2006-1708: EDUCATING THE BUSINESS PROCESS MANAGERS OF THE FUTURE: THE SIX SIGMA TECHNIQUES

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Abstract

Six Sigma is a strategy designed to improve efficiency in manufacturing and business processes. Its basic focus is to decrease defect, improve overall quality, reduce cost and increase profit in production. Modern operations managers recognize the tremendous advantage of applying innovative and advanced techniques that would increase productivity and customer satisfaction. Tomorrow's managers are being educated at universities today. Implementing business processes analysis and improvement methodologies should be considered an important component of this education. Six Sigma methodology offers a comprehensive body of knowledge to aid with such process improvements.

This paper suggests a road map for implementation of a graduate course in Six Sigma. Students would start by acquiring the basic cognitive skills and mastering the necessary underlying concepts and theories. These theories are then put into practice through a project selection and execution. Finally, students would be prepared to offer recommendations and suggestions for the selected business on manufacturing processes.

As with any instructional and curriculum material, a course in Six Sigma methodology should also provide a means of assessing outcomes and student learning. This paper will present and discuss these issues and should be of great interest to those educators who wish to offer instructions on this topic.

Key words: Six Sigma, Yellow Belts, Green Belts, Black Belts, Master Black Belts, process management, DMAIC, ANOVA, SIPOC analysis, VoC (voice of the customer) analysis, CTQ (critical-to-quality)

INTRODUCTION

The only certainty in the business and industrial world is that it is in a constant state of change. The use of new manufacturing methods based on technology has created the need to re-consider and to modify several management tools in order to keep high quality standards and minimum possible cost. The Six Sigma techniques definitely take the lead for such changes in the industrial world.

The Six Sigma techniques allow the manager to produce with efficiency and to decrease defects. Companies are in the permanent search for executives and managers who can improve capabilities and efficiency, reduce cost and achieve better results for customers. Consequently, it is crucial to train students in Six Sigma, and to expand their understanding and skills in this production technique.

THE SIX SIGMA STRATEGY

Yang and El-Haik describe the six sigma strategy as follows:

> Six Sigma is a methodology that provides businesses with the tools to improve the capability of their business processes. In Six Sigma, the purpose of process improvement is to increase performance and decrease performance variation. This increase in performance and decrease in process variation will lead to defect reduction and

improvement in profits, to employee morale and quality of product, and eventually to business excellence. (Yang & El-Haik, 2003, p.21) [42]

Based on statistical knowledge, the variance and the standard deviation are the two most well-known and helpful measures of variability. “Sigma” is the Greek letter (σ) used to refer to standard deviation. This concept is based on the difference between an observed value and the average of the distribution. In the normal distribution (a hypothetical distribution of data that is completely symmetrical) the probability of finding a point within a range of six times the standard deviation around the mean is almost 100% (0.9999966). For manufacturing companies, this measure indicates that defects in production will be 3.4 defects per million units. Six Sigma denotes insignificant variability. With little variation, it is possible to have irrelevant standard deviations. In production words, this goal will imply very low rates of defects, therefore efficiency in quality.

Six Sigma strategies would replace the employment of older quality techniques such as ISO 9000. Therefore, an education in Six Sigma is very important. As a prerequisite, students should be prepared in basic statistics and the use of Minitab software. Sampling, histograms, Bar Charts, Pareto Diagrams, regression analysis, probability distributions, hypothesis testing, and design of experiments are the basic topics the Six Sigma student should be familiar with. In the Six Sigma language, the level of knowledge and skill is measured emulating martial arts categories. Six Sigma ranks expertise into Yellow Belts, Green Belts, Black Belts and Master Black Belts.

SIX SIGMA YELLOW BELTS

Six Sigma Yellow Belts have a thorough knowledge of the basics of Six Sigma. A Yellow Belt is trained to do research oriented to solve problems that affect profits in the organization. They usually act as assistants to Green Belts and Black Belts in larger endeavors. A Yellow Belt course would last for 24 hours. In a university setting, it can be divided into four sessions per week. Each session lasts one and a half hours. The total duration would be one month.

Topics for a Yellow Belt Course

At the Yellow Belt level, students should receive all the basic knowledge of Six Sigma. Pyzdek (2001) [30] displays basic Six Sigma methods that could be used in the preparation of a Yellow Belt.

First Week

- Six Sigma concepts, execution, organization and administration (one session)
- The Six Sigma improvement process (D-M-A-I-C, Define, Measure, Analyze, Improve and Control) (one session)
- Six Sigma objectives and metrics (two sessions)

Second Week

- Focusing on Customer Satisfaction (one session)
- Problem solving tools
    - Process mapping (one session)

- Flow charts (one session)
- Pareto Analysis (one session)

Third Week

- 7 M (management) Tools
  - Affinity and tree diagrams (one session)
  - Process decision program charts & matrix diagrams (one session)
  - Interrelationship diagrams and prioritization matrices (one session)
  - Activity network diagram (one session)

Fourth Week

- Knowledge discovery tools
  - Run charts (one session)
  - Descriptive statistics (one session)
  - Histograms (one session)
  - Exploratory data analysis (one session)

SIX SIGMA GREEN BELTS

A Green Belt is a professional that organizes Six Sigma systems for specific projects. Green Belts have preparation in statistical tools that allows them to collect data, analyze it and run tests to obtain conclusions. They are qualified to do research at a deep level and they support Black Belt professionals.

The Six Sigma Green Belt serves as a specially trained team member within his or her function-specific area of the organization. This focus allows the Green Belt to work on small, carefully defined Six Sigma projects, requiring less than a Black Belt's full-time commitment to Six Sigma throughout the business. Six Sigma Online's Green Belt Training provides participants with enhanced problem-solving skills, with an emphasis on the D-M-A-I-C model. (http://www.sixsigmaonline.org/greenbelt.html) [4]

Topics for a Green Belt Course

A Green Belt course would last for 48 hours. It can be divided into four sessions per week. Each session lasts one and a half hours. The total duration would be two months.

After becoming a Yellow Belt, the Green Belt candidate must learn about statistics and the D-M-A-I-C (define, measure, analyze, improve and control) method. Gitlow & Levine's work (2005) [17]contains good topics for a Green Belt course such as the following:

First Week

- Probability Distribution (two sessions)
- Binomial Distributions (one session)
- Normal Distribution (one session)

Second Week

- Confidence Intervals (two sessions)

- Predictions (two sessions)

Third Week

- Hypothesis Testing (two sessions)
- One-Way ANOVA (two sessions)

Fourth Week (The D-M-A-I-C Model – Define)

- Organize a project charter (two sessions)
- Conduct a SIPOC analysis (one session)

The SIPOC analysis consists of "identifying the suppliers and their inputs into a process, the high level steps of a process, the outputs of a process, and the customer segments interested in the outputs" (Gitlow & Levine, 2005, p. 74) [17]

- Perform a VoC (voice of the customer) analysis (one session)

Fifth Week (The D-M-A-I-C Model – Measure)

- Define the critical-to quality (CTQ) characteristics of a product. This is an appraisal of customer satisfaction. (one session)
- Determine the validity of the measurement of each CTQ (one session)
- Set the baseline capability for each CTQ (two sessions)

Sixth Week (The D-M-A-I-C Model – Analyze)

- Find the Xs for the process and for each CTQ (one session)
- Determine the measurement system for high-risk Xs (one session)

- Stabilize high-risk Xs (one session)
- Establish hypothesis about the relationships between the high-risk Xs and the CTQs (one session)

Seventh Week (The D-M-A-I-C Model – Improve)

- Experimental designs (one session)
- Two-factor factorial designs (one session)
- Pilot study (two sessions)

Eighth Week (The D-M-A-I-C Model – Control)

- ISO 9000 norms (one session
- ISO 14000 norms (one session)
- Control plan for the Xs (one session)
- Name benefits and costs of the project (one session)

SIX SIGMA BLACK BELTS

The Black Belt in Six Sigma is a professional with high levels of quantitative preparation. This is and expert capable of performing thorough research, identify quality and its costs and conceive, assess and examine customer surveys. The Black Belt possesses deep knowledge of statistics and is capable of achieving constant improvement in production. Pyzdek [29]describes the characteristics of a Black Belt as follow:

> Candidates for technical leader (black belt) status are technically oriented individuals held in high regard by their peers. They should be actively involved in the organizational

change and development process. Candidates may come from a wide range of disciplines and need not be formally trained statisticians or engineers. However, because they are expected to master a wide variety of technical tools in a relatively short period of time, technical leader candidates will probably possess a background in college-level mathematics, the basic tool of quantitative analysis. College-level course work in statistical methods should be a prerequisite. (http://www.qualitydigest.com/feb00/html/sixsigma.html)[29]

A Black Belt certification can be obtained after 54 hours of training (nine weeks). After gaining the qualifications of a Green Belt, a Black Belt course can also be divided into four sessions per week. Each session lasts one and a half hours. Based on Pzydek (2001) [29]and Aveta (http://www.sixsigmaonline.org/SSO Brochure.pdf) [5], the curriculum for Black Belt proficiency can be organized as follows:

Topics for a Black Belt Course

First Week

- Statistical Process Control Techniques (four sessions)

Second Week

- Process Capability Analysis (four sessions)

Third Week Design of Experiments (DOE)

- Two way ANOVA with no replicates (two sessions)
- Two way ANOVA with replicates (two sessions)

Fourth Week Design of Experiments (DOE)

- Regression analysis (two sessions)
    - Linear models (one session)
    - Least-squares fit (one session)
- Correlation analysis (two sessions)

Fifth Week Process Simulation

- Simulation tools (one session)
- Model development (one session)
- Management constraints (one session)
- Backlog (one session)

Based on De Feo & Barnard (2004, p. 58) [14], the next three weeks can be devoted to the redesign of a process or Design for Six Sigma (DFSS) as follows:

Sixth Week Design for Six Sigma (DFSS) (DMADV-Define and Measure phases)

- Define Phase. Prepare and administer the project (one session)
- Measure Phase. Identify customer needs (one session)
- Measure Phase. Develop CTQs (one session)
- Measure Phase. Evaluate baseline operations (one session)

Seventh Week Design for Six Sigma (DFSS) (DMADV-Analyze and Design phases)

- Analyze Phase. Identify possibilities (one session)

- Analyze Phase. Create high level designs (one session)
- Design Phase. Develop and evaluate detail level designs (two sessions)

Eighth Week Design for Six Sigma (DFSS) (DMADV-Verify phase)

- Perform pilot plan (two weeks)
- Execute production process (two weeks)

Ninth Week. Lean Manufacturing

- The Eight sources of waste in factories: Overproduction, inventory waste, defective product, over processing, waiting, people, motion and transportation waste (http://www.asq.org/pub/qualityprogress/past/0403/qp0403alukal.pdf) [1] (two sessions)
- Steps for a change: Specify the value, identify the value stream, flow, pull and perfection (Womack, 2003) (two sessions)

MASTER BLACK BELTS

The Master Black Belt has the highest level of knowledge in Six Sigma techniques. He/she is a professional with skills and expertise not only in technical issues, but also in leadership.

> Master Black Belts are Six Sigma Quality experts that are responsible for the strategic implementations within an organization. Master Black Belt main responsibilities include training and mentoring of Black Belts and Green Belts; helping to prioritize, select and charter high-impact projects; maintaining the integrity of the Six Sigma measurements, improvements and tollgates; and developing, maintaining and revising Six Sigma training materials.   (http://www.isixsigma.com/dictionary/Master_Black_Belt-83.htm) [35]

Organized in the same way as explained previously, the Master Black Belt course will last four weeks (24 hours) after the completion of Black Belt courses. Based on "Smarter Solutions, Master Black Belt Training" (http://www.smartersolutions.com/masterblackbelt.php)[37] the topics to cover would be the following:

Topics for a Master Black Belt course

First Week

- The satellite level and the 30,000 foot-level metrics (two sessions)
- Creation of a Lean Measuring system (two sessions)

Second Week

- Utilization of the Montecarlo Simulation for the implication of variability on testing and analysis (two sessions)
- Performing evaluations (two sessions)

Third Week

- The use of the DOE Collective Response Capability (DCRCA) for success in new product launching (two sessions)
- The Response Surface Methods (RSM) (two sessions)

Fourth Week

- Project management (two sessions)

- Project financial benefits (two sessions)

EVALUATING RESULTS: TESTING STUDENTS IN SIX SIGMA

In order to evaluate students in a Six Sigma course, it is a good suggestion to create a complete report of the student's improvement in skills and capabilities in this technique. Kubiszyn (2003) [24] refers to this evaluation method as "portfolio assessment."

"Portfolio is a planned collection of learner achievement that documents what a student has accomplished and the steps taken to get there. The collection represents a collaborative effort among teacher and learner; to decide on portfolio purpose, content, and evaluation criteria" (Kubiszyn, 2003, p.174). [24]

This evaluation method offers the professor a great advantage: the opportunity to work together with students and monitor their performance. Kubiszyn (2003) [24] displays seven steps in order to develop a portfolio assessment: deciding on the purposes for a portfolio, deciding who will plan the portfolio, deciding which products to put in the portfolio and how many samples of each product to include, building the portfolio rubrics, developing a procedure to aggregate all portfolio ratings and determining the logistics. These steps can be applied to a Six Sigma educational setting as follows.

Deciding on the Purposes for a Portfolio

The purposes for developing a portfolio are oriented to measure students in their ability to obtain and interpret information. Data obtained by students could be used to analyze the current situation of a manufacturing setting or to explain the benefits of Six Sigma where this technique has been successfully implemented. With a portfolio, the professor can evaluate students in their ability to assess and explain the Six Sigma aspects exposed by Pande et al (2000, p. xi): [27]

- Cost reduction
- Productivity improvement
- Market-share growth
- Customer retention
- Cycle-time reduction
- Defect reduction
- Culture change
- Product/service development

Identifying Cognitive Skills and Dispositions

In a Six Sigma program, students can be assessed in: manufacturing process recognition, description of market needs, appraisal of contemporary operations and Six Sigma implementation. Additionally the students' cognitive skills can be determined by evaluating their level of investigation, understanding, development, management and control of the possible success factors for Six Sigma and Lean (efficient, low cost and productive) Six Sigma designs.

Deciding Who Will Plan the Portfolio

The portfolio for testing students in Six Sigma should be designed by the instructor and communicated to students timely to achieve agreement and consent on clear goals.

Deciding Which Products to Put in the Portfolio and How Many Samples of Each Product to Include

"In deciding what you would like to see included in your learner's portfolios, you will have to ensure that you only require products that your learners were prepared to develop" (Kubiszyn & Borich, 2003, p. 177). [24]

Building the Portfolio Rubrics

For each of the assessment topics mentioned above (manufacturing process recognition, description of market needs, appraisal of contemporary operations and Six Sigma implementation) students will be graded based on a uniform scale (i.e. 1 to 10 points).

Additionally, students should also be evaluated on their overall performance. In other words, the instructor will appraise students' cognitive level in theoretical knowledge, case analysis and solution suggestions in a project.

Developing a Procedure to Aggregate All Portfolio Ratings

Once students' scores have been obtained, it is necessary to unite all marks into one final grade. This could be achieved with a simple average calculation or a weighted mean.

Determining the Logistics

According to Kubiszyn & Borich (2003), [24] determining the logistics include steps such as establishing timelines and deciding how products (in this case Six Sigma recommendations for manufacturing improvement) are turned in and returned. Furthermore, it is necessary to settle where Six Sigma recommendations are going to be kept, who has access to the portfolio and how to communicate results (i.e. offering an oral presentation).

CONCLUSION

To conclude, Six Sigma is the strategy and the technique of the future. It will be the key for successful production and successful business practices.

> In business speak we are compelled to use short phrases to describe complicated ideas. "Six Sigma" is no more a thing than is "economic policy" or "organizational excellence" or any dozens of other shorthand terms we use everyday. Six Sigma is a system that encompasses may concepts, tools, and principles (Pande et al, 2000, p. 382).[27]

There are hundreds of thousands of manufacturing companies. Only a few are capable of implementing Six Sigma programs successfully. The leaders who are well-trained in this technique are closer to success. Six Sigma implies lots of changes always keeping in mind customer satisfaction. Reduction of defect level and accuracy in production are terms that define Six Sigma.

While people, rather than computers, are the ones who seek for constant innovation and improvement, executives should be educated and trained. A course in Six Sigma is the base for future success in operations.

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