve them.*
4. *More advanced statistical analysis tools yield better process knowledge. Statistical analysis provides answers.*
5. *A roadmap exists for Six Sigma implementation that ensures successful project results.*
6. *Six Sigma applies everywhere.*
7. *The merits of a Six Sigma consulting organization can be assessed through portfolio evaluation and benchmarking.*
8. *A major strength of Six Sigma approaches is the organization of the effort around specific projects.*

Counter-Discussions to the Myths about Six Sigma Implementation

1. Six Sigma efforts are not always the quickest way to obtain permanent solutions.

Consider –a product goes through a clean cycle prior to further downstream processing. Contamination (dust, etc.) affects critical downstream product parameters. In order to improve yield, one solution is to simply run all parts through the wash cycle twice –additional rework at the sake of achieving project objectives. If the gains in yield outweigh the cost of the recycling of parts through the wash stage, then the solution is easily justified. Without considering parallel paths of investigation, yields are increased while many questions remain unanswered. Could the same gains be achieved with the existing equipment without recycling product? Do we know what the critical sources of variation are? Is the contamination common cause (impacting every lot or unit) or sporadic? Are some model variations (SKU's) more likely to experience contamination problems than others? Are some materials (i.e., product lines or SKU"s) more likely to be affected by contamination than others are? What about lot-to-lot differences in raw materials? Supplier-to-supplier differences? Shift-to-shift differences?

The answers to such questions require the ability to measure the variation in contamination across different possible sources. Downstream inspection measurements of final product (e.g., final counts of defects by type) may provide insight into some of these questions, but will not be adequate to provide information on the variability unit-to-unit coming out of the upstream stage of the process. If current measurement systems are inadequate to gain answers to the above questions (and contamination is identified as a critical response parameter), then the development of a new measurement process is needed. If the focus is knowledge accumulation, time must be spent to be able to measure such a critical response. If the desire is an immediate, short-term increase in yield (to meet quarterly goals), maybe the solution is to simply put another rework loop in place. Often, however, such a short-term solution (and the resulting increase in overall yields) will often discourage the organization from gaining knowledge on critical sources of variation in the process.

Obtaining solutions does not require obtaining process knowledge. If management does not value process knowledge, and only desires quick, short-term elimination of problems, then Six Sigma may not be the best approach.

> *Deming Obstacle: "Hope for instant pudding"-- "…the supposition that one or two consultations with a competent statistician will set the company on the road to quality and productivity—instant pudding." "It is not so simple: it will be necessary to study and to go to work".*[1]

2. ***The common metrics associated with Six Sigma initiatives are often stifling and counter productive.***

Common metrics associated with the implementation of Six Sigma include number trained in Six Sigma, dollars saved per "Six Sigma" project, and number of projects completed. The authors have participated in many organizations that hold such metrics as indicators of success of their Six Sigma initiative. While such metrics can and do motivate the leadership to embrace Six Sigma initiatives, the exact same metrics often create cynicism when applied to individual sites and the individuals participating in Six Sigma project work. Consider a target of saving $200,000 per Six Sigma project worked. One engineer works in a facility producing over 8,000 units a day. One way to obtain such a target is to take eight (8) cents out of the cost of manufacturing each and every unit. Such an agenda is easily masked behind a more "educated" project objective statement such as, "Reduce variability in component XYZ through the improvement of the component design." The true project is to take an existing alloy component and replace with a cheaper, injection molded component. Whether or not the design change truly enhances average product performance (or increases process or product variability) is often secondary to the business objective of reducing the near term cost of product.

Consider a second engineer that works in a manufacturing process that provides a relatively inexpensive component to another internal assembly site. Reducing variability in a critical dimension to target may only yield $20,000 in annual savings. Recognizing the inability to meet the financial goals of the project, the engineer chooses not to participate in Six Sigma training (unless required by the organization). A potentially valuable opportunity for the professional development of the engineer is sacrificed at the fear of falling short of the global target set by management.

So certain organizational metrics in no way demonstrate the true value of process knowledge to the organization. They do not reflect improvement in quality of product or process (from the customer's viewpoint), nor do they indicate the sustainability of solutions into the future.

Some other measures associated with applying Six Sigma to process or product are defects per unit (i.e., dpu's), the "sigma level" of process or product, and rolled-throughput yield (i.e., RTY). Consider the goal of becoming "six sigma" on every product and service. This goal translates into a numerical target for every portion of the company. The assumption of such a goal is that the sigma level directly correlates with the number of defects produced. Philosophically and idealistically, the concept of becoming Six Sigma is motivational, powerful and valuable. To truly focus the energies of the organization on reducing the sources of variation that affect the critical process/product performance characteristics is an honorable objective. *The downfall of such a concept is when the notion of six sigma processes is transported from a management philosophy (supporting "constancy of purpose") to numerical targets for individual processes.* At least two of Deming's fourteen points specifically address the issues associated with the establishment of slogans, targets and numerical goals. As paraphrased from Brian Joiner, when presented with any goal or target, an individual has three choices -- one can change the system, distort the system, or distort the data.[4]

Practically, just requiring each and every area of the organization to take the time to count defects and record defects can be extremely costly without substantial gains in process knowledge. More beneficial might be the allocation of resources to understand the key parameters that need to be measured on process or product and to develop continuous measurement systems that are adequate, relevant, and valid for process study and improvement. These 'enabler' projects yield indirect but tangible results.

> *Deming discussion of Disease 3: "Degeneration to counting." "It is easy to count. Counts relieve management of the necessity to contrive a measure with meaning." "Number of designs that an engineer turns out…would be an example*

of an index that provides not chance for pride of workmanship. He dare not take time to study and amend the design…. To do so would decrease his output.”[2]

Deming Point 11b: “Eliminate management by numbers, numerical goals.”

3. *All key characteristics are not measurable.*

A major focus of Six Sigma initiatives is on the ability to measure critical response variables **on product or process** for the sake of discovering sources of variation. Consider a manufacturing line on which the only current measurements consist of counts of defects from visual inspection, daily total yields, and first pass yields. A process engineer from a wet granulation process is assigned a project to reduce rework and line defects. Historical data shows that large proportions of the defects (based on visual inspection) are classified as discoloration of final product. However, the discoloration can be attributed to many possible process stages, including nonhomogeneous mixing of a batch, inadequate granulation time, insufficient moisture in a batch, variation in coating thickness, etc. The engineer has two choices – (1) make changes to the potentially contributing stages and hope to see the impact of the changes on the visual inspection data with its exorbitant amount of measurement error, or (2) study the process to understand the variations in solids within batch, in coating thickness, and possibly post granulation moisture content. To understand the true causes contributing to the defect category, measurements must be established at upstream process stages. Reliance on end-process counts will provide very little insight of the variations contributing to overall yield issues.

However, many individuals involved in Six Sigma implementation erroneously focus solely on measurable performance features. In fact, in our own training materials we quote, “If you cannot measure, you cannot improve.”[3] Taken out of context, this statement can quickly be perceived to be in conflict with the wisdom of many quality experts. Lloyd Nelson claims that “the most important figures that one needs for management are unknown and unknowable”.[4] Obviously, to think that the true contributions of an individual to the organization are adequately represented via performance evaluation metrics is absurd. To manage human resource allocation on purely numerical figures or assessments implies lack of knowledge on both the needs of the organization as well as the strengths and needs of the individual.

The need to measure critical process or product parameters to understand cause and effect relationships does not imply that all important aspects of management can or should be measured. The main failure of management measures is that most metrics reflect end outcomes (e.g., number of noncompliances, attrition rate, etc.) as opposed to drivers or causes of outcomes. One cannot always measure the means to the end – nor would one want to. "Measures of productivity do not lead to improvement in productivity."[5]

> *Deming Disease: "Management by use only of visible figures, with little or no consideration of figures that are unknown or unknowable."*

4. ***The power of Six Sigma is not in the statistical analysis of data but in the acquisition of the data. Statistical analyses only lead to insights and new questions – not solutions.***

Recently, an engineer working to improve variability in coating adherence was presenting his Six Sigma project work. Many pages of data and subsequent analyses (performed by a Ph.D. statistician) were shown based on months of studying historical process data covering a three-year period. When the engineer was asked what questions he was attempting to answer with this large set of data, his response was, "I don't know. I was just trying to see if I could find anything." A statistical model was developed that accounted for 51% of the variability in the response. Unfortunately, many of the variables that showed up "statistically significant" (e.g., temperature readings from thermocouples located inside the furnace) are not explicitly manageable in the process. Even though a multitude of data existed, information was not available on many of the causal variables that could contribute to this variability in temperatures. Information was not available on when the material from two different suppliers were processed, when lots changed within a supplier, or how much variability existed within lots from either supplier. Also, other processing events, such as calibration of measurement instruments or cleaning of feed tanks, were not recorded in the historical database. So what operational information does the statistical model provide? Did the processing variables (e.g., chemical flows, temperatures, etc.) merely correlate with coating adherence or did they actually cause variability in the response? What uncontrolled (and therefore not measured) noise factors could have contributed to the problems with coating adherence variability? How might one know? What about the other 49% of unexplained variation? Is the current process represented adequately by data from even one year ago? Historical data has little value without an understanding of its limitations (which are completely unclear without subject matter knowledge), no matter what a statistical model might infer.

A statistical model has no meaning without subject matter knowledge. Statistical significance is limited praise. Indeed, statistical significance is a conditional statement, a comparison of factor effects to some unexplained variation. Whether those factors are manageable at the levels included in the study, whether the unexplained variation reflects what the process will see in the future, or even whether the results will be the same in a different (but possible) environment are not statistical questions. Properly designed sampling plans and designed experiments rarely provide *the* answer, but they can provide insight and direction to an engineering or organizational solution. "In general, industrial experimenters are running experiments to improve a process or product in the future. For their results to be applicable to that process and product in the future, the experimental material must not only be randomly allocated, it must be representative of the population to which the results will be applied."[6] Without a clear understanding of the subject matter at hand (including both operational and engineering knowledge and theory), this issue is will not be given appropriate consideration. The result is what Daniel calls "The mistake of premature generalization"[7]. In other words, conclusions are limited in scope and cannot be broadly extrapolated (without engineering and process knowledge).

Proactive data acquisition cannot lead to a solution unless the data collection strategy is carefully planned based on explicit and specific questions that need to be answered (questions based on process and engineering knowledge). In fact, the quantity of data that needs to be collected and the statistical technique needed for analysis is usually much simpler when the questions dictate the data acquisition strategy. Consider the following question in a drilling operation: "Are the holes that are drilled close to the angled edges of the part more variable than those in the center?" The simple data collection strategy shown in Figure 1 will provide sufficient data, and simple graphical analysis is adequate to gain insights into the existence of

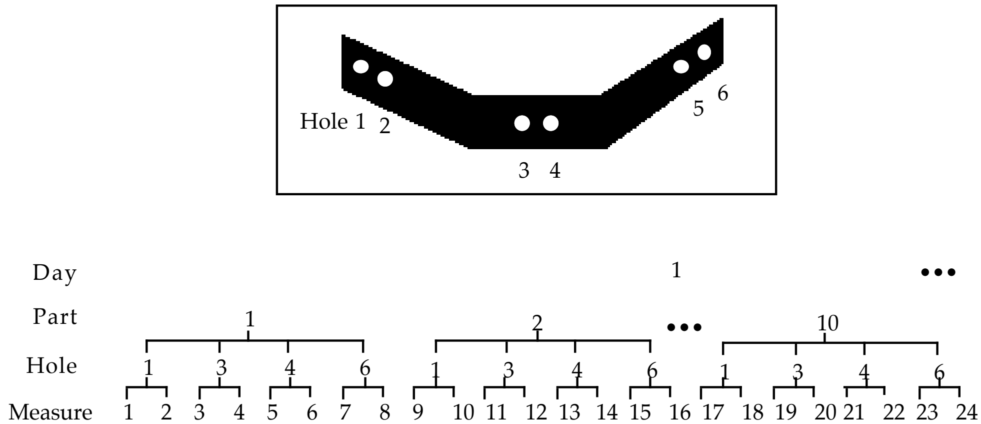

FIGURE 1. A Sampling Plan for Understanding Systematic Effects

systematic differences. (This wisdom is captured in "Ross's Rules of Analysis: Practical, Graphical, and then Quantitative."[8])

Engineers do not need to be experts in statistical methodologies. They do need to be wise in terms of when the use of statistical methodologies can provide more efficient, effective information on sources of variation in product or process. The applicability of results is entirely dependent on the incorporation of subject matter knowledge into data acquisition plans.

> *Box, Hunter and Hunter on the Role of Experimental Design: "If the experimental design is poorly chosen, so that the resultant data do not contain much information, not much can be extracted, no matter how thorough or sophisticated the analysis."*

5. ***There is no roadmap that is flexible and thorough enough to adequately guide all types of project work. Roadmaps are over prescriptive.***

A typical Six Sigma course will include a roadmap that supposedly increases (or guarantees!) the likelihood of successful application of the concepts or methodologies. A roadmap usually shows a sequential path of activities and decisions required to achieve improvements in process outcomes or parameters. Such roadmaps are over prescriptive. A

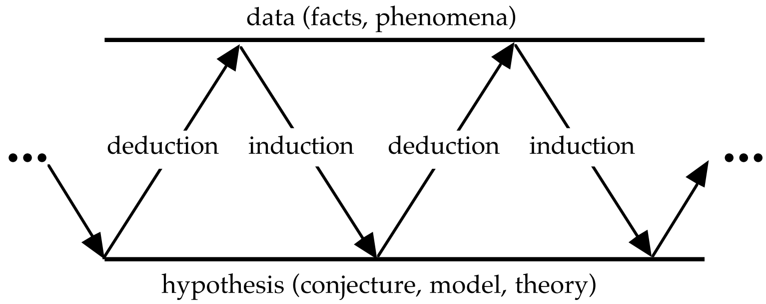

FIGURE 2. The Learning Process of Induction/Deduction

claim that following a prescribed roadmap will lead to successful project work is counter to the scientific process that is a process of induction and deduction. Figure 2 illustrates the iterative learning process as portrayed by Box, Hunter and Hunter.[9]

"For those individuals with technical backgrounds, the idea of a "roadmap" or flowchart is consistent with their educational training which has taught them there exists a formula, methodology, or piece of equipment that provides the 'right' solution for any problem. *More often than not, it is not the formula, equipment, or roadmap that leads to the solution, it is the questions that are asked*. True solutions, as opposed to repairs or fixes…come by asking new and different questions. The investigation of multiple questions requires the consideration of alternative paths of work. A single path is rarely the "right" path for all problems and issues involved."[10]

An important strength of the Six Sigma process should be the development of critical thinking and improved use of data by the individuals of the organization. The learning process (one of induction and deduction) is iterative and dependent on subject matter knowledge. To insist that all individuals should apply the same set of tools in the same order quickly creates cynicism in the organization. In fact, there is no roadmap that could possible encompass all requirements for successful completion of all projects – much less one that encourages the study and incorporation of methods and tools that are **not** included in the Six Sigma training.

Box, Hunter and Hunter on the Role of Experimental Design: "Two equally competent investigators presented with the same problem would typically begin from different starting *points, proceed by different routes, and yet could reach the same answer. What is sought is not uniformity but convergence."*[11]

6. The applicability of any particular tool set or methodology is not universal.

A common question that is often asked by management is, "Does Six Sigma apply everywhere?" A common response is, "Oh yes, it applies anywhere." Wrong!! Commonly, Six Sigma consists of the application of a specific set of statistical and process improvement tools to understand sources of variation causing problems in process or product. First, every issue does not need an advanced set of statistical tools in order to obtain sustainable gains. Consider an engineer working to improve cycle times in a final assembly process. Upon mapping the process, redundancy and key differences in activities are identified. A major portion of cycle time is easily attributed to unnecessary movement of materials, including the need to kit assembly components twice during the subassembly stages. In fact, two days of cycle time is absorbed in moving kits in and out of work-in-process inventory cages. Fundamental process layout principles and elimination of redundancy in the process can provide major strides in the reduction of cycle time. To assume that advanced Six Sigma methodologies are needed to attain such solutions is to belittle other process management and engineering methodologies, including single-piece flow techniques, control system implementation, poka-yoke, etc.

Secondly, while it is true that the most critical element of the scientific method is *subject matter knowledge*, it does not follow that the same tool set should be taught to all personnel regardless of process type or organizational needs. To believe that one specific tool set applies everywhere or across every issue is to ignore fundamental differences across different types of processes. As discussed in Hild, Sanders and Cooper, the unique characteristics of manufacturing processes (discrete, batch with reaction, or continuous) dictate the need for flexibility in the tool set needed to apply Six Sigma. "These characteristics lie in the nature of the processes, the resulting paradigm for managing variation, the measures and data typically collected on the processes…."[12]

Similar issues exist for nonmanufacturing processes. In marketing for instance, it is common for large amounts of historical data to be available in databases. Much of this data is retrospective in nature and attribute in type. Practical limitations of the usage of this data are similar to those encountered in using historical data in manufacturing process study. Plus, different analysis techniques are required for gleaning any available information from the data. Methods such as principal component analysis (PCA), cluster analysis, multivariate regression techniques (e.g., principal component regression) are very helpful in developing insights in these types of areas. However, such methodologies are typically not covered in Six Sigma training programs.

Thirdly, all organizations are not at the same place with respect to their needs. One organization may need to reenergize to focus on improving performance. Hence, it might be necessary to train all members in fundamental improvement philosophies and tools. A different organization, perceiving itself as well motivated with an ability to consistently manage processes, might need to focus on the quicker development of new products and processes. Thus, they might choose to train their product and process engineers with a more advanced tool set. Other organizations may desire to supplement the skill sets of a few key individuals based on strategic selection of projects.[13] In this situation, the training content (and the set of tools provided) will be dictated by the nature of the selected projects. Each individual (even though they are in the same organization) may not need the same set of tools.

The types of tools that are appropriate to include in a Six Sigma training program are dependent upon the nature of the processes and products as well as the needs of the organization. It is impossible (and undesirable) in a training initiative to thoroughly cover every tool/methodology that is essential for all project (or process) types.

> *Miller on Scientific Method: "Science is not any particular method or set of techniques. It is a way of reasoning. The standards are intellectual rather than procedural. The method of observation, formalization, and testing must vary with the nature of the problem".*[14]

7. *Selecting an appropriate Six Sigma consulting organization (and most importantly the individual consultants) requires "taking inventory of knowledge"*[15] *– not a simple task.*

Six Sigma instruction remains a growth industry. The demand for instructors is great (and still increasing) and consulting firms emerge to meet that demand. In response to market demand, there is a large, increasingly diverse pool of consultants that organizations can utilize in Six Sigma training and implementation efforts. The needs of the organization should dictate the qualifications sought in partnering with a consulting group. When an organization's need is to motivate and focus all members from all areas on improvement opportunities, training a large percentage of personnel in the Six Sigma philosophy, ideas and fundamental tools is useful.[16] In such a situation, the organization needs a consultant skilled and practiced in motivational speech, organizational behavior, and organizational strategy. A statistical expert is not required. A different company may prefer to focus Six Sigma training efforts only or initially in their engineering organization. In this situation, knowledge and experience of the individual consultants in product development, process management, fundamental manufacturing practices (e.g., lean manufacturing concepts) and statistical methodologies is critical.

It is not sufficient to evaluate the consulting firm's client list in order to determine if there is alignment with the organization's needs. The "expert", principal, or salesperson of the consulting organization is often not the individual performing the actual training and work. A 'certification' of mastery in Six Sigma may or may not provide insight into the experience and knowledge of the individual as there is no universal licensing or certification agency for graduates of Six Sigma courses or even the instructors of such courses.

> *Deming states "…no one should be teaching statistical theory and application, especially to beginners, unless he possess knowledge of statistical theory through at least the master's level, supplemented by experience…. A hack of a statistician should be studying, not teaching".[17] Most Six Sigma instructors are not statistical experts, nor do they necessarily need to be. Many statisticians tend to emphasize statistical tools and analysis over subject matter knowledge. However, all instructors do need substantial experience and knowledge in statistical work. It is the responsibility of the organization to determine the expertise and experience required to align the Six Sigma efforts with the organization's objectives and needs.*

Deming on where you can find the right man: "The combination of knowledge and leadership is exceedingly rare, and will require patience and earnest prayer to find. Enquiry of competent consultants may bring forth candidates. You may have to interview many applicants to find the right one."[18]

8. *The orientation of most Six Sigma initiatives around specific projects is both a strength and a weakness.*

One difference between most Six Sigma initiatives and preceding quality improvement efforts is that the work is organized around projects (and project completion). Typically, projects are assigned to the individuals or small teams that will participate in the Six Sigma training. Ideally, these projects flow down from business strategies and provide a connection between senior and lower-level management. The projects are hopefully selected so that there is no contradiction between business and functional objectives and therefore daily and quarterly work schedules.

The specificity of projects is both a strength and a weakness in terms of the sustainability of Six Sigma initiatives over the long-term. The strengths of this project focus are:

- The removal of uncertainty concerning where management wants work directed;
- Required practice in application of the Six Sigma concepts and tools while undergoing training (thus, promoting more critical thought and appropriate tool usage);
- A strengthened understanding of the need for a combination of good process and engineering knowledge and statistical thinking; and
- The development of an appreciation for the strengths and limitations of the methods learned.

On the other hand, certain characteristics of project work can help shorten the life of a Six Sigma initiative if not managed properly. First, the nature of project work is that it is of finite duration. Individuals often conclude, "I've finished my Six Sigma project, so I'm returning to my normal work." For Six Sigma to actually become a management philosophy, there cannot be a "normal work vs. Six Sigma work" attitude. As a result of short-term focus on specific projects, the organization may undergo the usual burst of improvement only to eventually return to status quo. Often, the selection of project objectives by management confine the investigators to narrow or inflexible paths of work, not allowing for sequential evolution of investigative direction based on the knowledge acquired.

Finally, project orientation often focuses the work on the problems themselves and not on the processes that cause the problem.[19] Project work alone does not embed (in individuals or the organization) different behaviors in inductive and deductive learning, nor organizational and individual behaviors to take advantage of knowledge learned. Similarly, if the organizational focus is on project selection, management, and completion, opportunities to study the systems that contribute to the need for projects is often foregone. For instance, in one particular company, the design organization focused projects on the release of new designs incorporating the latest technology. Many projects were identifiable in this area because the technology was rapidly evolving. Manufacturing projects were selected based on the need for cost reduction, partially due to the constant release of new designs. Opportunities for studying the overall system were not captured in the project selection. In fact, the independent selection of projects by both design and manufacturing was an indictment of organizational practices. Manufacturing did not provide process capabilities to design, nor did design attempt to retain certain existing components (for manufacturing reasons) when new components were not required for functionality.

Much can be learned if the initial selection of projects is viewed as an opportunity to learn how to improve the overall systems of the organization as opposed to merely solving the problems of today.

> *Deming diary entry: "It is easy to stay bound up in the tangled knots of the problems of today, becoming ever more and more efficient in them."*[20]

Conclusion

Successful Six Sigma programs are gaining much attention and scrutiny. Success, if defined by continuous improvement of processes and continual advancement of skills and knowledge, is due to a multitude of factors. Many of the myths discussed in this paper are merely a claim that a single factor, disunited from the others, determines success or failure of the overall initiative. Other factors that contribute to the success of Six Sigma initiatives include:

- the training content;
- alignment of expertise with organizational needs;
- allocating of key individuals to critical issues;
- selection of individuals to be trained and projects to be worked;
- the alignment of project objectives with organizational objectives;
- the expertise and experience of the consultants;
- the will of the organization.

The most successful Six Sigma programs enjoy vocal praise and close inspection by high level management, often by the organizational leader, who may have initiated the work. This is a distinctive advantage over many quality attempts that are conducted under the human resources or traditional quality department. In fact, such attention from senior management could easily be argued to be the most important factor for success.

In summary, managerial leadership (and not the toolbox, training, or consultant) determines the degree of success of Six Sigma. So, don’t believe everything you hear.

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