Title: Practical Application of Six Sigma in Team Environments

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Course Title: Communication and Team Building
Course Number: ETM 522 / 622
Instructor: Dr. Charles M. Weber
Term: Winter
Year: 2017
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ETM OFFICE USE ONLY
Report No.:
Type: Student Project
Note:

Contents

Abstract

Since the mid 1980's, Sig Sigma has been offering tools and techniques to reduce process and organizational variations within manufacturing and heavy industries. The concept of Six Sigma evolved from total quality management methodology of the 1950's. Lean was developed by Toyota to reduce costs and eliminate non-value added activities and Six Sigma was developed by Motorola to reduce process variability and capture metrics for statistical analysis [1].

Thesis

Six Sigma is a framework "useful when the focus is on process outputs and the team needs to collect and analyze data to localize the problem and identify root causes. [20]"-"Six Sigma gained its reputation by proving statistical evidence" [16]. According to Banuelas et al. [4], Six Sigma is a powerful tool because it rigorously uses data and statistical analysis to measure and improve a company's performance by eliminating defects or errors in the process. "Six Sigma had its origin in the introduction of the normal distribution as defined by…. Gauss (1777-1855). Shewart expanded this concept by introducing mean value as a key mechanism for quality control" [2].

One of the great advantages to team building that Six Sigma offers is a methodology bookended by managerial commitment and employee participation. Aspects that makes Six Sigma attractive is its flexibility. Six Sigma can be associated with Lean methodology. Umude-Igbru and Price [32] review the two methodologies separately; while Six Sigma looks at the statistical data to improve the process, Lean methodology looks at the non-value added activities and elimination of waste in the process. The initiative to combine these two methodologies is based on maximizing the benefits each methodology offers, hence the Lean Six Sigma (LSS) initiative. L6S (also known as LSS) is the "merger of two quality improvement methods: Lean and 6 Sigma" [16]. The L6S approach is to improve value and used KPI's. Lean and Six Sigma are closely related. The techniques of LSS are easy to use, with proven, and effective applications to teambuilding, and organizational processes.

Six Sigma is also applied to new product development in the form of Design for Six Sigma (DFSS)When used in lean manufacturing, its considered Lean Six Sigma (LSS). "If the project tendency is towards the creation of a new product or service DFSS (Design for Six Sigma is a better choice" [2]. Other methodologies are "Lean Manufacturing, Total Quality Management and the International Organization for Standardization (ISO) quality systems" [33]. Organizational Executives are called Champions and Executives while members are called Green, Yellow, and White Belts are supported by leaders called Black Belts and Master Black Belts. (See Figure 1).

Literature Review

Total Quality Management (TQM) played a big role in the early development of Six Sigma strategy, many different aspects of Six Sigma came from adaptation and improvement of the TQM process. Both TQM and Six Sigma are aimed at improving quality, and customer satisfaction. TQM is more management-centric, where each manager tries to improve the processes under his/her responsibility. Six Sigma, on the other hand, integrates management, improvements, and processes to produce short-term and long-term improvements. It also puts emphasize outside the group in the process of improving customer's satisfaction [32]. Six Sigma built on the TQM philosophy that "all concepts, principles and their interrelationships should be seen as a whole and not in isolation. [33]"

TQM literature review could be summed up to "Customer defines quality; quality in turn creates customer satisfaction" (Alsmadi and Khan) [2]. The Six Sigma ideology that customer requirements determine the analytical metrics of processes and organization was greatly influenced by TQM methodology.

Six Sigma has a wide range of other benefits. Team building, and culture is increased within an organization by reducing environmental variables. Alsmadi and Khan recognize: On the shop floor level, when quantifying root causes of problems, understanding and controlling variations, the game of exchanging blames between employees will have an end. By eliminating firefighting tasks that occupy most of floor managers time and replacing it by logical procedures to uncover variation causes, knowledge will be created and translated into business growth for the organization [2].

In 2010 Tchidi & He recommended software development organizations use DFSS to establish best engineering practices. "The success of the project is through the outstanding efforts of all the team" [25].

Up to 35% of literature on Lean is focused on health care service improvements [1].

- In a Staten Island University Hospital, they reduced waiting delay in patients to obtain bed from assignment to admission by 43% [1].
- Missouri Baptist Medical Centre used Six Sigma to reduce surgical infection and therefore Six Sigma implementation resulted in better patient care [1].
- Schneider Children's Hospital improved average length of stay [1].

Key performance indicators used in the healthcare industry include: On-time start percentage, average turnover, staff overtime, change in operating margin, throughput or patient flow, patient satisfaction, cost, medical errors, and length of patient stay [1]. Chen and Molnar [5] explain that Six Sigma strategy is used to improve cycle times, reduce costs, raise customer satisfaction and therefore increase profitability in many different companies worldwide.

Research Questions

Affecting Teambuilding

The primary concept that Six Sigma methodology stresses is building teams and teamwork (Banuelas Coronado and Antony, 2002). Effective teamwork is vital for successful project executions (Halliday, 2005). Team-learning is viewed as a process of aligning and developing of a team to create the results its members want (Senge, 2006). Six Sigma teams are typically led by a Black Belt who "is a skilled and respected design or research engineer who has received training in the core philosophy of DFSS beyond what is expressed in literature as well as the concept's potentials of appliance in development projects." [6]. Timing of training implementation should also be an important consideration. A quickly developing team may need a rapid deployment of training to stay abreast of the task at hand. Katzenbach & Smith (1993, Loc. 2003) stated that "each team must find its own path to its own unique performance challenge."

Adopting and Adapting Six Sigma in real environments

Many companies over the years have adopted the initiative of LSS, which is the integration of Lean strategy with Six Sigma, companies have found both strategies are complementary to each other. In the heart of the integration is the objective to improve a company's ability to do the right things successfully, the first time. Banuelas et al. [4] state that companies should selectively choose the right projects and complete them successfully within the allowed duration. This will lead to higher quality, higher productivity, faster delivery, and lower costs. Other objectives of LSS include the reduction in process variability, cycle time, changeover and setup time. Once these objectives are met, it will be easier to expand the objectives to include improving the factory layouts, floor space, capability, and stability of the processes.

DFSS training programs suggest that team leaders may not need to be an expert of any one subject as they will always have support of the Master Black Belt. Instead, it is offered that they simply

need to be trained on when to use the training. Würtemberg & Lilliesköld state [6], when it comes to the competence profile of a trained DFSS Black Belt the essential parts according to this study are:

- understanding of "just-in-time training" for engineers
- conversance of the methods within the concept
- comprehension of the purpose with tools and techniques within the concept and when to use them

Choosing the best method

Choosing the right projects is a process, and the selection of good projects is a major factor in achieving the objectives of LSS. Management should define the goals, direction, priorities of the organization, and projects selected should be closely aligned to those priorities. This approach aligns with the objective of Lean principle, once the right projects have been selected and started, the Six Sigma objectives of improving the performance will ensure that the processes associated with those projects are flawless.

Research Design

We reviewed 33 articles from IEEE, Research Gate, Ebsco Host and the internet to find Practical Application of Six Sigma in Team Environments.

Model Framework

The steps for Lean Six Sigma follow five phases, as outlined by Smith and Walz [13] [14] in their literature review. These phases include Define, Measure, Analyze, Improve, and Control (DMAIC). Furthermore, Lee and Su [15] describe the Define phase as the phase to define the problem, the system, the customer requirements, and selection based on a cost/benefit analysis. Measure phase is described as the phase where the problem transforms into a measurable form as the data collection process takes place. The Analyze phase is the phase where the data from the problem is analyzed to reveal the causes and effect, and determine which factors should be considered. The improve phase is defined as implementing and verifying the solution. Control phase, is maintaining the organizations solution. In 2008 Antony realized "SS will survive only when it has a strong theoretical supporting and link with other management theories" [30]. SS has adopted language like the customer voice. ISO 9001 began the concept to the customer voice [33]. The voice of the customer (VOC) is a primary objective of Six Sigma. VOC is that the "customer of present day is the center of business" [16].

In 2010 Alsmadi and Khan answer the question: What makes TQM fail? "TQM literature points to the following common factors: lack of universally accepted framework, variation in national cultures, incompatibility with organizational culture, resistance to change, and ineffectiveness of top management leadership" [2].

Results and Application

Six Sigma has found "great support in Northern and Central America and to a lesser extent in Europe and Asia. In South Africa, there has been very little penetration" [11]. South Africa has favored ISO and other standards for quality and continuous improvement." [11].

Smith [2] and Adams [31] presented the experience of TBM Consulting Group in implementing Lean Sigma. The company first implemented Lean principles to expose waste, and then Six Sigma principles were adopted to reduce variation. Lean principles resulted in over a million in savings annually.

"The Six Sigma methodology was developed by Bill Smith of the Motorola Corporation… in 1981" [1]. "Motorola registered the Six Sigma trademark" They "developed tools and methodologies

aimed at improving product quality" [1]. Motorola used Six Sigma for their HR team to drive improvement in the supply chain [16]. The goal was to meet the business requirement, regain HR's reputation for contracting in the company, support global HR goals, and the global manufacturing goal [16]. Six Sigma has gained popularity in North America, Europe and Asia by bring about better customer service and higher levels of productivity [16]. Six Sigma has saved billions for organizations in waste, rework, and reclaim costs. It requires organizations to examine their processes from a customer's perspective [16]. The team came up with "evidential statistical numbers to validate the improvement" [16] they gained. The HR project "ensured shorter new hire cycle time with less money spent" [16]. It achieved "more cost-effective HR services to the manufacturing business, improved internal customer satisfaction, and enhanced HR's reputation within Motorola" [16]. Motorola used statistical methods to achieve improvements in quality, and bottom line results [16]. Some techniques for analysis and improvement include Kaizen, Kanban, 5S, etc. [1].

A South African mining company used Six Sigma to attain a "target of achieving accelerated economic growth and reducing unemployment and poverty by half by 2014" [11]. The Six Sigma methodologies used analysis and indicators to relate the deployment plan to senior executives and technical support to motivate the project. Questions were asked about how internal and external suppliers relate and engage with the organization. Finally, training, communication and incentive programs were used as empowering tools.

In some Asian countries Six Sigma has not been achievable. Empirical analysis of existing literature points to Six Sigma implementation as still not popular in the Malaysian manufacturing industries. Many organizations consider Six Sigma initiative as complicated, and not realistic for improving their business processes [12].

"DMAIC is the most used Six Sigma Methodology" [16]. DMAIC "originated from concepts introduced by W. Edwards Deming---Plan-Do-Check-Act… which describes the basic logic of data-based process improvement" [16]. Ngoune and Kholopane [18] illustrate the application of Lean Six Sigma tools in water management systems. The Six Sigma steps of DMAIC were adopted where multiple factors contributing to the water shortages were identified, data was collected and analyzed to find the sources of variations and defects. The fishbone or cause-and-effect diagram was employed to find issues in operational, maintenance, and management systems of water supply. Solutions were put in place and monitoring systems were implemented. As a result, the water management systems were improved to fix the issue of water shortages in Limpopo, South Africa.

The major steps of the "define" phase are problem statement definition, team member selection, and project scope definition, including metric and goal settings. In defining the problem statement, the focus should be on collectively understanding what is wrong rather than explaining why its wrong (which will be uncovered through the course of the project). For this Six Sigma project, the problem statement was originally defined by the quality engineer (QE) as: "Soldering defects are due to the obsolete robot". This problem definition, however, already included the presumed cause of (and implied solution to) the soldering defect, which was likely to undermine team-learning and teamwork. However, rather than potentially creating an intimidating or combative environment by indicating this deficiency a priori, the black belt (BB) instead focused on gaining commitment and cooperation among team members by initially proposing that the DMAIC method might be helpful for preparing a "statistical" (factual) justification for the acquisition of a new robot. In this way, potential team members readily agreed to cooperate with data gathering, meeting attendance, and an active participation in workshop sessions. The first step in the project was then to induce team members to open-up their views regarding the nature of the problem. To do this, the BB first had team members generate a problem statement individually, and then collectively, each member's perspectives of the problem was integrated into a new problem statement. Team dialogues and discussions based on data

served to combine their ideas, and the problem redefinition. After several group discussions, a solid plan was formulated [27].

The project therefore helped the company move from a very hostile relationship with the customer, to a more confident and gratifying one. Instead of losing the current business with the customer, the ICV division won new business opportunities with this customer with the manufacturing of two new products. The results from this project were not only shared with the customer but also across other business units. As previously mentioned, this was the first project executed with the DMAIC methodology in this company and, given the tangible benefits and the championing by team members, who were now firm believers in the methodology, the company quickly endorsed the SS strategy throughout the organization [27].

Discussion

Researchers on the topic agree that extensive training is necessary [3], [4], [7], [8], [20], [23], [26]. There are two apparent deficiencies in current practice in these areas within most organizations. First, Six Sigma training is primarily conducted on an individual level rather than within the team context. Second, related to the first point, Six Sigma training and facilitation in organizations may not adequately address or encourage team-learning processes. While Six Sigma training is often carried out individually, the application of Six Sigma is typically performed collectively through team-based projects [27]. People who are highly trained in Six Sigma methodologies can help with deployment. These professionals are called Black Belts.

One thing that a lot of organizations fear is that if they speed up production, that they lose the ability to create a high-quality product. This is not true with Six Sigma strategy. In Six Sigma, when production speeds up, there is a lot of emphasis put on creating a high-quality product, while reducing the amount of waste that it takes to create the product.

Some of the tools Six Sigma uses are strategy maps and process models. A strategy map which introduces all perspectives of the organization can help one begin to understand what methodologies one might want to use. A process model is used for deployment. Often, this is in the form of financial, processes, learning and customer models that center around the vision and strategy of an organization.

Future research should seek to determine whether specific learning processes are more vs less important at different stages of the DMAIC process, or for particular problem, industry or team types. Future research should also seek to determine whether teams display any other differentiating patterns in their learning processes, which may represent different learning styles. A related line of study is to understand why some teams may learn faster than others, achieve better results (that cannot be directly tied to differences in learning), and negotiate change better than others. Finally, the development of standard interpretation guidelines or other decisions support criteria for Six Sigma tool outcomes might be another promising area for improving learning in Six Sigma teams. Literature reviews have acknowledged that Six Sigma tools are typically applied by "non-statistical" people.

Conclusion

Within a highly-driven culture focused on customer satisfaction, implementing a teambuilding framework can make every member of the organization feel important. Employees will feel like they are all working towards the same goal. Six Sigma not only helps enforce teamwork in an organization, it also strives to help identify and create leaders as well.

Black Belts have many tools at their disposal when dealing with the typical organizational struggles within a team. Need to know knowledge sharing will be replaced by just in time training. Synergies will be bolstered by deep subject knowledge and support structures. Common purpose will be found through a common knowledge & comprehension training the black belt constantly implements.

Aside from increasing teamwork, and locating leaders within an organization, the strategy also strives to organize and perfect processes and tasks. The strategy helps to assist organizations with finding systematic methods to engage in their products. This speeds up production, and ensures that everyone is doing their part at the same time.

Exhibits

Figure 1 – Team Roles in Six Sigma

Team Handbook Role	Six Sigma Role	Description
Sponsor	Champion	Executive Management
Members	Supporter	Employee
Members	White Belt	Employee
Team Lead	Yellow/Green Belt	Project Participant/Project Lead
Team Lead	Black Belt	Project Lead
Coach	Master Black Belt	Proven track record of delivering results

Note: Adapted from [16] and [20].

Table 1 – The belts explained

> Six Sigma teams that are built, are comprised of individuals in a tiered-level hierarchical system that is similar to the same systems that exist in karate. This belt training system even uses colors to designate the experience that each member has under his or hers "belt" so to speak. There is the yellow belt, green belt, and black belt. Teams are set up, with a mixture of individuals who possess these different belt certifications, and every member of the team is given a set of tasks, roles, and responsibilities that they must complete.
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> Every individual that participates in obtaining the training, will earn a specific belt color, based on the level of training they have received. In order for the individual to be able to be put in charge of a specific project, they must obtain a designated colored belt, most often, a black belt. The only way to obtain a higher color belt is to receive the belt before it, and work your way up the ladder of training levels.

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