

AC 2008-1460: SIX SIGMA: DOES IT BELONG IN THE MANUFACTURING CURRICULUM?

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Six Sigma: Does it belong in the Manufacturing Curriculum?

Abstract

Six Sigma has morphed through three generations: focus on quality to focus on process improvement (cost reduction) to focus on value (a strategic management strategy). This paper will discuss the three generations of Six Sigma, compare the tenets of Six Sigma to Lean Manufacturing and evaluate whether it has a place in the manufacturing curriculum.

Introduction

In a recent review of several “Lean” and “Six Sigma” technical articles published in the Society of Manufacturing Engineering Technical Articles section, Six Sigma was primarily identified as a quality program with a focus on reducing process variation and Lean as a program focused on eliminating waste and improving flow using problem solving and statistical tools.¹ Many of the articles simply focused on the Lean and Six Sigma tool kits.

In a recent article, the author advocated an integrated approach to process improvement using lean manufacturing and Six Sigma principles.² Another article which focused on Lean, argued that “successful execution of the corporate strategy is the ultimate goal not merely becoming Lean” and offered Profit Mapping as a methodology for tying Lean to the Corporate Strategy.³

In his book *Fusion Management*, Stanley Marash notes that since the 1960’s more than 32 quality programs have come and gone at an average of almost one per year. He further noted the emergence of a common pattern: “A few pioneer companies adopt or develop a program and achieve great success. The business press takes notice and other companies seek to emulate the pioneers. But as the idea spreads it becomes diluted. Senior management tries to adopt the model without ever really comprehending what is required to make the program successful.”⁴ It appears from the review of recent articles there is some lack of understanding regarding the evolution of Six Sigma and Lean.

What is Six Sigma?

While Six Sigma began as a quality program at Motorola in the 1980’s it has since undergone two evolutions. In the 1990’s Allied Signal and GE picked up the Six Sigma torch, but changed the primary focus of Six Sigma from quality to cost reduction. As a quality initiative at Motorola, the focus of Six Sigma was on the customer. As a cost reduction initiative, the focus of Six Sigma reverted to focusing primarily on the bottom line of the organization.

In the 2000’s, Dupont evaluated Six Sigma and realized that it could make the best possible products; but, if they didn’t make a profit they wouldn’t be in business. Further, if the sole objective was to optimize profit and quality slipped, market share would be lost and the organization would not be competitive. Dupont realized that they must optimize both customer and stakeholder value and Six Sigma evolved to what is known as the Third Generation. An

important part of Six Sigma Generation III, was tying Six Sigma projects to the organization's strategic objectives.

While working with industry, it is clear that many know Six Sigma simply as a quality program and think that it is nothing new. It is true that many of the tools in the Six Sigma toolkit can be traced back to AT&T Bell Laboratories in the 1920's where Shewhart introduced his revolutions on variation. Components from Deming, Juran, Feigenbaum and others are prevalent throughout Six Sigma as well. However, Six Sigma has evolved far beyond a quality program to a strategic management system.

Six Sigma is a flexible system of management which provides a way of reasoning and knowledge intervention designed to create value for both the organization and the customer. It utilizes current technology and analytical tools in combination with best practices and tools from the past to design, implement and monitor everyday business activities for purposes of improving the organization's bottom line and customer satisfaction. The Six Sigma approach to managing is all about helping to identify what isn't known as well as emphasizing what should be known. Six Sigma translates knowledge into a breakthrough strategy for business growth by taking action to reduce variation and waste, which results in a loss of time, money, opportunities, and customers.⁵

What is Lean?

Lean is a term that has been popularized by Womack, Jones, and Roos:

- *The Machine that Changed the World*, James Womack, Daniel Jones, and Daniel Roos, Simon & Schuster, 1990
- *Lean Thinking* James Womack and Daniel Jones, Simon and Schuster, 1996
- *Lean Solutions*, James Womack and Daniel Jones, Simon and Schuster, 2005

The first of this series introduced the world to the Toyota Production System which is synonymous with Lean Manufacturing. More recently Lean Manufacturing has simply been reduced to Lean, recognizing its application to all types of organizations, not just manufacturing companies.

In *Lean Transformation*, Henderson and Larco lists six principles of the lean production system:⁶

1. *The lean organization will be safe, neat, and clean.* This principle is primarily known through the 5S system. There are many "S's" used and one might even find the 5C's. However, a common reference is Sort, Set in order, Shine, Standardize, and Sustain.
2. *The lean organization will build products just-in-time.* In the 1980's when interest rates were 20+%, the concept of JIT Inventory grabbed the attention of many CEO's who were struggling with reducing the need for any kind of liability.
3. *The lean organization will design Six Sigma quality into products and the manufacturing processes.* Six Sigma in this context means zero defects.
4. *The lean organization will have empowered teams.* Employees will work as a team to solve problems which were previously solved by management.

5. *The lean organization will have a visual management system.* Workers will have visual feedback regarding their goals and inventory will be clearly visible through the use of a kanban system.
6. *The lean organization will have a relentless pursuit of perfection.* Pursuit of perfection is through the concept of continuous improvement.

Just as many question the originality of Six Sigma, Jim Huntzinger in his article “*The Roots of Lean: Training Within Industry: The Origin of Kaizen,*” argues that Lean is not the invention of Toyota but is actually traceable back to the Training Within Industry (TWI) Service which was developed to support U.S. Industry during World War II.⁷ Juran and Deming are well known for the efforts in training the Japanese after the war. In fact, Japan’s national quality award is named after Deming. Likewise, “as many as ten million Japanese managers, supervisors, and workers graduated from the TWI programs or one of their derivative courses.”⁸ Not only may TWI have been the basis for Lean, but it appears that the “Multiplier Principle” of “develop a standard method; then train the people who will train other people who train repeated groups of people to use the method, .”⁹ is replicated by the Six Sigma Belt system of training.

Linking Six Sigma and Lean

Both Six Sigma and Lean became popular in the U.S. around the same time during the 1980’s. Advocates of Six Sigma will argue that Lean is a tool of Six Sigma and Lean advocates will argue that Six Sigma is a part of Lean. Trying to sort out who is right is like trying to determine which came first “the chicken or the egg.”

Elzbieta Trybus in his article *Six Sigma and Lean*¹⁰, points out some basic differences between Lean and Six Sigma. “Lean manufacturing addresses visible problems in the process, such as inventory, material flow, and safety, while Six Sigma is concerned with less visible problems, for example, variation in performance. Lean manufacturing tools are simple and easier to apply, while Six Sigma tools require advanced training. The practical approach would be as follows: start with basic lean manufacturing tools and then move towards Six Sigma.” While this author might disagree with the premise of starting with lean tools and then moving toward Six Sigma, the concept of Lean as a simple and easier to apply set of tools intended for visible problems – waste and flow; and Six Sigma as an advanced set of tools being concerned with less visible problems – variation, provides a valuable perspective.

Six Sigma Generation III is well documented in Mikel Harry’s book *Six Sigma – the Breakthrough Management Strategy Revolutionizing the World’s Top Corporations*.¹¹ Generation III has two key elements in its evolution:

1. The focus of the organization should not be on the customer alone (quality), or the organization alone (cost reduction); but, rather on value for both the customer and the organization.
2. Six Sigma projects should be tied to strategic goals. Strategic goals are used to create Six Sigma projects and stretch goals which are driven down through the organization in order to create improvements which will in turn amalgamate back up through the organization to cause breakthrough improvement directed at the strategic goal.

The integrated approach argued for by the authors introduced in the introduction of this paper, already exists in Six Sigma Generation III. By focusing on strategic goals it doesn't matter whether the problem is customer related or shareholder related; it doesn't matter if the problem is a process problem or a design problem; and it doesn't matter if the problem requires what one might classify as Lean or Six Sigma tools. What matters is that the strategic goals are determined by reflecting on both the customer and shareholder values and projects are selected in such a way that they have the largest impact on the strategic goals.

Does Six Sigma belong in the Manufacturing Curriculum?

Average without Standard Deviation or some other measurement of variation is inadequate to describe a set of data. The central tendency tells us where the target is located; but, does not tell us how the values are distributed about the target. Likewise it is not enough to simply focus on Lean which targets primarily waste and flow. There must also be an understanding of the variation associated with all measurements in order for waste to be fully eliminated and for flow to fully optimized. Additionally, in order for Lean or Six Sigma projects to be effective, they must be linked to the organizations strategic goals. It seems clear that Lean should be a part of the manufacturing curriculum and whether one is a Lean advocate arguing that Six Sigma is a part of Lean or a Six Sigma advocate arguing that Lean is a part of Six Sigma, it is apparent that Lean and Six Sigma are intrinsically intertwined. Therefore, Six Sigma should also be included as a part of the manufacturing curriculum.

A framework for Implementation of Six Sigma in the Manufacturing Curriculum

At Ball State University, the manufacturing engineering technology program requires a course in statistical quality control and a course in design of experiments. Both of the courses provide technical tools which are part of the Six Sigma toolkit. Lean is taught in other courses offered in the manufacturing curriculum. Ball State University also has a strategic mission to provide students with an immersive learning experience.

There was no room in the manufacturing engineering technology curriculum to add additional courses; therefore Ball State University elected to develop a Minor in Process Improvement. This minor will provide students an opportunity to complete Six Sigma Black Belt training and then through an immersive learning experience, complete a Six Sigma Black Belt project. Students who pass all certification exams and complete a project at a professional level as judged by the faculty in charge of the immersive learning course, a Six Sigma mentor from the community partner, and a program advisory board, consisting of Six Sigma Black Belts, can earn certification prior to graduation. Those passing the exam but not completing a project to a satisfactory level will earn a Six Sigma Black Belt proficiency certificate acknowledging that they passed the battery of exams.

The Minor in Process Improvement requires 18 credit hours as described below:

- 100 Level Course: Introduction to Six Sigma – This course introduces the Six Sigma philosophy and methodology and typical white belt level tools.

- 200 Level Course: Statistical Quality Control – This course introduces such topics as basic statistics and probability, SPC, hypothesis testing and confidence intervals, and measurement systems analysis (Gage R&R). This course is an existing course in the MfgET curriculum.
- 300 Level Course: Advanced Six Sigma Methods – This course introduces Lean tools, non-parametric methods, survey methods, and other advanced tools.
- 300 Level Course: Six Sigma Project Course I – This course provides project planning skills and development of a Six Sigma Project Charter (contract) in cooperation with the community partner. The student will begin the project in the second portion of the course.
- 400 Level Course: Design of Experiments – This course provides training in DOE and Design for Six Sigma, including robust design. This course is an existing course in the MfgET curriculum.
- 400 Level Course: Six Sigma Project II – This course is for completion of the Six Sigma Project and writing of a formal report. The formal report must be written from the position of a consultant and not simply a practitioner. This is important because the formal report is what the student will have to demonstrate their abilities and it is important as a tool to determine if the student’s technical writing skills are developed at an appropriate level.

Conclusion

Ball State University not only believes that Six Sigma belongs in the manufacturing curriculum; but, has taken action to implement a strategy whereby students can both be trained and certified in Six Sigma. Manufacturing Engineering Technology students may complete the Minor in Process Improvement by taking an additional four courses. Since these students have twelve hours of free electives available this should not impose any issues for students who are properly advised and plan ahead.

The Minor in Process Improvement is able to stand on its own with regard to Six Sigma training and as a result has attracted students from Chemistry, Physics, Pre-Engineering, Computer Science, and Business who have observed the popularity of Six Sigma throughout almost every element of the economy.

The 100 level Introduction to Six Sigma course is being taught for the first time in Spring 2008. Manufacturing Engineering Technology students who have already taken statistical quality control and design of experiments will be able to complete the minor in time for a Spring 2009 graduation. A handful of these students have agreed to consider postponing their graduation until the end of the Summer of 2009 in exchange for an opportunity to perform their Six Sigma project with a community partner in China.

Literature shows¹², that there are no entry level Six Sigma Black Belts. In considering the program there was a concern whether or not recent graduates, with minimal commercial experience, would be worthy of such a certification, even if they satisfactorily passed the exams and completed a professional level project. This question was not considered lightly in the development of the program. Extensive discussion was held with renowned Six Sigma professionals. As there currently is no professional organization that is recognized as “the” Six

Sigma certification authority, there is a disparity of qualifications among Six Sigma Black Belts regardless of years of experience. Some Six Sigma Black Belts earn their certificate by attending a three week training session and completing a project that is documented via a PowerPoint presentation. The students in the Minor in Process Improvement:

- will have well beyond the traditional 160 hours of training;
- will be required to complete comprehensive battery of 20 exams covering all topic areas in the Six Sigma body of knowledge at the end of their training in addition to the exams and assignments given during the coursework;
- will be required to do a formal written report fully documenting their project, which
- will be evaluated by faculty, a community sponsor, and an advisory board, all whom hold Six Sigma Black Belt Certification.

Companies considering employing these students will be able to ascertain through the quality of their written report the worthiness of their certification.

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