AN APPROACH ON IMPLEMENTING INTEGRATED LEAN SIX SIGMA FOR SOFTWARE DEVELOPMENT

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Abstract: *Lean Six Sigma is being used in many industries to achieve dramatic performance improvements in their operations, maintenance, engineering and business processes. The purpose of this paper is to implement an integrated Lean Sixsigma methodology for process improvement thereby reducing cost of software development improving profitability. The paper begins with a review of literature of Lean, Six Sigma, Lean Six Sigma and their role in the software industry. The integration of Lean Six Sigma in the software domain is presented, followed by presentation of the results from an empirical investigation of Lean Six Sigma for software development. The empirical case study of software development is examined here for establishing the effectiveness of this methodology.*

The research reflects the Lean Six Sigma application and implementation in the software industry, using the commonly used statistical and non-statistical and software engineering tools and frameworks used within software business; and determines the critical success factors (CSFs) for a successful Six Sigma initiative in the software/IT industry. The research brings out Lean Six Sigma, for achieving operational excellence, can, as it turns out, do more than simply improve processes. The paper also brings out how it helps discovering innovation opportunities far beyond operations, enhance financial performance.

This paper focuses on integrated lean six sigma programs in practice, rather than the theoretical basis or motivationally based argument. The adoption of methodologies outlined in this paper in software companies would enable them to attain improvements in terms of cost, schedule and quality.

Keyword(s): Lean; Six Sigma; Function Point Analysis; Software Development

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1. Introduction

The current economic downturn has shaken the fabric of many businesses and has accelerated the pace of change and business consolidation by placing the innovation on the top priority list. Cost reductions, faster time-to-market, better products and differentiated services are now the important pillars. The software engineering approach is undergoing a shift from the typical Software development life cycles (SDLC) towards higher predictability and risk reduction by ensuring that business deadlines are met. This will also help in cost reduction and seamless productivity improvement by ensuring optimal developmental cost.

Recently the germination of the idea about combining Lean methods with Six Sigma approaches for continuous improvement has attracted the attention of academia and industry. Even though both Lean and Six Sigma are rooted in the manufacturing arena, it is becoming a major focus to all sectors. Therefore, the objective of this research, in the field of quality management is the combination of Lean Six Sigma to bring you the best of both worlds. This combination can be synergistic for quality improvement in the booming service sector. This paper attempts to help start and develop a journey towards an integrated Lean Six Sigma, Improving quality by capitalizing on an integrated Lean Six Sigma methodology - for the quality improvement in Software development.

An empirical case study of software development is conducted to illustrate the deployment processes and to investigate the effectiveness of the methodology proposed. The case study is derived out of a software development undertaken by software IT Services Company from one of its customers, a division of a US based media conglomerate who provide healthcare marketing services. The rationale for the combination of the two disciplines is also examined and justified on theoretical basis.

2. Need For Implementation

Jovanoic and Shoemaker (1997) argued that ISO 9000 is appropriate for software development processes as well. Jalote (2000) found the Software Engineering Institute's Capability Maturity Model (CMM) to be a widely used framework for quality management in software companies. Organizations that have acquired the fifth level of CMM and PCMM are expected to maintain very high quality standards (Harter et al., 2000). Issac et al. (2004) proposed a descriptive TQM model for quality management in the software industry.

Most of the existing research deals with improving Service Quality in the service sector whereas there are few research studies conducted in the area of its applicability in Software development. The quality of software is of significance to everyone, including users and developers. Software development and services companies are trying to control costs (Phan et al., 1995) through excelling in operational efficiency to counter intense competition and to combat financial setbacks.

Over the last decade, the world has witnessed an exponential growth in improvement initiatives such as Lean and Six Sigma. Dozens of documents have chronicled the successful implementation of either Lean or Six Sigma. Although it is possible to achieve independent success in Lean and Six Sigma, they do have few pitfalls. Lean does not possess the tools to reduce variation and bring a process under statistical control, while Six Sigma views elimination of variation as essential. On the other hand, Six Sigma does not attempt to develop a theoretical or practical link between quality and speed; this is the area where Six Sigma falls short compared to what Lean can offer.

The integration of Lean and Six Sigma can achieve combined benefits of cycle time reduction and defects reduction in the software products or services thereby reducing the cost of software construction achieving operational efficiency.

3. Literature Review

3.1 Lean Methodology

Lean production or lean thinking (Womack et al., 1990; Womack and Jones, 1996) has its pedigree in the philosophy of achieving improvements in most economical ways with special focus on reducing muda (waste). The concept of muda became one of the most important concepts in quality improvement activities, primarily originated by Taiichi Ohno's famous production philosophy from Toyota in the early 1950s (Dahlgaard-Park, 2000, p. 128). This philosophy was widely called as Toyota production system in Japan (Udagawa et al., 1995; Womack et al., 1990), and it was later (1986) labeled as lean production and lean thinking by Womack et al. (1990).

In the book "Lean Thinking", the very first word is interestingly the Japanese word for waste (muda), and it is concluded that muda is everywhere. This is a very important observation not only in relation to Lean Production but also to Total Quality Management (TQM).

5S OR Workplace Organization - This tool is a systematic method for organizing and standardizing the workplace. It’s one of the simplest Lean tools to implement, provides immediate return on investment, crosses all industry boundaries, and is applicable to every function with an organization.

Japanese Term	English Translation	Equivalent 'S' term	Connotation
Seiri	Organization	Sort	Identify Value
Seiton	Tidiness	Systematize	Value Stream Mapping
Seiso	Cleaning	Sweep	Root Causation
Seiketsu	Standardization	Standardize	Flow/Pull
Shitsuke	Discipline	Sustain	Pursue Perfection

3.2 Six Sigma

The roots of Six Sigma can be traced to two primary sources: Total Quality Management (TQM) and the Six-Sigma statistical metric originated at Motorola Corporation. Six Sigma a well-structured data-driven approach to eliminate defects, was originally a collection of practices designed to improve manufacturing processes, but today Six Sigma has stepped out to every other type of business processes.

Bill Smith (widely regarded as Father of Six sigma) was the first to coin the elements of the methodology at Motorola in 1986. Six Sigma was heavily inspired by six preceding decades of quality improvement methodologies such as quality control, TQM, and Zero Defects, based on the work of pioneers such as Shewhart, Deming, Juran, Ishikawa, Taguchi and others.

Methods, Tools & Techniques are vital to the success of any Six Sigma project. Six Sigma can be accomplished using two key methodologies: DMADV and DMAIC - both inspired by Deming's Plan-Do-Check-Act Cycle. Every stage of a Six Sigma project recipe requires a mix of these methods, tools & techniques.

- DMADV (Define-Measure-Analyze-Design-Verify) is used when creating a new product or process. Using DMADV for new projects usually results in a more predictable process and ultimately higher quality product.

- DMAIC (Define-Measure-Analyze-Improve-Control) is used to improve an existing business process. DMAIC is an acronym for a series of steps used to measure defects in business processes and improve profitability.

DMAIC methodology is a five step improvement process comprising the following:

• Define the problem, process, improvement goals and the project goals that are consistent with customer demands and enterprise strategy.

• Measure and collect the key aspects of the process and collect relevant data.

• Analyze the data collected at the measure stage and convey a cause and effect relationship. Determine what the relationships are, and attempt to ensure that all factors have been considered.

• Improve or implement the process based upon data analysis using techniques like Design of Experiments. A key aspect to this stage is implementation and there may be various test or pilot activities to ensure the intended improvements have the desired outcomes.

• Control to ensure that the improvements implemented are sustained and that the desired outcome is achieved. Any deviations from target are corrected before they result in defects. Set up pilot runs to establish process capability, move on to production, set up control mechanisms and continuously monitor the process control mechanisms

The Six Sigma methodology that is most widely used is known as DMAIC for process improvement. DMAIC offers a structured and disciplined methodology for solving business problems and enables a business to achieve extremely low non-conformance rates (Harry and Schroeder, 2000). The Six Sigma tool kit includes a variety of techniques, primarily from statistical data analysis and quality improvement. Many quality tools are descended from TQM; others are more recent and sophisticated (Breyfogle, 1999). New tools will continue to be selectively added from other disciplines, for example, the field of operations research (Hoerl, 2004).

3.3 Lean Six Sigma

Lean six sigma is a relatively new methodology, has not been studied in great detail. Some organizations use both methodologies in parallel to each other, while some have focused on implementing lean and sixsigma separately as an isolated methodology for improvement. Lean and six sigma individually cannot achieve the required improvements at the rate at which lean six sigma can. Lean six sigma maximizes shareholders value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed and invested capital (George, 2003). Using a combination of lean and six sigma, a greater value to the customer can be provided. While lean seeks to eliminate waste, six sigma seeks to reduce variation. By combining the two, waste is first removed, which then allows for variations to be spotted more easily.

Today, the distinction between Lean and Six Sigma has become somewhat blurred though they were originally developed by different people and different schools of thought (Kubiak, 2003). However to demonstrate the rationale for the synthesis of Lean and Six Sigma, it was noted in the literature that despite having the potential of reaping individual benefits from the two disciplines, some challenges were also highlighted for Lean and Six Sigma. Literature review of publications by McAdam and Evans (2004), George (2003) and Nave (2002), there are some complementary and commonality results obtained from comparing both Lean and Six Sigma approaches.

Lean Six Sigma (LSS) is being used in many industries to achieve dramatic performance improvements in their operations, maintenance, engineering and business processes. Pranckevicius,D (2008) etal. has applied Lean SixSigma DMAIC model for improving a plastic cup manufacturing process. Thomas, S (2008) etal. developed and implemented a Lean SixSigma model for manufacturing industry.

CT Su (2006) etal. demonstrated a case for improving service quality for help-desk service in an Information Technology environment. This literature provides a guidance to use an integrated Lean Sigma for a Software development environment. But, there is hardly any literature exists on implementation of Lean and Six Sigma for Software development for Products and Services. Though it is learnt from the websites of companies' viz. Accenture, IBM, Xerox Corporation evidence of usage of Lean Six Sigma for process and productivity improvements thereby improving bottom line.

4. Overview of Lean Six-Sigma Implementation

A web based Global Physician Polling Application is developed which shall enable administrators to create Physician surveys based on client requirements. The application shall also enable manage the Physician registration, review and payment status reporting.

Global Physicians Panel application is proposed to be built by CDM to manage information collected from a Global List of Physicians. Information is collected from the Physicians using Surveys created by the administrator/s of the application based on the requests from clients. Physicians are compensated for their participation in the Survey. This compensation may be paid directly to the Physician or to a charity selected from the list of charities available within the application.

In the current study, the Lean Methodology using 5S is integrated with Six Sigma methodology using DMAIC.

Phase 1: Define/identify value

The scope of the Lean Six Sigma project is to systematically implement the Integrated Lean Six Sigma methodology in various phases of the Software development project and analyze the benefits described in the literature and the ongoing research of the implementation and evolve this methodology for continuous process improvement. The scope includes use of various tools within Lean and Six Sigma methodologies and measures the quantitative data to analyze the improvements.

Using a SIPOC (supplier-input-process-output-customer) diagram, all relevant elements of the improvement project is identified at the start of the project.

The VOCs are identified as follows through the surveys conducted among the company's customers and employees to understand the requirements for the product under development.

Each of the screened VOCs in previous step are translated into a measurable items which are Critical to Quality, as follows.

Critical to Quality (CTQ)

- Data Accuracy
- Defect reduction
- Cycle time reduction
- Rework Reduction

Phase 2: Measure/value stream mapping

A current-state value stream map shows work processes as they currently exist. This is vital both to understand the need for change and to understand where opportunities exist.

Prior to starting data collection, the measurement system should be examined. Function point analysis is being used for sizing the software.

Function Point Analysis is a structured technique of classifying components of a system and is one of five currently recognized ISO standards for functionally sizing software. It is a method used to break systems down into smaller components so that they can be better understood and analyzed.

Value stream Mapping:
The current value stream map is identified and identified the non-value added steps in the value stream. The future value stream map is constructed after removing the non-value added steps.

The next step is to determine the specification levels of the CTQs. The target values of the metric measurements and the acceptable variation is given in Table

#	Metric	Target Value	Acceptable variation
1	Defect Density	0.6	+/-0. 2
2	Effort Slippage	10.00%	+/-5
3	Productivity	1.88 PD/FP	+/-0.5
4	Rework Effort	8%	+/- 2
5	Schedule Slippage	10.00%	+/-5

Phase 3: Analyze/determine root causation

The data collected is examined to characterize the nature and extent of the defects occurring in each phase of the software development process. The next step is to identify the root causes of why defects occur in the non-value added steps. Once the root causes are identified, the immediate priority is to remove them from the process.

Phase 4: Improve/flow and pull

Based on the findings of the significant causes in the Analyze phase, the solutions for eliminating these causes are proposed as follows.

- Strengthen the review process
- End user expectation (Requirements) are better mapped
- Use of the Architect and Solutions team as external reviewers

End result is reduction of rework on the software product at every phase of development. This reduces defects, cycle time and the cost of the product.

Phase 5: Control/pursue perfection

The purpose of this step is to make sure that the solutions endure. In addition, the control of the software development and delivery process must occur at both the strategic and tactical levels.

The attributes used for continuous improvement is meticulously used in the existing product enhancement, maintenance and support life cycles. Also, keep track of the process performance after improvement, also to control the critical variables relating to performance on a continuous basis for consistency and repeatability in future software development projects.

5. Summary of Results

One of the major findings in this study was that the cycle time is reduced by 10 to 12 % equivalent compared with the performance before implementing the Lean Six Sigma methodology, and it also reduces the defect density by 32%. This achievement in cycle time reduction implies that the Lean Six Sigma methodology has proven its power to accelerate the process flow by eliminating the non-value-added steps while also streamlining the remaining value-added steps.

Using Six Sigma framework, this project achieved a 3.4-sigma quality level result combining both hard and soft savings valued at US$ 23,040 annually, based on the calculations of the obtained data. The hard savings refer to the Six Sigma project benefits that allowed this firm to do same amount of business with a fewer employees or handle more business without adding people. On the other hand, soft savings are Six Sigma project benefits such as reduced time to market, cost avoidance, improved employee morale and other intangibles, which contributed additional savings to the firm.

6. Conclusions

It was noted in the case study that combining the advantages of speed and consistency, the productivity level could be substantially improved and cycle time is considerably reduced. These considerable benefits highlight the competences of the Lean Six Sigma approach. However, there are two limitations, which reside in this research. First, the Lean Six Sigma methodology was applied to just one case, which prevents the generalizability of the methodology to other software development projects. The second issue regarding the sustainability of the results from implementing the methodology had not been investigated. Future studies are planned extending the research into other software life cycles involving, testing, maintenance and support of software products.

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