Chapter

Services Six Sigma: Knowing the Debates and Failure Modes to Drive Better

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Abstract

The challenges in lean Six Sigma implementation start from terminology to applicability to actual application and finally in terms of experiencing the change. Six Sigma projects are being used as an event response antidote rather than as a culture in organizations. Could there be a debate on your "X sigma" versus my "Y sigma"? Should lean practice be the front end or the back end or somewhere in the middle embedded in the Breakthrough Strategy has been a matter of debate among practitioners for many years now. Ego centric debates, a reason to justify failures, a failure to identify the purpose are contributors to the dilemma. Historically, the genesis of Six Sigma carries a setting of manufacturing yards, so should that be a reason to brand it as unsuitable for services, or is there a need to "dilute" the rigor in methodology or search for alternative techniques to facilitate application in a pure services context? Now, in an era of Industry 4.0 and Big Data Analytics, does Six Sigma continue to have a relevance? Should machine learning algorithms remain in the ever evolving list of tools and techniques within the Six Sigma book of knowledge? This chapter aims to address the above questions and more number of questions that we experience on a day-to-day basis in Six Sigma applications in the real world.

Keywords: business excellence, lean Six Sigma, breakthrough strategy, industry 4.0, big data analytics

Chapter learning objectives: understanding of evolution of TQM, lean, Six Sigma in the industry, application issues in services sector, financial and overall evaluation of application, failure modes & critical success factors, emerging trends in application.

1. Introduction to TQM and lean Six Sigma evolution

Tracing the history of quality journey up to the age of total quality management, it was a period of promises such as enterprises being strongly committed to customers and their problems being of utmost priority for the senior management. People of the firm realize that they are there because of the customers, hence it becomes imperative that customer problems are be resolved. Also ways and means to be found out to make sure, problems do not recur. But, the obvious fact is assurances never satisfy a professional management, unless tangible achievements are showcased. Thus, managers slowly started withdrawing any long term support to such total quality management initiatives as they found nothing that contributes directly

to their success. As business milieu became competitive with the entry of products and professionals, the demands on quality also underwent transformation.

A professional manager is looked upon as a sophisticated engine that leads, creates strategies, solves problems and generates revenue. Out of the outcomes expected, revenue and profitability end up as the most difficult mounts to surmount due to the dynamic nature of the target and quantitative measurements associated with it. As always, a resourceful manager finds cost savings as a possible strategy to overcome this mount. Cost savings promote the thoughts of waste reduction in the system, which indirectly forces organizations and management to concede to the fact that there exist systemic wastages. If quality efforts are identifying wastes and enables subsequent management of waste, then eventual reduction in waste will curtail the quality spend. Thus, savings too emerges as a form of revenue; then, it promotes the objective of the managers. This realization has actually led to convergence of quality and economics.

Cost accounting of wastage reveals prevention costs, failure costs, and appraisal costs. But reduction in cost is possible only with a deliberate, determined and systematic series of interventions. This is where breakthrough methodology of Six Sigma comes handy. It is a combination of a methodology and classical total quality management tools, where selection of the tool and its appropriate use will influence the outcome [1]. Because of its disciplined methodology, strict data orientation, innovation methodologies to generate solution, alignment to business this makes it a strategic intervention.

2. Lean-or/and-Six Sigma: the right medicine for services sector

Lean or Six Sigma, which is better? Is there a scope for argument? At least, there is a visible trend in organizations, to promote lean in a major way. The advantages people tend to present for lean include—Lesser time to prepare a resource for a lean engagement, lower competency demands due to lesser mathematical content to understand the lean principles and techniques, shorter cycle time of projects due to logic based driving, lack of data rigor are cited as reasons. But are we considering convenience over appropriateness while choosing the methodology?

People saw lean as a spectacle to find waste, but that is a very narrow view of the methodology. Lean can bring change only with end-to-end visibility of the system. Thus, many times lean takes the blame that it is not outcome focused, but that is not all that true. Lean focuses on flow, which means, lean creates the channel, maintains uninterrupted channels, and enables swiftness in the flow of material and information through the process channel. That philosophy, underlines the innate intend of lean to bring in acceleration. But during the times when scientific developments are exceeding the speed of thought, lean takes up the initiative to adopt and adapt organization to latest scientific and technological developments. Thus, customer, the end beneficiary starts seeing value and velocity while meeting their expectation.

Six Sigma is intended to be strongly customer driven and aspires for near perfect output. The mainstay of this strategy is methodological discipline underpinning the philosophy. It embraces data analytics to extract information out of the process and utilizes rigorous causal analysis techniques to unearth the failure modes proactively at a critical sub-process level. Thus scope is well dissected. The competency needs are stringent and hence it is a costly process. The systematic methodology definitely induces a bureaucratic approach. Size or business is not the criteria for deciding suitability for Six Sigma, rather existence of processes determines suitability for the methodology.

The objective of introducing Lean Six Sigma [2] is to enable organizations to reach the desired state of excellence. A state of performance excellence is a by-product of achieving highest level of performance in effectiveness and efficiency in a process. The term effectiveness is a metric traditionally being associated with reviews, tests and audits. Rather, the term means effectiveness of a work performed. From that

angle of thought, the performance of a reviewer or tester or auditor who is inherently being despised as defect mongers, their output indicates the perfection of the business process they verify. In other words, defects detected in a product is indicative of the performance of the process quality underlying it. Defect reduction and reaching near zero defects is the self-adopted motto of any Six Sigma project as its performance metric upholds the unit of DPMO (Defects per Million Opportunities).

The service business is an outcome of globalization and liberalization [3]. Let us consider the case of out-of pocket expense management in a typical multinational corporation. The reports are created in a software tool, and then hardcopies are deposited in office. This box will be shipped to another nation to do scanning, the scanned files will be exported to a second country to verify its quality, a third country does accounting entries, in a fourth country expense audits take place and finally a fifth country will conclude the funds transfer. Teams and processes are spread out in five countries, they have their own business goals and objectives to achieve, the process implementation styles are different, operational metrics and their definitions too are different. Now, implementing a Six Sigma methodology in a segment will not create a huge impact on the final outcome and implementing methodology in end-to-end process is not practical as it is not under the eye-sight of a single master black belt.

Most of the services business running on time-and-material with a budget cap would insist on shorter turn-around-time with zero defects. Shortening turn-around-time, demands reduction of effort wastages to remain with shorter life cycle, more value adding activities, and increase in agility. Being agile is necessary to augment productivity and ensure efficiency in the system. But, many of the techniques in lean prefers to remain superficial, more logic centric, believes in low hanging fruits and cannot assure a prevention. Sometimes, even professionals tend to adhere to the count in technique name to find the stopping point. For example, the 5Y analysis, despite its inherent reluctance to approach a problem from diverse dimensions to find out potential root causes, practitioners impose the restriction of seeking "why" to fifth level, thus bringing out a suboptimal outcome.

Service projects are time sensitive. A caller to a call center wants the agent to attend to his call in the first ring, customer wants the call to be resolved in the third minute, and finally solution applied must be defect free. For an IT super market that serves maintenance, enhancement and different kinds of support, productivity is measured through metrics such as calls attempted (a measure of productivity), turn-around-time per call (a measure of efficiency), call reopen-rate (a measure of effectiveness). So an engagement is assessing the success of the deal with service provider on the basis of a combination of metrics that suggest a balance of effectiveness and efficiency.

Thus, if state of excellence is a combination of efficiency and effectiveness, then lean and Six Sigma has their own territories and both carries with them a role to play in the process improvement journey. Thus, there is no significance in the debate on lean or Six Sigma, as both are necessary to play their specialized roles and process remains as the ultimate beneficiary. The choice of methodology is only secondary to the decision to pursue with the state of process excellence in the debate.

Case 1:

A mechanical engineering service company trying to reduce the invoice process cycle time and reduction in invoice errors. This helps avoid huge accounts receivables that impacts operating income. In this situation, Accounts receivables became CTB, the CTQs are errors and invoicing time. Value stream studies performed. An exploratory regression was conducted to ascertain the phase that significantly contributes and followed up with a Ishikawa's fish bone analysis to identify root causes. An action plan created to mitigate all root causes. At the end, cycle time improved from 16 to 8 days, and errors reduced from 40,000DPMO to 100,000DPMO.

3. Six Sigma: actual application versus definitions

If all what is said about Six Sigma is true, then the Six Sigma benchmarking is for a process which may translate to a function of a department. For example, procurement is a department where vendor management, processing of purchase requisition, and supply of products are connected but well dissected process that has ability to remain independent. Thus, organizations claiming sigma status at enterprise level or even for a department brings out the dichotomy in understanding. Sigma level is for a process and that identity needs to be necessarily protected.

Your three sigma is my Six Sigma—an argument that we may not regularly see but definitely not a rarity. The context of this claim is, the criticality of the product or function must determine the sigma level that must be targeted. In other words, all need not fancy achieving Six Sigma status, if the product is not critical. A patient going under the knife of a surgeon may not be happy about the fact that surgeon is operating at Six Sigma levels, or a patient approaching a pharmacist supplying medicines with Six Sigma assurance, so as an astronaut in a space vehicle made to Six Sigma standards. Those are situations where a Six Sigma level becomes inadequate. But, a balloon manufacturer need not aspire to operate at Six Sigma level. This is not because a higher quality for balloon is not a necessity, but for achieving the optimum cost-returns balance, a lower sigma level will not impact the health and safety of its consumers, and at the same time, sales may not drastically improve due to that one sigma level improvement from 3 to 4 sigma.

Six Sigma is not an initiative without a cost, hence striking the optimum sigma level that provides the necessary balance in quality that justifies the cost and revenue at the same time without impacting the well-being of consumers is a good business sense. That is a well sounding, realistic argument. But, the claim of Six Sigma status while the statistical performance matches with a lower degree on sigma performance scale on the ground of a business justification is not an acceptable situation. This is due to the same argument given above, that the benchmark Six Sigma level matches with a performance that equates to 3.4 Defects per Million Opportunities, which is statistically derived.

Irrespective of the stories around the origin of Six Sigma, there lies a fact that there exist a computation and sound statistical basis for fixing the sigma level for process performance. Process performance is assumed to follow always a normal distribution. 3.4 defects per million opportunities is a statistical computation, where the area of rejection region beyond the specification limits imposed on normal distribution is its basis and 1.5 times standard deviation shift of the distribution is an empirical observation. Process shift with time is a reality due to umpteen reasons that are associated with factors that determine a process in operation. The debate over the constant is insignificant considering the benefits the proponents of the methodology has demonstrated across the world in various leading industrial houses.

Case 2:

A leading automobile manufacturer while assessing the customer satisfaction levels of after sales services realizes that their highway breakdown service cycle time is around an hour. On analysis of the phases, it is found that the interval between ticket creations to dispatch of service engineer consumes the most of the time. Process flow was created, Value Added-Non Value Added analyses performed, for the NVA, a detailed causal analysis also conducted. Ultimately, linear regression study finds selection of mechanic and dispatching are the two activities that contributes most. A causal analysis revealed significant findings, for which corrective and preventive actions were planned and implemented. Using X-mR charts the time intervals are plotted and compare for significant changes before and after implementation of actions. The CSAT improved from 53 to 70%, and proportionately revenue increased as customers started relying on the company's service center rather than third party service stations.

4. Lean to begin or end or remain within

There are arguments favoring conducting a lean project and then sustain with Six Sigma method, or conduct a Six Sigma project and sustain with lean, or let lean techniques remain alive throughout and apply wherever relevant without a definite role. This debate is circling around the reluctance to assign a definite role and absence of a definite idea on the outcome expected. Lean must be seen not as an easier option to Six Sigma, rather as a methodology to skim the wastages in the system.

Waste is a term with the widest scope in quality science. Industry wide for many years now, waste is a term that encompasses many activities and by-products that does not directly contribute to the final deliverable. Indirectly, learn philosophers concluded them as non-value generating outcomes, rather to make it straight, something for which a client is unable to pay the service provider. In a typical IT environment now a days, we observe, hundreds of mails being send across cubicles transporting huge amount of bits, the IT professionals continuously complaining of inadequate disk space to store the huge amount of files, think about the bandwidth and energy being consumed. Most of the day, an IT professional moves from one floor to the other participating in not less than five meetings, assume the waiting time before elevators and traveling time and finally meet to decide again to meet. End product has many functions to elate the customer, but the essential needs demanded remains incomplete. Every stage goes to multiple iterations of rework to achieve the requisite quality, because defects injection and detection turned out to be specialized jobs. Then most of the scenario has an underlying issue called defects, over use of energy, excessive time spent, etc., so needs a more intrusive methodology to unearth the hidden causal elements to prevent the occurrence, else, this waste reduction ends up as a regular routine job as operations. So lean needs to be planned and must be part of life, rather than a stereotypic engagement. Else, it leads to a state where one fails to plan, ended up planned to fail.

If lean has to be a deliberate and structured engagement, then what approach is beneficial? The lean tools and techniques enables to identify the waste in the system. If lean operation is conducted and then move into a Six Sigma methodology, many wastages, may return to system under the banner of essential non-value adding activities. Therefore, it is more appropriate to preserve the benefits realized in Six Sigma projects then further promote with reduction and prevention of wastage to provide an enhanced value to the stakeholder. Both approaches are far better than sprinkling lean techniques within Six Sigma methodology which will fail the team from recognizing the benefits realized out of those techniques and many times even fail to understand the failure of the techniques as well and eventually, process may not reap the right benefits due to inappropriate and inadequate usage of lean techniques. Thus, we agree with Bendell in [4] conclusion that lean and Six Sigma can be effectively integrated.

> According to Taiichi Ohno, waste reduction must be planned only when company is profitable, as any trimming during difficult times becomes risky, as none will be sure about the appropriateness of the action and its impact.

5. How methodology gets defeated

Invariably, the motives for application of Lean Six Sigma spans from meeting a target in terms of number of projects or to achieve targeted savings need not build a culture. While, becoming a culture, the methodology actually must

become part of the genetics of the organization, which means it becomes an institutionalized approach, rather a day-to-day behavior. In the run-up to meet the count target, there will be attempts to force fit a breakthrough methodology on to a resolved problem, even wrong choice of problems for LSS intervention, and finally sub-optimal performance change will end in blaming the methodology. When cause is unknown and demand is a breakthrough performance, then a lean Six Sigma is the approach to try. But, if the scenario changes to a routine continuous improvement while causes are known, a pure lean intervention too is a good try.

Now, what constitutes a breakthrough and what definition it carries and who authorizes it? Breakthrough is radical performance improvement. A continuous improvement journey is a process of steady and gradual ascend in performance over a time period. But such a growth path will not create substantial improvement from baseline performance. Therefore, it became necessary to puncture continuous improvement journey with periodical breakthroughs to make sure while maintaining a steady performance growth, there is periodic transition to higher plains that leads to achieving a high performance level compared to continuous improvement highway. Typically, statisticians identify a step function with continual improvement journey that would yield a higher performance after a pre-determined time period when compared with a continuous improvement journey during the same interval is treated as breakthrough performance.

The gold standard of a Six Sigma project lies in the revenue it generated. The revenue could be savings by plugging financial leakages, or even a fresh source of income. However, it may be, the financial officer who upholds independence with respect to the operational process, and as the custodian of the cash chest, best suited to vet the financial benefit. Then, a natural counter argument is if source is out of scope of the LSS but revenue is earned, will the credit goes to the project executed. Naturally, no. Unless the source of revenue is verifiable and can be tied to the performance variable that acts as critical to process and quality metrics, the benefit of the funds cannot be tied to the project.

6. A post-mortem examination of DMAIC

Many LSS projects fail to begin with a phase to recognize the problem. This is the phase to realize the damage, relate with the financial outcome, and reiterate the importance after careful introspection. A business case is the outcome. When a case is documented, it must highlight the necessity of the project by explaining the gains out of the project and loss if project is not undertaken. Unless there is a statistical proof around the performance parameter and its causal association with financial performance parameter, a conviction cannot be generated. But the problem that manifests need not to be the real issue one must try to resolve with a LSS methodology. That is where an operational drill down is required. But, a systematic operational drill down and statistical association verifiable with a sound logic is consistently missing now a days in Six Sigma projects.

7. Relating to financial outcomes

A significant financial outcomes demands sufficient improvement in product overall quality and process performance. Overall quality is determined by process

quality and output quality that gets revealed by the verification and validation activities on the process outcomes. Thus, process quality is more to do with compliance, hence could be measured by non-conformances (NC) from process appraisals and process adequacy satisfaction surveys, but output quality is essentially defects. But defects in itself may be caused by factors such as quality of input, complexity of work products, quality of safeguards in the process, competency of the reviewer or tester, etc. Thus overall quality could be represented by cost-of-quality metric.

Financial performance could be modeled as below:

$$\text{Financial performance} = f(\text{process performance, quality}) \quad (1)$$

Then,

$$\text{Process performance} = f(\text{variations, efficiency, productivity}) \quad (2)$$

$$\text{Variations} = f(\text{size of work, processing speed, complexity, competency}) \quad (3)$$

$$\text{Efficiency} = f(\text{input quality, processing quality, competency}) \quad (4)$$

$$\text{Productivity} = f(\text{input quality, processing speed, technology, competency}) \quad (5)$$

Hence,

$$\text{Process performance} = f(\text{size of work, processing speed, complexity, competency, input quality, processing quality, processing speed, technology}) \quad (6)$$

Similarly,

$$\text{Quality} = f(\text{process quality, work} - \text{product quality}), \quad (7)$$

that is,

$$\text{Process quality} = f(\text{NC, process adequacy satisfaction index, defects}) \quad (8)$$

Then, work product quality can be termed as defects, therefore

$$\text{Defects} = f(\text{input quality, work} - \text{product complexity, process quality, competency}) \quad (9)$$

Thus,

$$\text{Quality} = f(\text{NC, process adequacy satisfaction, input quality, work} - \text{product complexity, process quality, competency}) \quad (10)$$

Therefore,

$$\text{Financial Performance} = f(\text{size of work, processing speed, complexity, competency, input quality, processing quality,}$$

technology, NC, process adequacy
satisfaction, input quality, work
–product complexity, process quality) (11)

Here financial performance is otherwise called as critical-to-business parameter. This is a lagging indicator as we get to know its status only after the event. To control this lagging indicator, we need leading indicators that are there as part of the transfer function (Eq. (11)). All transfer functions must be transformed to statistically valid linear regression equations, so that we get only a set of statistically valid causal variables (leading indicators) to act. But all statistically valid leading indicators will not be useful for Six Sigma, we need to identify the most significant process related contributors from the leading indicators. Only those indicators that are controllable yields a Six Sigma project. Probably, process adequacy satisfaction may provide process improvement change requests handling process improvement, incoming inspection process improvement will enable better input quality, processing error reduction of different critical sub-processes, process optimization to reduce the turn-around-time, competency enhancement process improvement to increase competency development are typical green belt projects that can support in the above specimen.

8. Who is responsible for driving improvement?

The quality of product and process, and process performance improvements could be responsibility of black belts and financial performance ultimately is the responsibility of master black belt. Thus, belt system is aligned to the metrics architecture to achieve an improvement roll-up from critical sub-process performance enhancement leading to critical quality and process performance improvement leading to breakthrough financial gains. This means, a swarm of green belt projects in parallel driven to achieve critical quality and process performance objectives at a higher plane and finally meets with the business objective at the apex of the architecture. Such a system will reflect Six Sigma true to its definition that includes terms such as focused, strategic, disciplined, critical problem management and high intensity engagement.

Recognizing problem to the level of the relevant process and there on to identification of critical sub-process set the stage for defining the problem. Thus problem, finds its expression through a performance metric (objective) on the critical sub-process. Here, choice of the metric becomes critical. The goal with which we are measuring the critical process must decide the facet of measurement we make on the process. But, the question is problem itself, without knowing it, a definition is not possible. Here, problem is the gulf between the target set and actual performance. Then a more fundamental question arises, if target itself is unscientifically set, then its relevance to engage in identifying the gap is unreasonable. Therefore, the target for the performance objective must be such that achieving that target must automatically ensure achievement of higher goals, which means, the target setting has to start from top and must percolate down.

The only target that is imposed will be the financial performance target. Financial target will be derived from the targets for the chief executive so that it remains consistent with the higher objectives of the organization and will enable a reporting to the board. Now the question is, to meet the financial performance target, what targets must be there for the process performance and quality objectives, this must be statistically derived. Then, for the set targets for process performance and quality objectives, what targets needs to be set for their leading indicators also must be derived statistically. So that, the targets are consistent and it enables and

ensures transmission of benefits from lower order to higher order. This logic finds support from Antony et al. [5], where a consistent explanation of achieving financial goals is explained.

Pilot baselines created with data collected (and not what is anticipated or perceived) from the process for a short duration and utilizing statistical process control techniques to understand the triplets of stability (Upper Control Limit, Central Line, Lower Control Limit) and twins of capability (Cp, Cpk) subject to nature of data type. Find the gap between target and mean, where target is the center of specification limits and mean is the actual performance average. It is equally necessary to decide on variance reduction by comparing the intended standard deviation and actual standard deviation. Thus, this article emphasizes the fact that the concept of improvement is realized only when mean and variance improves. Thus, a typical problem statement will accommodate facts such as nature of distribution, actual average and standard deviation values, percentage of improvement computed with the aid of targeted values for average and standard deviation, committed count of days to turn around the situation, targeted date of Six Sigma project closure and committing that other performance parameters of the process will not be negatively impacted due to this project. Every performance objective must have a problem statement that includes the financial performance parameter, quality and process performance objectives, and their leading indicators pointing to the critical sub-processes. Thus, a LSS project run on critical sub-processes to improve the leading indicators, such that benefits cascade till financial performance measure.

When it comes to process mapping in LSS, a hierarchical approach is advisable where a high level process map with many sub-processes, then every sub-process being exploded to understand the series of activities, thus drill down till we reach a set of tasks. Only a mapping at task level will enable us to investigate for root causes, identification of waste, and dissection of value stream blockers. Thus, a typical LSS project must create thorough process drawings for all relevant processes and drill down till task level drawings are created for the critical sub-processes that are represented in the linear equations generated for the final transfer function (Eq. (11)).

9. Nuances of Six Sigma application in a services context: critical success factors

In a service environment, the problems being investigated as per LSS may not be prevalent across all engagements, therefore, uniformity of the service process being followed across needs to be ascertained. The tools and technologies involved also needs to be identical. The business process being serviced needs to identical in nature and complexity. Then the most critical item arises, the measurements. Here, if individuals are involved in data collection, we can safely assume that will be the biggest challenge as humans are the weakest link in a data collection process. We have identified situations, where in service industry data mix-up due to reasons such as, collecting data from unintended process steps, data units are widely different, even derived metric formulae differing. Most of the occasions, we have observed there is no rationalization of competencies among data collectors before data collection. The best example, is the defects data itself, the problems start from even determining a defect, then goes to misunderstanding in identification of source of defects, categorization of defects such as technical classification of defect, operational classification of defect severity, etc. are results due to absence of a descent data definition document and a measurement system analysis. After collecting the data, in case of data storage, the practices related to privacy, security, integrity, and completeness of data needs to be validated and ascertained else there

could arise allegations of data manipulation and theft. Without plugging this failure mode, no reliable data collection is possible in measure phase.

The analytics part of measure phase is yet another area where too many questions, too many personal biases and many assumptions and practices are observed. All project reports carry the customary descriptive statistics possibly it is easier to get as a software output. But, invariably interpretation and inferencing part is mostly inadequate. For example, classical mean, standard deviation, skewness and Kurtosis need not carry any relevance when data type is discrete. When data is continuous, reports fails to present an understanding the statistical significance of the mean, tolerability of standard deviation, the presence of skewness. Since samples are used for the study, and when multiple samples of data are available from different engagements, without an inferential statistics proves identical mean and standard deviation, samples cannot be mixed, even when all other environmental and data specific factors are identical. When samples needs to be compared for their descriptive statistics, their appropriate derived metrics for measures of central tendency and dispersion may have to be employed to enable a comparison. Applying inferential statistics and statistical process control techniques without statistically concluding on the data type of the variable will lead to wrong choice of tests and charts leading to wrong inferences.

In analyze phase, invariably we find either a 5Y analysis or a fish-bone diagram and rarely a Failure Modes and Effects Analysis (FMEA). Just because a number five exist, there are no demands to stop our Why-Why analysis at the fifth Y, as long as we have not hit the root of the cause. To be true to the technique, it should be "5Ys and 4Whats," which means every time a Y is answered, its impact gets documented as "what" but most unlikely practiced that way. Also, this technique drive the root cause analyst with blinders such that only a single cause gets identified and excavated to five levels. A fish bone diagram, by its facilities allows multi-dimensional exploration. But then people takes pride in their experience and knowledge without examining to a subset for exploration. Hence, it is advisable to explore all the 7M (Man, Money, Material, Method, Measurement, and Milieu) dimensions, at least as a minimum criteria should be examined to plug the possible recurrence of assignable cause associated variation. Even a rigorous technique called FMEA can be defeated by half-hearted approach. A thorough process FMEA is performed at task level, where each task is examined for all the 7M dimensions to unearth the possible failure modes of that step. Unless all kinds of failure modes are listed, including hypothetical possibilities to plug corrective and preventive actions, controlling common cause variation becomes impossible.

Control phase is denoted by the application of statistical process control to monitor the stability and capability of the evolved process. An improved process, need to display stability and substantial variability reduction. It is equally demanded that the improved process must have a Cp and Cpk, greater than 1 or around 2 Defects per Million Opportunity to grade a process as significantly improved with LSS methodology. But, all improvements deteriorate if process is not properly maintained. Therefore, without sustainability plan concluding a LSS project will be a hasty move.

Sustainability plan is a combination of standardization and institutionalization phases. A stable and capable process delivering near perfect outcome is devoid of all defects. Hence, a value stream mapping at this stage on the reformed process will identify non-value added and essential non-value added activities for which an impact assessment will clarify the risks in eliminating each of them. In a controlled environment, non-value additions can be eliminated step by step after evaluating. At the end, an optimized process needs to be made the culture of the organization, there techniques such as 5S, visual mistake proofing, Gemba and other lean techniques will assist.

10. Emerging trends in application

As part of Industry 4.0, even if Cyber-Physical Production Systems take over, still micro computers will react to signals from sensors by sending signals to mechanical systems, but the underlying service with mechanical systems still will be prone to have the same failure modes. Overall, the failure modes could increase due to interface complexities. Robotic automation in the manufacturing and service industry will allow preventive measures and bypassing algorithms to continue the process but failure of machines, electronics and processes driven by people will continue to be the reality. The intelligence of the machines is limited by the quality of input training algorithms utilized for self-learning. Therefore, Six Sigma will find relevance in providing a complete learning feed into the training algorithm, preventing identical failure.

Big data from Industry 4.0 systems needs machines learning algorithms to support the analysis. Machine learning algorithms will aid in failure pattern recognitions, which will trigger preventive Six Sigma operations. So it is well in conjunction with Antony in [6, 7], that the Six Sigma tool box will continue to grow with emergence of applicable management and statistical techniques.

11. Future research potential

Lean and Six Sigma have permeated into every industry. In spite of a plethora of success stories, still maturity in LSS usage as a breakthrough methodology to achieve business excellence in a sustained manner is yet to be ascertained [8]. There are Six Sigma professionals in practice who make a range of inappropriate choices from selection of problem to choice of methodology.

It remains to be seen how Six Sigma application helps in the innovation process. The classical methodology and tool set can be made more vibrant by integrating LSS methodology with methodologies that provides innovation techniques to overcome constraints and speed [9, 10].

There are corporate organizations which do not adhere to the principle of monetary performance as the basis of determining project success [11, 12]. There are professionals who believe that application of design of experiments, Markov's switching models are adequate to qualify a black belt project. Utilization of this methodology in corporate strategy building and corporate leadership creation is an area to be further explored. Therefore, a LSS implementation maturity model is essential to provide a highway for improvement and segment the corporates into different levels of maturity [13].

Since there are many practitioners who still think that this is a management philosophy created by mixing many aspects of past trends with statistics, fewer academicians are venturing into scientific research in this area. Unless scientific research happens, an efficient implementation methodology cannot continuously evolve. Till that point application of Six Sigma will remain as per the beliefs and based on the appetite for trial and error studies. This will result in a large share of projects not yielding the expected results and finally leading to a premature conclusion that the methodology ineffective and inefficient. One of the key factors that prevented aggressive academic research in this area is the branding of Six Sigma as management fad, but over the last three decades, the methodology survived its critics, pervaded into different industries to solve a range of problems from customer satisfaction, productivity, defects, etc., thus it showed its potential [14, 15].

Being a disciplined methodology rooted in a trained army of resources, creates two parallel organizational hierarchies, one for business and other for process improvement. This creates stress on the organization to do capacity and availability management and competency management for two streams separately. Managing resource conflict in a LSS organization is a research area to be further explored.

Since LSS is highly prescriptive in approach, mechanical organizations with repetitive processes will find it appealing, but a service industry which would prefer to accommodate flexibility at the cost of a few defects will find LSS as a conflicting paradigm. So DPMO or DPMU or something else should be the benchmark of performance. Studies are possible in this conflicting territory [16].

There are arguments that stereotypic methodology of Six Sigma impedes innovation and rather relies on cluster of improvements that solves few of the pressing problems to get the desired output. Thus, exploration or exploitation, what is the priority of LSS methodology? [17, 18]. Of course, Schroeder et al. [19] provide evidence for ample number of patents to prove explorations as well happens with exploitation. This is a topic for further research across global context.

Should Six Sigma remain as a stand-alone initiative or be part of the day-to-day operations is a vital question. That is an area of study in itself [20].

12. Concluding thoughts

There could be many more failure modes and criticisms on lean Six Sigma, but as a methodology it has helped many companies to earn quality savings and thereby become a benchmark for business excellence. Definitely, this is not a methodology that will yield a solution for a problem overnight as methodology needs to complete full life cycle. Success of this methodology is dependent upon the culture organization builds, for which a large sets of professionals need to be trained at various competency levels to occupy different belt positions. The training time is a significant investment as it is not practical to master process and required quantitative skills in a short time.

As a practical impact in implementation, Six Sigma could instill the must needed knowledge of systems and variations in the minds of leadership. Most importantly, a Six Sigma project is most likely to fail, when methodology is improperly implemented with wrong choice of tools and techniques that leads to poor inferences. But lean Six Sigma, armed with open tool box, will always find newer management techniques to resolve the problems of the modern times and the new generation methodologies of innovation also finding a place in improve phase will significantly cap the criticism around creativity in such implementations. Data analytics being the new buzz word, the methodology will continue to remain relevant in the intense digital era of Industry 4.0. Machine learning will enable pattern recognition to identify precise possibilities of failures, and design of corrective actions driven by data out of DMAIC when loaded into AI will allow their application at the most opportune moment to make sure failure modes are adequately mitigated and even might allow for extreme positive sigma performance in services context.

Academic community has enough to further their research interests in this field. Failure studies on LSS projects can create vital case studies for training material. It is possible to look at integration with methods from specialized areas that augments the effectiveness and efficiency of current LSS methodology. Studies around institutionalizing Six Sigma practice and integrating with corporate strategy planning, organizational leadership competency building, etc., can be undertaken to further the knowledge of LSS.

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References

[1] de Mast J, Bisgaard S. The science in six sigma. Quality Progress. 2007;**40**(1):25-29

[2] Byrne G, Lubowe D, Blitz A. Using a lean six sigma approach to drive innovation. Strategy & Leadership. 2007;**35**(2):5-10

[3] Does R, van den Heuvel E, de Mast J, Bisgaard S. Quality quandaries: Comparing nonmanufacturing with traditional applications of six sigma. Quality Engineering. 2002;**15**(1):177-182

[4] Bendell T. A review and comparison of six sigma and the lean organizations. The TQM Magazine. 2006;**18**(3):255-262

[5] Antony J. Six sigma: A strategy for supporting innovation in pursuit of business excellence. International Journal of Technology Management. 2007;**37**(1/2):8-12

[6] Antony J. Six sigma for service processes. Business Process Management Journal. 2006;**12**(2):234-248

[7] Antony J. Some pros and cons of six sigma: An academic perspective. The TQM Magazine. 2004;**16**(4):303-306

[8] Raval SJ, Kant R, Shankar R. Revealing research trends and themes in lean six sigma: From 2000 to 2016. International Journal of Lean Six Sigma. 2018;**9**(3):399-443. DOI: 10.1108/IJLSS-03-2017-0021 [Accessed: 01 April 2019]

[9] de Feo JA. Creating strategic change more efficiently with a new design for six sigma process. Journal of Change Management. 2002;**3**(1):60-81

[10] Ehie I, Sheu C. Integrating six sigma and theory of constraints for continuous improvement: A case study. Journal of Manufacturing Technology Management. 2005;**16**(5):542-553

[11] Goh TA. Strategic assessment of six sigma. Quality and Reliability Engineering International. 2002;**18**(5):403-410

[12] Linderman K, Schroeder R, Zaheer S, Choo A. Six sigma: A goal-theoretic perspective. Journal of Operations Management. 2003;**21**(2):193-203

[13] Frings GW, Grant L. Who moved my sigma effective implementation of six sigma methodology to hospitals? Quality and Reliability Engineering International. 2005;**21**(3):311-328

[14] Abrahamson E. Management fashion. Academy of Management Review. 1996;**21**(1):254-285

[15] Harry M. Six sigma: A breakthrough strategy for profitability. Quality Progress. 1998;**31**(5):60-62

[16] da Silveira GJC. Effects of simplicity and discipline on operational flexibility: An empirical reexamination of the rigid flexibility model. Journal of Operations Management. 2006;**24**(6):932-947

[17] Benner MJ, Tushman ML. Exploitation, exploration, and process management: The productivity dilemma revisited. The Academy of Management Review. 2003;**28**(2):238

[18] Benner MJ, Tushman ML. Process management and technological innovation: A longitudinal study of the photography and paint industries. Administrative Science Quarterly. 2002;**47**(4):676-706

[19] Schroeder RG, Linderman K, Liedtke C, Choo AS. Six sigma:

Definition and underlying theory.
Journal of Operations Management.
2008;**26**(4):536-554

[20] Doganaksoy N, Hahn G, Hoerl R.
The evolution of six-sigma. Quality
Engineering. 2000;**12**(3):317-326