Ongoing Discussion "Thought Piece"

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Six Sigma, through the Lens of Dr. Deming's Philosophy and the Science of Improvement

In the years since Dr. Deming's passing, much has been made about the "new wave" of quality methodology, Six Sigma. In *"Six Sigma, Through the Lens of Dr. Deming's Philosophy and the Science of Improvement"* **David Wayne offers insights into the commonalities, differences and effectiveness of each by comparing and contrasting Dr. Deming's philosophy with that of the Six Sigma approach.**

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***There is no substitute for knowledge*.**
W. Edwards Deming

Truth, like gold, is to be obtained not by its growth, but by washing away from it all that is not gold.
Leo Tolstoy

Get your facts first, then you can distort them as you please.
Mark Twain

Purpose/Aim

The aim of this paper is to compare and contrast Deming Management Methods and the quality/process improvement approach known as Six Sigma. There is much confusion and disagreement, it seems, over the operational definitions of the concepts. Any meaningful discussion must begin with an understanding of how the author is using these terms.

Deming Philosophy

Dr. W. Edwards Deming was a prolific writer in the fields of mathematical physics, statistics, and later in his career, management philosophy. This paper will primarily consider Dr. Deming's teachings on "management philosophy" and the science of improvement.

Dr. Deming's management philosophy may best be summarized by two major components: Profound Knowledge and the Fourteen Points. Dr. Deming's Fourteen Points (and their partners, the Seven Deadly Diseases) first appeared in print in the landmark publication *Out of the Crisis* in 1986. The Fourteen Points are a collection of advice, warnings, and admonishments for management to use for improving their business.

A more cohesive theory, A System of Profound Knowledge, is presented in *The New Economics,* (Deming, 1994) and, according to Dr. Deming, "…provides a map of theory by which to understand the organizations that we work in." This theory is supported by four major tenets:

1.) Appreciation of a System
2.) Theory of Knowledge
3.) Theory of Variation
4.) Psychology

Many themes echo the Fourteen Points and appear in various parts of the System of Profound Knowledge, particularly those relating to organizational purpose, driving out fear in an organization, and understanding the implications of variation.

Dr. Deming's Appreciation of a System describes methods with which management can turn their organization into a system, and the advantages of doing so. Optimizing only parts of the system results in sub-optimization of that system. Dr. Deming's writings also describe many typically unrecognized obstacles to the creation of an organizational system, such as performance incentives for any targeted segment of the system, internal competition, and the use of the performance appraisal.

The Theory of Knowledge describes a system for learning, and the importance and use of theory to promote learning. Deming presents the latest version of the Shewhart cycle, the Plan-Do-Study-Act (PDSA) cycle as a model for achieving this goal.

The Theory of Variation describes the need for management to understand variation, and to use this understanding to improve processes and systems. Deming describes management itself as primarily prediction, and an understanding of variation is critical to being able to predict, to separate the signal from the noise, the "common cause" variation from the "special cause" variation.

Psychology comes into play in all aspects of the System of Profound Knowledge model; management must be aware of underlying psychological influences if the business is ever to approach becoming a true system.

The Various Definitions of "Six Sigma Quality"

Two of the major advocates of Six Sigma, Dr. Mikel Harry and Richard Schroeder, define Six Sigma in this way: "… a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction." Further amplification is provided in their book, *Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations (Harry & Schroeder, 1999).* Six Sigma is referenced as "… a disciplined method of using extremely rigorous data gathering and statistical analysis to pinpoint sources of errors and ways of eliminating them." As described in the book, a Six Sigma project will follow the principles of RDMAICSI: Recognize, Define, Measure, Analyze, Improve, Control, Standardize, and Integrate. Similar approaches can be found in advanced product quality planning (APQP) introduced in the early 1990s by the Ford Motor Company. APQP is a very prescriptive approach focusing on projects that add directly and obviously to a company's bottom line.

Six Sigma is commonly used by many as a synonym for “improvement” or “variability reduction”. Additionally, it is used to describe the measurement tracking system for determining six sigma, usually Defects per Million Opportunities (DPMO). Consultants and practitioners push major Six Sigma projects rather than integrate the improvement efforts into everyday work life.

Deming Approach vs. Six Sigma: Is It Really an Either/Or?

In considering the Deming Approach vs. Six Sigma, it is not necessarily an either/or determination. Six Sigma, while purporting to be a management philosophy, really seems more closely related to Dr. Joseph Juran’s predominately project-oriented approach, with a deliberate, rigorous technique for reaching a problem resolution or an improvement. Dr. Deming’s approach is more strategic, theoretical and philosophical in nature, and does not carry the detailed explicitness of the Six Sigma approach. As such, the Deming philosophy is not necessarily at odds with any approach that is tactically oriented. So can the two work together? Is Six Sigma just a tactical application of Deming’s theoretical models? Or are the two completely incompatible? The answer seems to be mixed: some practices are very compatible, while others are at cross-purposes.

Practices that seem to be Compatible

Undeniably, some companies have experienced successes using the Six Sigma approach (although greatly exaggerated in the press in general and within companies). For all its shortcomings, the Six Sigma approach has had a positive effect, and upon examination, is not appreciably different from the detection and corrective action techniques in use in the automotive industry in the late 1980s.

Top Management Commitment

What *has* been accomplished in companies that have achieved some success with Six Sigma is management support from the very top levels, and the willingness to stay the course over many years. These characteristics bring to mind what Deming had been saying for decades. Top management support and constancy of purpose are cornerstones of the Deming philosophy. “If you cannot come, send nobody,” a quote from William Conway, then CEO of the Nashua Corporation, related by Dr. Deming (Deming, 1986, p.21). Mr. Conway was responding to a vice president’s request for an invitation to visit the Nashua Corporation. Dr. Deming elaborated for clarity: “If you don’t have time to do your job, there is nothing I can do for you.” His point, driven home with typical Deming wit, illustrated that there is no real substitute for leadership, for top management support and involvement.

Constancy of Purpose

Constancy of purpose seems to be an additional common characteristic of those companies that have had some success with Six Sigma. Deming wrote extensively about the dangers of over-adjustment, of lack of constancy of purpose, of succumbing to the lure of the “program of the month” to drive improvement. “There is no instant pudding”, was his constant rejoinder. This does not imply that all change must necessarily be gradual; rather, Deming suggests that devotion to the principles of Profound Knowledge should not waver. The principle of constancy of purpose, applied on the tactical level with improvement projects, can have some impact as well, as some Six Sigma successes have shown.

Mapping the DMAIC and PDSA

Many Six Sigma practitioners also trace the roots of the DMAIC (Design-Measure-Analyze-Improve-Control) model to Deming’s (PDSA) Plan-Do-Study-Act, and this does seem to have a measure of validity. A good case can be made that the two map well together. As practiced, the DMAIC model tends to give the impression that one grand movement through the cycle is enough to achieve sufficient results. The PDSA cycle has a greater “small scale testing” feel employing multiple learning and improvement cycles before objectives are achieved; this seems to ring more true to real life experience. That said, it is important to note that these concerns reflect Six Sigma *as practiced*. There is nothing in the DMAIC model to prevent multiple cycles; it simply is not often done. The structure of the DMAIC model is linear, and it often leads to linear thinking. Unfortunately this is only appropriate for the most simple of projects. Most improvement efforts involve consideration of the (business) system as a whole, and are more complex than one way linear deployment can accommodate.

Practices that Appear to Conflict

Though some Six Sigma theory and practice seem compatible and in alignment with the Deming philosophy, there are many more that are not. Some seem to be in opposition to Dr. Deming’s approach. These conflicts fall under two categorical headers: (1) Technical (Major conflicting engineering and statistical issues), and (2) Implementation/human factors (Destructive practices to creating a true system with a common aim).

Technical issues when comparing Deming’s approach with Six Sigma

Treatment of Variation

The Six Sigma approach relies on the histogram as the primary means of describing variation. Diagrams in related publications use the histogram to describe a specific process, with comparisons illustrating its “sigma level”.

Because processes tend to "shift and drift" (Harry and Schroeder, p.143) over time, an allowance is made for "centering error for a typical process": 1.5 sigma. The oft-quoted "3.4 defects per million" statistic touted by Six Sigma is therefore loosely derived, and not from Six Sigma at all, but from 4.5 sigma (Although the term "4.5 Sigma" may have less marketing appeal…)

Why 1.5 Sigma?

There are several problems with the 1.5 Sigma approach. One might first wonder how this figure was selected. References to a 1.5 sigma allowance are found in writings by A. Bender (1962) and J. Gilson (1951), but in the entirely different context of tolerancing component assemblies. It is prudent to design assemblies so that the variation experienced in manufacturing or processing does not affect the performance of the system. When estimating worst case system performance, it may make sense (As indeed is suggested by Bender) to inflate the estimation of the standard deviation *for the assembly.* This is fundamentally different from allowing for such a shift in the *process* mean of *individual components*. To allow for this type of shift in the process mean "just in case" seems extraordinarily wasteful, tantamount to keeping large inventories of parts (or anything else), or adding inspection as a substitute for process improvement, in order to allow for excessive process variation.

Detecting "shift and drift"

Detection of such a shift is the job of another tool, one of Deming's favorites: The Shewhart Control Chart. Originally devised by Dr. Walter Shewhart in the 1920s, the control chart provided what no enumerative study ever had: a basis for prediction. To be sure, any Six Sigma Quality course on the market will feature the control chart as an offering. Of grave concern to a student of the Deming approach, however, is how routinely predictions are made about future process performance using only a histogram and an apparent assumption of normality. The histogram is a useful tool for describing the spread of the data in a process; however, this alone is seldom of much use, and may be misleading unless the condition of statistical control of the data is achieved. Additionally, the Shewhart control chart does not require the underlying data to be normally distributed, as is required by the Six Sigma approach. Dr. Shewhart's famous example concerning the elongation data of springs shows a histogram appearing perfectly bell-shaped, normally distributed, and yet when the data are plotted over time, there is a clear downward trend (Shewhart, 1939). Dr. Deming's comment on this example is particularly insightful, and may perhaps be generalized: "Any attempt to use the distribution [in this example] would be futile. The standard deviation of the distribution, for example, would have no predictive value. It would tell nothing about the process, because this is not a stable process." (Deming, 1986 p. 313). One could argue that "allowance" is made for any potential changes by the 1.5 sigma shift built into the Six Sigma approach, but Deming's approach would perhaps counter that the control chart should be used to detect a shift in the process, and would require far less data than if using the histogram. Approaches to improvement described by and derived from Deming would entail improvement in the form of reduction of variation about a target value and keeping it there, using the control chart as a guide.

Visibility/Insight into how Variation Causes Loss

This leads to the next area of conflict between the approaches: Six Sigma seems to ignore the Taguchi Loss function. Six Sigma approaches generally use either DPMO (Defects per Million Opportunities) or DPU (Defects per Unit) to describe process performance. Both seem to be dressed up versions of the control chart for attributes data known as the "u" chart, but without the control limits. Again, a "sigma level" is calculated for a process and is so labeled without benefit of any statistical tool providing a basis for prediction. The major issue here, though, is in the use of defects themselves to describe process variation. There are times on some processes where it is necessary to resort to defect tracking as the best way to gain insight into process performance, but this is not generally the case. Dr. Genichi Taguchi demonstrated with his famous "loss function" how variation generally causes loss even when all parts meet specification (Taguchi, 1983). John Betti, then of Ford Motor Company, captured the idea in 1985: "We in America have worried about specifications: meet the specifications. In contrast, the Japanese have worried about uniformity, working for less and less variation about the nominal value…". (Deming, 1986 p. 49) As Deming summarized, Dr. Taguchi's parabolic loss function describes a realistic world, "…in which there is minimum loss at the nominal value, and an ever-increasing loss with departure either way from the nominal value." (*Out of the Crisis*, p. 141). Of course there are also one-sided loss functions, where loss occurs on only one side (such as metallic hardness). A well-designed assembly or system has components with very few loss functions that are steep (that is, where a small amount of variation causes a large amount of "loss") and many that are flat, where process variation can be tolerated because of design robustness.

The process insights provided by the loss function are not available from the Six Sigma perspective, because in order to be visible, process variation must produce some defects. "Zero Defects", the nostrum that describes perfection in the Six Sigma system, cannot detect any process variation that does not actually produce defects. There is no way to recognize loss occurring from variation that is within specification. This is further emphasized in the tendency in Six Sigma literature to characterize improvement as synonymous with the elimination of errors. This overly simplistic characterization is only one small aspect of improvement. Without the insights provided by the control chart, one cannot tell whether these so-called "errors" belong to the system or are attributable to a special cause, requiring two distinct approaches for resolution or improvement.

Major Problem with DPMO as Commonly Practiced in Six Sigma

Deming often observed a tendency in American industry for companies to compromise their business system while striving to achieve certain individual or departmental goals optimizing only pieces of the system. DPMO (defects per million opportunities) is often used in such a fashion. DPMO is a ratio. A business wants to reduce it. There are two ways this can happen: the numerator can be reduced (defects), or the denominator can be increased (opportunities). Often times, higher so-called "sigma levels" are reached by doing the latter: actually *increasing* the opportunity for defects, either in actuality or by creative counting methods. "Creative counting" is generally just a waste of time, but increasing opportunities for defects could actually make things worse!

Problem Solving vs. Improvement

The Six Sigma methodology uses the same approach for both problem solving and improvement. The issue here is that, depending on one's definition; fundamentally different approaches may be needed. A problem, in general, is an unusual occurrence requiring intervention in the short term, to return the process to where it would have otherwise been if the special cause had not occurred. There are many good problem-solving approaches currently in use (such as the 8 Disciplines approach used by Ford Motor Company and their supplier base). But they all have one thing in common: their objective is to return the process to where it was before the problem occurred. Can this be improvement? Resolving a special cause utilizes an approach called Root Cause Analysis, a standard part of the Six Sigma approach, in which corrective action is a required step. But once the problem is solved and corrective action taken, have we really made the process better? Consider the example of an automobile that gets, say, 25 miles per gallon of fuel on average. Suppose the immediately preceding 8 tanks have yielded between 20 and 23 miles per gallon. This would produce an out of control condition on a Shewhart control chart, and we would be justified in checking a list of things, trying to solve this problem (air filter, spark plugs and so forth). We find the root cause; fix it, and the process returns to what it had always been before the problem occurred. This is important, and must be done, but is it *improvement*? Per the Deming approach, this would simply be special cause removal, and not a true improvement. The process has been returned to where it was before the problem occurred, whereas *improvement* would be taking a stable, predictable process (that is, one exhibiting statistical control) and making changes to it that caused an improvement, and renewed stability at a better level. What would it take to get 40 miles per gallon from the process? A fundamental change in the process, product, or the system is required to achieve this. Some of the tools of problem solving can be used, but the fundamental approach is different. This approach requires knowledge of process stability, which cannot be achieved by the limited understanding of variation provided by the Six Sigma approach.

A better methodology is provided by Associates in Process Improvement: the Improvement Model (from *The Improvement Guide*, 1996, 2009). This approach is derived from the Deming Cycle (as it became known by everyone but Deming; he called it the Shewhart Cycle. See *Out of the Crisis*, p. 88, and *The New Economics*, 2d edition, pp131-133). Briefly stated, the model asks three questions:

(1) What are we trying to accomplish?
(2) How do we know that a change is an improvement?
(3) What changes can we make that would be an improvement?

This is followed by the PDSA cycle: Plan-Do-Study-Act. This methodology, described in theoretical and practical detail in the book, *The Improvement Guide* (1996, 2009), has proven to be a robust means of developing a change, testing on a small scale, and implementing the change with the accumulated learning from the test(s).

Implementation Practices/Cultural Issues when Comparing Deming's Approach with Six Sigma (Human Factor Issues)

Implementation of any improvement strategy must be done with careful planning and execution. Some of the principles of the Six Sigma Breakthrough Strategy are advocated by proponents of Dr. Deming's philosophy, such as upper management support and constancy of purpose (as was discussed earlier). There are, however, a number of principles that are at odds with Deming's approach, to the detriment of the implementing company.

Arbitrary Goals

It is common practice for Six Sigma companies to set targets that appear to be arbitrarily chosen. Most frequent are those relating to the achievement of a "sigma level" and "10-fold improvement" (though the relationship between these is never clarified). From where do these goals come? Has anything been done to understand the cost or benefit of achieving 10-fold improvement? How will we achieve this goal? "By what method?", Dr. Deming used to ask. Additionally, we should ask leadership and management at all levels: "What is the total cost? What are we trying to accomplish? Are we keeping the customer in mind with these improvements?" (I am grateful to Barbara Ward, Quality and Process Improvement Leader and herself a Master Black Belt, for providing insights contained in this paragraph.)

Dr. Deming has much to say about arbitrarily chosen goals that are outside the bounds of the current system's capability without a plan to achieve them. As Dr. Deming put it, paraphrasing Lloyd S. Nelson, "If they can do it next year with no plan, why didn't they do it last year? They must have been goofing off. And if one can accomplish improvement of 3 per cent with no plan, why not 6 per cent?". (*Out of the Crisis*, pp. 76-77)

There is more. "A numerical goal leads to distortion and faking, especially when the system is not capable of meeting the goal." (Deming, *The New Economics*, 2d edition, p.31). Problems occur here when the improvement experts are given numerical dollar improvement targets and are held accountable for achieving them. The experts are typically provided with substantial monetary incentives if these goals are accomplished, causing problems on several levels. The process owners rarely share in the recognition. Savings estimates are routinely grossly inflated, and that which truly *is* achieved is often transitory because of inadequate involvement of the process owner. Achievement of these goals is often on paper only, for the purpose of gaining recognition for the black belt (the Six Sigma name for improvement tools expert) rather than accomplishing all that could be achieved for the company. There are even some incentive programs that, incredibly, pay and certify black belts based on the number of improvement tools they have shown that they can use. (This seems a little like paying a plumber for fixing your sink based on how many tools he/she uses to do the job).

The methods for achieving these goals in many companies are also of concern: whipping packs of crazed black belts into a frenzy, unleashing them on unsuspecting process owners, and waiting for the cash savings to pile up. Unfortunately, once the simplest, easiest to solve problems are gone, the turnaround begins to wane. This approach also tends to rob the process owner of something Dr. Deming considered sacrosanct: pride of workmanship and accomplishment. The process owners should be involved and assisted in making improvements, not brushed aside only to have solutions that may or may not help or hinder imposed on them by someone without process knowledge. Frustrated and disillusioned process owners are often left in the wake of these types of efforts, and a rougher row to hoe is found the next time an attempt at improvement is made that involves them.

Strategic Focus

Devotion to Six Sigma as the key to a company's success can also bring about a myopic loss of strategic focus and can compromise viewing a business as a system. Six Sigma's emphasis on the bottom line is one major cause of this. Deming had no problem with emphasizing the bottom line, understanding clearly its importance. "But he that would run his company on visible figures alone will soon have neither company nor figures." (*Out of the Crisis*, 1986, p.121). Deming's concern lay in the belief that the most important knowledge about running a business as a system could not be reduced to visible figures alone (quite a pronouncement from someone who always referred to himself as "… only an apprentice statistician."). Focus on the visible figures alone always tends to focus a business on the short term—this quarter's earnings report and the impact it may have on the stock price, for example. This often leads to compromise of the long term to accommodate the short term.

Of even more concern long term is the tendency of companies using Six Sigma to substitute Six Sigma Quality for the need for good strategic planning. Deming again: “What business are we in? [To make carburetors?] Yes, the makers of carburetors made good carburetors, better and better. They were in the business of making carburetors. It would have been better if they had been in the business to put a stochiometric mixture of fuel and air into the combustion chamber, and to invent something to do it better than a carburetor. Innovation on the part of somebody else led to the fuel injector and to hard times for the makers of carburetors.” (*Deming, 1994*, pp. 9-10). Perhaps an even better characterization of this business would be “vehicle acceleration devices”, which would create an unbroken chain starting with the buggy whip.

More from Deming: “Efforts on reductions of defects [may be] successful. At the same time, demand for product, sales may slide downward toward zero. Simply to [reduce or] eliminate defects does not guarantee jobs in the future. No defects, no jobs can go together. Something other than zero defects is required.” (*Deming 1994* pp. 9-11). He might have added, it takes more than mistake proofing as well.

The point here, of course, is that improvement in quality, as important as it remains, is not enough to sustain a business long term. Reducing defects, continual improvement, none of these will serve long term without innovation and continually asking the questions, “What business are we in? What is the societal need we are trying to serve? How can we do it better for our customers and potential customers?”

The dual conclusion: Six Sigma as often practiced has its limitations; however, to argue that it has brought no value is to risk throwing the baby out with the bath water. The insight as to the similarities and differences between Dr. Deming’s philosophy and Six Sigma should help foster understanding of the underlying principles of each, and how to deploy the science of improvement in practice.

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BIOGRAPHICAL SKETCH

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