Lean Six-Sigma (LSS) Workforce Readiness Identifiers!

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Successful implementation of lean six sigma (LSS) program requires both organizational and workforce competencies. This paper hypothesizes that workforce skills and competencies needed to execute LSS develops through experience with other data driven quality systems and lean implementations, and the foundation for a quality culture for Lean six-sigma (LSS) takes root only through years of practice. Although literature demonstrates the requirements for a dominant quality culture for LSS, the competency issues have not been addressed through a formal study. In this study we address the workforce competency issues through detailed analyses of eight LSS implementations. These selected LSS companies were categorized, through a detailed study, into successful and unsuccessful adopters based on their level of experience with quality programs. Seven workforce competency variables – the content validity of which were verified through literature review – were tested for both successful and unsuccessful adopters support our hypothesis that competency for LSS develops through implementation of other quality/lean programs that are precursors to LSS. Most unsuccessful LSS adopters performed poorly on all workforce competency dimensions, but their performance on goal setting and process control & improvement were the poorest.

Keywords: lean, LSS, workforce readiness identifiers

INTRODUCTION

Lean Six Sigma (LSS) quality program is a comprehensive and flexible system for achieving, sustaining, and maximizing business success. It is uniquely driven by close understanding of customer needs, disciplined use of facts, data, statistical analysis, and diligent attention to managing, improving, and reinventing business processes. The six sigma principles and tools, built into a Define—Measure—Analyze—Improve—Control (DMAIC) framework for improving processes to deliver consistent goal achievement in accordance with company strategy and customer requirements, while the lean principles identify opportunities for elimination of waste, and unwanted errors and process variations (Madani, P. M., 2020; Al-Najjar, Suzan and Rahim, Suzari A., 2023). Lean was first a human-based system where people were involved with continuous improvement, and the foundation for the system was leadership and empowerment through education and training as opposed to the six-sigma approach in which the human element is totally removed, and elite elements of the production staff are brought together to work on CTQ (Critical to Quality) projects using scientific methods. Both Lean and six-sigma sprang from the same root – developed in Japan – and share common elements in their strategic and tactical implementations.

Combining both approaches may ensure waste reduction, process flow maximization, and at the same time, critical to quality issues can be addressed by the company (Reuben, B. F., Strawderman, L. and Bullington, S., 2016; Sreedharan, V.R., Balagopalan, A., Murale, V., & Arunprasad P., 2020). However, combining both Lean and six-sigma is easier said than done because Six-sigma achieves efficiency and effectiveness by focusing entirely on quality, while lean achieves that by improving quality through process improvements. Lean emphasizes process flow, and six-sigma focuses on process defects. Lean deals mostly with visible process problems, such as inventory, bottlenecks, and safety whereas six-sigma tries to dig out quality problems that are not readily obvious. Six-sigma uses a parallel organizational structure with liaison from the executive suite while lean uses a bottom-up approach by including all process owners for improving and controlling the process. Both values involving management and the employees for improving performance, however, in six-sigma the involvement of employees is less pervasive (Huq, 2022).

To successfully implement Lean six sigma program a company needs to have certain competencies (Moosa & Ali, 2010; Jones e al., 2010; Huq, 2006; Eriksen & Mikkelsen, 1996; Escrig_Tena & Bou-Llusar, 2005)**.** The needed competencies can be viewed from two different perspectives, namely: (i) as assets, skills, or resources belonging to the company that allow an activity to be performed systematically, in other words the competency of its workforce, and (ii) firm's ability to integrate the assets and orchestrate a cohesive implementation of the program. Cohen and Levinthal (1990) state that a firm's stock of prior knowledge determines the ability of a firm to absorb new knowledge and apply it successfully. For LSS it means abilities and specific skills that the firm possesses in the deployment of its resources, as well as its cognitive characteristics, which are geared toward the accomplishment of LSS results. This paper looks at the workforce skills and competency needed for LSS implementation. It affirms that for novice companies that are embarking on LSS for the first time, without proper experience with Lean and quality programs, LSS can pose to be a challenge.

Although empirical research on determination of competency resources -- as to how they are formed or acquired -- remains rare (Gutierrez et al., 2012; Pfeifer et al., 2004; Williamson, 1999), case studies (Huq, 2006; Escrig-Tena & Bou-Llusar, 2005) have shown that successful LSS adopters had years of experience with quality systems. There is a hole in LSS literature as to what kind of competency is required to implement LSS, although LSS has been around for about twenty years no framework has been developed to address this important research question. A framework for determining LSS competency, as it relates to workforce, will not only help companies to determine their readiness to adopt LSS, but it will also help companies plan, design, launch, and implement LSS in future.

SIGNIFICANCE/IMPORTANCE

From a management perspective combining Lean and six-sigma makes sense because lean will ensure that both process flow and efficiency are maximized thereby reducing waste in the system, and at the same time, critical quality (CTQ) issues for the business will be addressed by six-sigma. There is a difference of opinion as to how this integration should take place. According to Shah, Chandrasekaran, and Linderman (2008) and Hines, Holweg, and Rich (2004) the parent system should be Lean in which six-sigma should be applied as a sub-set of operational strategies to realize the maximum benefits of an integrated system. This has the advantage of implementing six-sigma in a company where they already have an integrated supply chain, where the roles and responsibilities of employees are clearly defined, quality and efficiency is addressed through transaction reduction, problem-solving, foolproof methods, and inventory reduction; overall, the lean system is a disciplined system where an intervention like six-sigma would be easy to apply. Lean tools can be very effective in the first stage of process improvement where the aim is to eliminate waste and simplify processes before starting to tackle the more difficult problems through optimization and process control aimed mainly at process steps (Snee, 2005). According to Rath and Strong (2003), certain organizational cultures are preferred in favor of Six Sigma applications, and lean offers such a culture. With a directive and highly hierarchical leadership style, there is only a limited decision-making authority given to the project teams. They can only make proposals and wait to obtain approval from upper management. The engagement of the management in Six Sigma projects could also be undermined in this case if the

management only acts as the authorization party in the Six Sigma projects. In an organization with a participative/collegial leadership style, i.e., a lean system, more autonomy is given to the project teams, and they would have the necessary authority when making on-the-spot decisions during recommendation and implementation. Lean is not well suited to resolving complex problems that require intensive data analysis and advanced statistical methods. When the problem solution is unknown, it is likely that extensive data collection and analysis will be required to resolve the issue. The need for careful diagnosis of the problem emphasizes the deployment of the Six Sigma. That is the ideal environment for six sigma to flourish. In addition, the upper management in a lean organization is more likely to be involved in the progress of a project, understand the project better and make sure its direction is aligned with the designated strategy of the company. Six Sigma methodologies appreciate to a greater degree group efforts rather than individual heroism. Smooth cross-functional processes hardly require individual heroes, but rather good coordination and sharing of common goals among different departments. The empowerment employees enjoy in lean systems offers an ideal environment for injecting six-sigma concepts into it. The concept of 'Lean Six Sigma' as an integrated strategy is still in development: since its inception in 2000, several academics have developed an integrated approach, while others have focused on a framework for the successful integration of Lean and Six Sigma (Laureani & Antony, 2019). According to Everton et al. (2014) companies that deploy lean manufacturing, Six Sigma or LSS models achieve superior performance in competitive priorities like quality, reliability and speed.

As opposed to other quality management approaches, such as Total quality Management (TQM), LSS takes a staggered improvement approach that uses customer preferences, non-intuitive data driven methodology, statistical evidence of quality, diligent attention to detail, and above all, uses economic justification for each improvement effort. LSS adopters must understand that it is lot more than just use of tools and techniques. The approach integrates strategic issues, technology, statistical tools and techniques, people, and training. Success of an LSS program is dependent on the right selection and prioritization of projects, and this is the most critical decision a LSS team must take. In many cases this decision is made on subjective judgment, or the project benefits are estimated under false or untenable assumptions. The firm must have in-house expertise to apply analysis tools such as NPV (Net Present Value), IRR (Internal Rate of Return), payback period etc. to determine the financial viability of the selected projects. Like other quality programs LSS also emphasizes leadership, but the emphasis is more passionate and institutionalized than any other program. Six sigma goes through a more regimented leadership structure by creating a cadre of professional leaders in the firm (they are called Master Black Belts, Black Belts, Green Belts depending on their level of training). Coupled lean concepts, structured leadership, customer focus and a passionate concern for company bottom-line, LSS focuses more on the process elements (process innovation, process management, workforce management, supplier relationship, design function, training, statistical analysis of process data, the measurement system analysis) than other techniques (Schroeder et al., 2008; Motwani et al., 2004; Coronado & Antony; 2002; Antony & Banuelas, 2001; Gabor, 2001; Oakland, 2000, Wilkinson et al., 1998; Kanji, 1996; Sitkin et al., 1994; Dean & Bowen, 1994). However, leadership, being an important moderating variable for Lean six sigma success, must depend on employee commitment and participation. According to a survey published by *Quality Digest* (Dusharme, 2004) more than 50 percent of companies – that followed the prescriptions of top management commitment – are abandoning LSS after three years of trial. In many of these companies either the top management changed, or the quality culture have not had long enough gestation period to take root. For LSS a dominant quality culture is a prerequisite, successful implementers such as Motorola, GE, Allied Signal, Citibank, and Sony had the required infrastructure for adopting LSS (Antony & Banuelas, 2001). Motwani et al. (2004) and Gabor (2001) report that the success of LSS at Dow Chemicals and Ford was preceded by a successful TQM implementation implying that a company that has emphasized problem solving through TQM implementation is ready to emphasize breakthrough rates of improvement and innovation. Gutierrez et al. (2012) show that the success of a program like LSS is predicated on absorptive capacity and organizational learning in the company, for new adopters this will be a challenge. The inability to create an organizational culture that is conducive and supportive of the proposed LSS change initiative is a major obstacle for implementing LSS (Davison & La-Shaghana, 2007). It is apparent from these studies that top management support and employee participation

vis-à-vis quality culture are interdependent, it is a hallmark of systems theory that all components of a system are interdependent (Haines, 1998).

It is generally accepted that failures in quality improvement programs are not because of basic flaws in the principles of quality concepts but are due mainly to lack of competency and ineffective implementation systems (Boerstter et al., 1996; Schroeder et al., 2008; Zabada et al., 1998; Huq, 1995; Huq & Martin, 2001). Authors such as Ericksen & Mikkelsen (1996) and Sanchez et al. (1996) offer the opinion that competencies are pools of resources that enable a company to perform specific functions, they also emphasize that the competencies must have an organizational component, management must deploy these assets/competencies in a coordinated manner to attain specific goals. The focus of this paper is on workforce competency, how it is formed, and its impact on LSS success. The following section develops the research hypothesis on workforce competency requirement for LSS implementation. The workforce competency variables are based on a literature review of successful implementers of LSS and include variables in the area of leadership, cultural compatibility, internal marketing, goal setting, performance appraisal, process management, and skills & training.

WORKFORCE PARTICIPATION AS A CONDITION FOR LSS

Involving employees in decision making to improve productivity and competitiveness seems to have many advantages for the individual as well as the organization (Stanton, 1993; Sashkin, 1984, 1986; Lindsay, Curtis, & Manning, 1989; Downey-Ennis, Harrington, & Williams, 2004). Workforce participation – especially in Lean systems - is a precondition for increased worker satisfaction, higher levels of motivation, improved organizational performance and effectiveness, and better implementation of organizational change, it is true for any change initiative. Pojidaeff (1995) report that according to Deming, "People are born with intrinsic motivation, self-esteem, dignity, curiosity to learn, joy in learning….a corporate commitment to quality that is not based on intrinsic motivation is a house built on sand." Traditional management is based on hierarchical structures, and managers are fearful that a change in the work environment will render them powerless. We need to understand that LSS can become successful only when there is workforce participation for process improvement and innovation.

LSS takes an innovative approach to process management, for which employee empowerment is of paramount importance. It is consistent with the concept of "empowered organization," one where managers supervise more people than in a traditional hierarchy and delegate more decisions to their subordinates (Malone, 1997). Managers (black belts & green belts) act like coaches and help employees solve problems. Employees, Malone concludes, end up having increased responsibility. According to Keller and Dansereau (1995) when superiors empower subordinates by delegating responsibilities to them it leads to more satisfied subordinates, and higher levels of performance. In a similar study surveying 393 middle managers of Fortune 500 corporations, Spreitzer (1996) found that employees who are empowered have low ambiguity about their role in organizations. The leaders in empowered organizations have a wider span of control which leads to more autonomy for the employee. Empowered employees feel that their organization provides them sociopolitical support, that they have greater access to information and resources than in traditional organizations, and that their work climate is participatory. LSS requires an empowered organization, where employees are able to fully participate as teammates to take bold initiatives and have the authority to make strategic decisions (Garfield, 1993). Management's job from the LSS perspective is to create a culture of participation by providing a compelling mission, a structure that emphasizes flexibility and independence, incentives for participation and a lack of punishment for risk taking. Mallak and Kurstedt (1996) believe that empowerment should be integrated into an organization's culture in a progressive manner. LSS offers that progressive empowerment; that is, with a pervasive culture of Lean concepts process members gradually learn to follow the process black belt's lead, then that person models his/her behavior after that of the black belt, next he/she develops an understanding of empowerment themselves and begins to act accordingly, and finally the individual becomes a leader and a model for others.

Based on an analysis of 450 published articles on participatory management Stanton (1993) report that employee participation will enhance productivity through intervening motivational processes, he concludes

that enhanced job satisfaction will increase employee involvement, something integral to the success of LSS. Although, a few researchers as well as executives have questioned (Stanton, 1982; Beehr & Gupta, 1987) the universal applicability of participative management arguing that employees often need directions and lack necessary self-discipline for it to work. However, the principles of LSS make it clear (Huq, 2022) that a company needs certain competency to implement it successfully. In addition, LSS approach only invites competent people in the organization to get involved with the initiative, as opposed to TQM that tried to involve everyone in the company. This is indeed a big strength of LSS and a convenience presented for participatory management. As it is a structured data driven approach, employees have clear guidelines to follow; and the LSS training helps develop individual competence – a critical moderator variable for participatory management. However, employees working in teams not only need to conform to LSS etiquettes, but they must also be passionate about it because process improvement efforts not only require a deep understanding of the process, it also requires innovation. The authors Eisenberger et al. (1990) found that perceived organizational support is positively related to innovation. They found that employees with high perceived support have greater affective attachment to the organization that finds expression in terms of greater number of constructive employee proposals to aid the organization. Mowday et al. (1982) report similar results, they state that strong employee involvement in the organization results in performance that goes beyond the normal call of duty.

Oliver (1996) has suggested that quality programs can be successfully implemented when employee rewards and incentives are based on team performance. If a firm's culture refuses to accept changes required by LSS, then such an initiative will fail regardless of the desires and efforts of top management. In the end, the only way to bring about lasting change that will support the LSS initiative is to create a working culture where employees can utilize LSS practices more effectively. It is easier for a firm to create such a culture when employees have the proper motivation. The reason GE, Motorola, Du pont (Motwani, 2004) were successful with LSS is because these companies created a quality culture through employee participation. If elements of the culture and work processes assure employees, give them worth and provide them with opportunities that enforce positive psychological well-being, employees will exhibit optimal performance. We need to understand that a quality culture develops not by just assuring employee participation at the shop floor level, but also at the strategic and tactical planning level. For example, Milliken (1996) shares insights about Eastman Chemical Company, a Baldrige winner, on how to motivate employees. He comments that a company cannot empower employees who: don't care; don't have authority; don't have appropriate skills. Along similar lines, the Dana Commercial Credit Corporation (DCC), another 1996 Baldrige winner, subscribes to the importance of employee empowerment for business results. Both companies solicit employee participation starting from process level to tactical and strategic decision levels. Both companies place great emphasis on involving employees in setting their own goals and judging their own performance; encouraging employees to take ownership of their actions; encouraging employees to identify with the whole company and to become shareholders. LSS provides the ways and means to achieve these goals and objectives by employing cross-functional teams so that employees understand their jobs, systems, and their roles in quality improvement. These cross-functional teams continuously evaluate systems and processes to ensure that customer expectations are met. The cross-functional teams also help identify the implementation barriers, and their removal. As in the case of TQM, these teams span an entire scope of activities - starting from process management to tactical decisions, to strategic decisions.

LSS is a strategic choice that focuses on coalition building with employees, departments, and functions; it can be surmised that a great deal of management time may be spent dealing with employee resistance and resolving interdepartmental problems. Internal marketing has been proposed to overcome such barriers, and to maximize employee participation and cross-functional coordination (Davis, 2001). Internal marketing should focus on how to persuade, influence, and convince the workforce to adopt the standard required by LSS, and the good thing about LSS is that management does not need to convince everyone – at least on the six-sigma side of the approach. Management must first obtain employee support for the strategic decision to implement LSS which in turn will support external marketing, then management should sell the concepts on company well-being to the employees through the human resources department (Collins &

Payne, 1991), and finally, marketing of services between departments or organizational units, i.e., to internal customers.

The process side of LSS implementation is very well known (Dasgupta, 2003; Harry, 1998, Linderman et al., 2003, Huq, 2022), only recent studies have started to pay attention to people side of LSS implementation (Fleming, et al, 2005; Hahn, et al., 2000; Wiklund & Wiklund, 2002). As already indicated, leadership plays a vital role in molding employee behavior towards LSS goals and objectives. The deployment of objectives is not a trivial task. It is not easy to set objectives for people at the lower levels such that their resulting behavior will contribute fully to the achievement of top-level objectives. Many senior management teams have produced an inspiring vision and very worthy high-level objectives but have then struggled to deploy these to lower levels effectively (Buch & Tolentino, 2006). One route top management can take is to tie performance appraisal to success of black-belt projects, this will ensure that people at all levels understand how their work is relevant to the wider objectives of the company, in addition, it will make it easier for employees to see how each black-belt project contribute to the company bottom line. It will help establish a clear sense of direction throughout the company, by publishing a meaningful vision and values, then deploying these to create objectives at all levels that are pragmatic, realistic, and meaningful for the employees.

LSS enthusiasts will recommend that for LSS success top leadership buy in is essential. However, we need to recognize the fact that high CEO turnover can pose to be a challenge for many LSS adopters. According to a survey by Quality Digest in 2003 (Dusharne, 2003 & 2004) more than 50 percent of the LSS adopters between 1998 -2001 abandoned the program after three years, during these four years 58 percent of these companies changed their CEO. The importance of involving the formal leaders, such as, the CEO and the executive suite is essential, but involving the informal leaders of the company quality culture is what keeps the program alive and steer towards LSS success. The executive suite cannot legislate employee commitment, it must come through a conducive cultural environment that synergize top managements LSS adoption and dissemination plans. Total quality management made the grave mistake of trying to improve everything simultaneously, it tried to boil the "ocean." The more people get involved with a new approach, the slower the rate of adoption and progress. LSS has an advantage in this regard, it does not involve everyone nor does it try to improve everything simultaneously. Starting small is a hallmark feature of LSS, and it should be kept that way; having success with few initial pilot projects can boost employee confidence in LSS.

The diffusion of a new approach is a social process (Rogers, 1999), and acceptance of a new management approach like LSS has its underpinnings in the company cultural environment. According to Rogers (1999), acceptance and diffusion of a new technology is a function of relative advantage, compatibility, complexity, trialability, and observability of the new approach. The relative advantage of LSS over other approaches is well known (Schroeder et al., 2008; Escrig_tena & Bou-Llusar, 2005; Motwani et al., 2004; Coronado & Antony, 2002; Antony & Banuelas, 2001; Gabor, 2001; Oakland, 2000; Wilkinson et al., 1998; Kanji, 1996; Sitkin et al., 1994; Dean & Bowen, 1994). From a competency perspective the most important factor is the compatibility of the approach with the existing practices in the company. If the new technology is compatible with the existing cultural environment, i.e., has similar implementation requirements but with a different focus, then the negative impact of other moderating variables, i.e., complexity, trialability, and observability, melt away. A company that has years of experience in building a quality culture their transition to LSS should be smooth because the company just needs to mold their employee and organizational competencies geared towards LSS implementation. Successful LSS adopters like Ford, Motorola, Dow Chemicals, GE, and Allied Signal (Gabor, 2001, Antony & Banuelas, 2001, Motwani et al., 2004) had years of experience with Lean and quality systems that testifies to the fact that a quality culture is a prerequisite for LSS. A company that has experience with quality programs is expected to have employed data driven quality management, i.e. statistical quality control, capability studies, etc. For them advancing to LSS imply relating the quality improvement efforts to the company bottom line, in other words, evaluating the economic justification for each improvement effort. This implies more discipline in selecting the improvement projects, one at a time, by employing advanced cost benefit analyses for the process improvement projects. Incorporation of this feature is easy to extend

in a data driven process management environment, by simply including cost benefit analyses in the black belt training programs. Therefore, in companies with a history of quality programs complexity is not an issue for adopting LSS. Next is Roger's trialability, this is a non-issue for a quality conscious workforce, and an advantage presented in support of LSS. Since LSS picks one process improvement project at a time, and since they are not pervasive projects involving a large portion of the workforce, gradual adoption is an advantage of LSS. Starting small and doing pilot projects – one at a time, can create inertia for LSS competency and eventual implementation throughout the company. The fifth moderating variable observability is not an impediment for LSS anymore, as success stories abound (Gabor, 2001, Antony & Banuelas, 2001, Motwani et al., 2004).

One of the key ingredients for LSS deployment is training, and training should extend beyond classroom instruction. With lean already in place, training for six-sigma part of the application becomes easy because a culture of improvement is already there with brainstorming, process mapping, mistake proofing, and quality tools (Everton et al., 2014). Bourg et al. (2010) recommend proactive coaching as a necessary condition for LSS preparedness. It is not the LSS tools that bring success in LSS implementations, it is the understanding of how the key process input variables (KPIV) impact the key process output variables (KPOV), and what kind of process improvement and innovation will deliver the desired results. Proactive coaching is based on a premise of definitive agreement between the coach, usually a black belt, and a green belt or key members of a process to meet on a regular basis to discuss many facets of product/process improvement. Bourg et al. (2010) also recommend an upfront agreement on the elements of coaching and a coaching schedule. The elements of coaching should focus on probing, aligning, and raising skills for understanding the relationships between KPIV's and KPOV's. The proactive coaching should follow the LSS process analysis and management training phase. As coaching becomes pervasive LSS principles will take root and contribute to the development of LSS quality culture. For companies with a history of commitment to quality improvement proactive coaching will be easy to implement.

LSS provides employees with opportunities not only to learn but also develop themselves through teamwork, it provides the opportunities for social interaction and reinforcement of the value of a quality culture. Involvement of the company leadership is essential for harnessing the powers of team approach, this leadership should not remain stagnant at the top level -- it should trickle down to lower levels to guide day-to-day work of the teams. The CEOs at Motorola, GE, Seagate technology provided the overall direction for LSS implementation, however, transactional forms of leadership at the lower echelons of the LSS hierarchy was instrumental in transforming the workforce culture into a LSS quality culture (Harry, 1998; Pande & Holpp, 2002; Harry & Schroeder, 2000). LSS leadership framework at the lower levels of the company hierarchy provides the guidelines for leadership at the managerial and shop floor levels. Coupled with this leadership structure the LSS culture requires continual reinforcement to keep the initiative alive, and employee motivation becomes the greatest when goal setting is done in a clear, specific, and pragmatic way.

Goal setting in LSS is different than goal setting in TQM. As opposed to TQM that tried to improve everything simultaneously LSS takes up one process aspect – critical to quality (CTQ) – at a time labeled as an LSS project and tries to achieve the project goals within a specified time interval. In addition, project selection in LSS implementations is not subjective, it uses economic justification – through application of cost-benefit analyses, NPV, IRR, payback period, etc. – for selecting the LSS projects. The first two steps in DMAIC are critical for goal setting in LSS, it requires both organizational and individual competencies for determining critical-to-quality aspects of product-process interaction. Juran (1989) gave a general framework for quality improvement, and LSS activities fit this framework. It involves three steps, planning, control, and improvement. The corporate strategic plan gives overall guidance to the planning process, it is usually organized by the staff departments with the involvement of the LSS champion and the executive suite, the process is often referred to as design for six sigma (DSS). The control function, focused on sporadic process problems, is usually the responsibility of the process staff under the guidance of a black belt. The third part of the LSS framework, i. e. Improvement, is where LSS makes the biggest contribution, and should not be fully centralized or decentralized (De Mast, 2007). For the sake of worker empowerment, and given that the process owners are the most knowledgeable people to drive the improvement effort, it

should be delegated to the process owners. However, to minimize the risk of project misfit with the corporate goals the project activities should be monitored by LSS champion and the corporate executives. For a novice company this may be a challenging step not only from the point of identifying an improvement opportunity but also from the point of putting together a cohesive team to carry out both Lean and six-sigma project activities.

LSS uses a top-down approach to set the goals and a bottom-up approach to achieve it, a common approach in Lean and six sigma implementations. Therefore, it requires an effective communications strategy. Management must provide continual reinforcement of its support, put employees at ease and drive away fear of taking risks. The reinforcement should come not only through web-based internal marketing, newsletters, recognition programs, etc.; it must also come through direct involvement of the executive suite with the employees through gatherings, Q & A sessions, etc.

METHODOLOGY

Overview

This study employs a quasi-qualitative case study methodology. In addition to evaluating the status of LSS implementation in eight companies on the eight workforce competency dimensions, the study draws heavily on the qualitative evaluation of the state of LSS implementation in these companies. The use of qualitative research techniques is appropriate for gaining information inductively in such behavioral studies. This approach gives company officials an opportunity to respond openly to inquiries about their experiences in implementing LSS. The inquiries, posed by the researchers, came from constructs presented in the literature on workforce competency dimensions (presented in Table 1), the content validity of these Lean six sigma constructs is determined by published literature (Al-Najjar & Rahim (2023); Huq (2022); Sreedharan et al. (2020); Everton et al. (2014); Jones et al., 2010; Shah et al., 2008; Schroeder et al., 2008; Huq, 2006; Motwani et al., 2004; Coronado & Antony, 2002; Antony & Banuelas, 2001; Gabor, 2001; Pande & Neuman, 2000). The study was carried out over a period of two years.

Sources of Data

Groups of executive MBA students interviewed key LSS personnel in each of the study companies. The team members were familiar with LSS, and each team consisted of at least one member who actually worked in a managerial position within the company studied. Each team interviewed at least 3 key personnel directly involved with LSS planning and implementation in each of the companies. Each respondent was visited 1-4 times by the teams over a semester and was interviewed by all members of the student group in one session.

An open-ended questionnaire with the workforce competency dimensions presented in Table 1 along with description and sample answers to fit description (Table 2) was developed as the format to be used in the interview of company respondents regarding the eight workforce competency dimensions for LSS. If verbal responses were deemed inadequate, students left the question with the respondent for a written answer to be collected later. Each questionnaire also contained self-report information regarding the respondent's degree of knowledge and involvement in the company's LSS program. The questionnaire did not contain any Likert type scale categories as the interviews were direct and extensive. Finally, each team was required to prepare a 50-page case study on the company's LSS implementation process.

TABLE 1
DEFINITION OF THE SELECTED WORKFORCE READINESS DIMENSIONS

Dimension Label		Descriptors/Identifiers
(1)	Compatibility of LSS with quality culture in company	Years of experience with quality programs, Lean systems, continuous process improvement, success with TQM/CQI, process control/process capability measures.
(2)	Leadership structure	Defined hierarchy of decision making, centralized or decentralized or integrated, top management's extent of involvement and worker empowerment. Evidence of use of employee suggestion systems to creation of self-managing teams or quality circles by entrusting (responsibility & accountability), enabling (ownership of process), and encouraging (skill & motivation) the employees.
(3)	Internal marketing	Steps taken to disseminate LSS knowledge through formal training programs, intra and inter departmental communications, Q & A sessions with leadership, commitment to LSS as reflected in the strategic plans, and coalition building with employees.
(4)	Performance appraisal system	Evidence of team based/result-oriented performance appraisal system as opposed to individual based/activity-oriented appraisal system.
(5)	Commitment to process control & improvement (LSS breakthroughs)	Separation and study of common (system defects) and special (employee induced) causes of quality variation and commitment to improve quality as evidenced by application of various quality improvement tools, Quality circles, process flow improvement.
(6)	Goal setting in LSS implementation	Evidence of use of team approach that goes through idea generation, alternative evaluation, and consensus building, design for LSS based on economic justification, use of NPV, IRR, payback period etc. or customer supplied criteria to select LSS projects.
(7)	Training vis-à-vis proactive employee coaching by black belts/champions	Beyond classroom training on LSS tools, what is done to familiarize process personnel in key process input variables (KPIV) and key process output variables (KPOV) and their interaction through which breakthroughs come.
(8)	Difficulty faced by top management to achieve employee buy-in	Deployment of objectives is not a trivial task, employee buy-in may depend on many factors, starting from challenges they face to lack of clear direction to questions of professional preferences to question of rewards & compensation.

Researcher Role and Criteria for the Soundness of the Study

The principal researcher content analyzed the collected data using a seven-point Likert scale to place companies *a priori* into two different categories – successful or unsuccessful LSS adopters -- on the basis of their performance on the first dimension (Compatibility of LSS with quality culture in company). This was based on our hypothesis that LSS adopters without much experience with Lean and data driven quality control practices are at a disadvantage to implement LSS, they have not yet developed the competency for LSS. Scores on other workforce competency dimensions were assigned to these studied companies – both successful and unsuccessful -- using a Likert scale from 1 to 7 based on detailed analyses of their performance on each dimension. Table 3 represents the average score on these workforce competency dimensions along with their coefficient of variation for both successful and unsuccessful LSS adopters.

TABLE 2
QUESTIONNAIRE RESPONSE FORMATS AND SAMPLE ITEMS

Dimension Label	Sample Answers to fit Description
(1) Compatibility of LSS with quality culture in company	**High score**: We have years of experience with quality programs and successfully implemented Lean practices, LSS offers an opportunity to take it further. **Low score**: We have tried other programs, they have not worked for us, LSS offers a new opportunity.
(2) Leadership structure	**High score**: We have an integrated decision-making structure; self-managing teams work with LSS champions under the overall direction of the executive suite. **Low score**: Our decision-making process is centralized/decentralized.
(3) Internal marketing of LSS	**High score**: We use very effective communications mechanisms with our employees, LSS is part of our strategic plan, our employees understand the importance of quality and process improvement (coalition building) **Low score**: Our process owners appear to resist LSS for multiple reasons.
(4) Performance appraisal system	**High score**: Evidence of team based/results oriented performance appraisal system as opposed to individual based/activity oriented appraisal system. **Low score**: LSS has not changed the performance appraisal system.
(5) Commitment to process control & improvement (LSS breakthroughs)	**High score**: Separation and study of common (system defects) and special (employee induced) causes of quality variation and commitment to improve process capability using various quality improvement techniques. **Low score**: We do not use any statistical tools yet.
(6) Goal setting in LSS implementation	**High score**: We use customer supplied criteria to generate new ideas, consensus decisions are taken after economic justification for the LSS project. **Low score**: LSS project decisions are either taken by the process people or by the executive suite with apparent benefit to the company.
(7) Training vis-à-vis proactive employee coaching by black belts/champions	**High score**: Our employees are trained beyond the classroom through proactive coaching routinely about process attributes and interactions. **Low score**: LSS training (green belt) was all that was done.
(8) Difficulty faced by top management to achieve employee buy-in	**High score**: Deployment was done through internal marketing emphasizing the importance of LSS as a strategic objective, Employees saw the benefits of LSS to themselves and to the company. **Low score**: Transition to LSS was not smooth in the absence of Lean practices, there were pockets of resistance, many still take it as "another fad."

The usual cannons or standards by which quantitative studies are judged --- internal validity, external validity, reliability, and objectivity --- have been deemed inappropriate for judging the merits of qualitative studies (Agar, 1986; Guba, 1981; Kirk & Miller, 1986; Lincoln & Guba, 1985; Merriam, 1995;

Sandolowski, 1986; Strauss & Corbin, 1988). Consequently, most qualitative researchers believe that these constructs require redefinition to fit the realities of qualitative research (Strauss & Corbin, 1998) and that more attention should be devoted to responding to the criteria for the soundness of conducting qualitative research (Marshall & Rossman, 1995).

Lincoln and Guba (1985) proposed four alternative constructs that more accurately reflect the assumptions behind conducting sound, trustworthy qualitative research. These constructs are (page 290, Lincoln & Guba) establishing the "truth value" of a qualitative study, its applicability, consistency, and neutrality.

Truth value refers to the researchers' ability to adequately and credibly reconstruct the respondents' reality or meaning of a situation. The principal researcher's interpretation of the data was checked by the graduate team's four members. They were also subjected to informant checking in which informants were allowed to review the case study and its evaluation process. Agreement by both the team and the informants supported the credibility of the interpretation assigned to the data by the principal researcher. Thus, the truth value of the research was achieved.

Applicability is the ability of others to apply the information in other settings if they so choose and is measured by using the criteria of both fittingness and transferability. Fittingness was assessed by the informant checking procedure, whereas the determination of transferability is the judgment of the reader. The 50-page case study report created a thick description enabling other readers to draw their own conclusions about the transferability of the findings to their own setting.

Consistency is the third factor and refers to other's ability to understand the researchers' perspective and come to the same or comparable results and conclusions. This factor is measured by the criterion of dependability which has been achieved in this study by including details of the researchers' perspective, the steps taken before, during, and after data collection, and the decision steps made during data analysis.

The three criteria of credibility, fittingness and transferability, and dependability have been adequately met in this study and consequently, the fourth factor for establishing rigor in quantitative research has been met. This factor is called neutrality, and its evaluation criterion is confirmability. Lincoln and Guba (1985) stressed the need to be sure that the findings are reflective of the subjects and the inquiry itself rather than the creation of the researcher's biases or prejudices. Various strategies for controlling bias in data interpretation were included in this study. The data were checked and rechecked by the respective informants and the principal researcher. The questionnaire was field tested through a pilot study before allowing the student teams to administer it to the study companies. Finally, the principal researcher conducted an audit of the data collection and analytical procedure via the team's 50-page case study. All these strategies helped to confirm that the data themselves were objectively interpreted (e. g. Marshall & Rossman, 1995).

QUANTITATIVE ANALYSIS OF THE QUALITATIVE FINDINGS

Table 1 represents the workforce competency dimensions along with their descriptors. Table 2 lists those workforce competency dimensions along with sample answers to fit description. Groups of executive MBA students interviewed key LSS personnel in each of the eight studied companies, they used an open-ended questionnaire to interview at least 3 company personnel regarding the eight workforce competency dimensions. The sample size of the study is small because detailed study of a company takes a long time. These eight companies were studied over a period of two semesters by eight EMBA groups of students. Because of the small sample size, and non-normality of the data, parametric analysis could not be carried out, instead non-parametric tests were applied.

Companies were divided into two categories of successful, and unsuccessful LSS adopters based on their score on the first dimension (also qualitative assessment indicated success of LSS): Compatibility of LSS with company quality culture. Companies that scored high on this dimension had years of experience with quality programs, and had successfully implemented TQM, or other data driven quality programs, were labeled as successful LSS adopters.

Table 3 represents the study results. Observe that companies labeled as successful scored high on all workforce competency dimensions with low coefficient of variation, in other words they followed good LSS standards, while the unsuccessful or the marginal implementers had low average scores on these dimensions with high CV, an indication that there are several poor performers on some of these dimensions. Observe that when the combined CV is calculated on each workforce competency dimension the CV goes up significantly highlighting a significant difference in the competency dimensions between successful and unsuccessful adopters.

TABLE 3
STUDY RESULTS INVOLVING WORKFORCE COMPETENCY DIMENSIONS

(Mean in Likert score, CV as a percentage)

Dimension Label	Mean/Coefficient of variation (CV) Within/between successful/unsuccessful Companies		
	Successful Mean/CV (%)	Unsuccessful Mean/CV (%)	Overall Mean/CV (%)
Compatibility of LSS with quality culture in Company	6.5/6.3	3/27.21	4.75/41.34
Leadership structure	5.75/11.22	3/27.00	4.37/37.03
Internal marketing	5.5/10.49	2.3/23.09	4/42.25
Performance Appraisal System	5.25/9.52	3/27.21	4.12/32.87
Commitment to process control & improvement (LSS breakthroughs)	5.75/8.69	2.75/34.81	4.25/41.23
Goal setting in LSS implementation	5.75/11.22	2.75/34.81	4.25/41.71
Training vis-à-vis proactive employee coaching by black belts/champions	5.25/9.52	2.25/22.22	3.75/44.5
Difficulty faced by top management to achieve employee buy-in	5.62/8.51	3.5/16.49	4.56/27.12

Table 4 reports the non-parametric test results. Kruskal-Wallis Chi-square was calculated between the successful/unsuccessful companies for each of the competency dimensions that tests the significant difference between the medians of these populations (since there are only two samples KW reduces to Wilcoxon rank sum test). Observe that the p-value indicates significant difference between these two groups of companies (successful and unsuccessful adopters of LSS) in terms of competency for the workforce.

TABLE 4
KRUSKAL-WALLIS χ^2 TEST

Dimension Label	**Kruskal-Wallis χ^2 Test** between successful/unsuccessful Companies		
	χ^2 value	**DF**	**Pr > χ^2**
Compatibility of 6σ with quality culture in Company	5.46	1	.019
Leadership structure	5.39	1	.020
Internal marketing	5.60	1	.018
Performance Appraisal System	5.67	1	.017
Commitment to process control & improvement (6σ breakthroughs)	5.67	1	.017
Goal setting in 6σ implementation	5.39	1	.020
Training vis-à-vis proactive employee coaching by black belts/champions	5.89	1	.015
Difficulty faced by top management to achieve employee buy-in	5.53	1	.018

IMPLICATIONS AND DISCUSSION

The detailed case study of the LSS program at each of the companies provide some degree of quantitative assessment of the eight workforce competency dimensions as well as providing some in-depth interpretation of the qualitative aspects of the results. Out of the eight companies studied four were labeled as unsuccessful or marginally successful based on their score on compatibility of their quality culture with LSS. This dimension reflects the shared values, beliefs, and norms regarding importance of quality and process efficiency within the company, something that develops over a period through adoption and

experience with Lean and other quality programs that are regarded as precursors to the LSS program. The results are consistent with Motwani et al. (2004) and Gabor (2001) that unless a company can create an organizational culture that is conducive and supportive of the proposed changed approach (LSS in this case) it will face insurmountable obstacles in its implementation. All those four companies – labeled as unsuccessful – had limited experience with other quality approaches, i.e., Lean, TQM, CQI, etc., and thus lacked the infrastructure and the cultural environment to implement LSS. Cultural transformation takes place over a period; the workforce must learn to overcome cultural barriers, understand clear-cut job expectations, learn how to measure and monitor process performance, and understand the importance of creation of systems and procedures that are simple, user-friendly, and fool proof.

The paper investigated the relationships of workforce competency dimensions that are critical – as reported by literature – for LSS implementation. The overall findings from the nonparametric results indicate that four out of eight companies studied had the required competency for LSS. These companies had years of experience with quality programs and had successfully implemented Lean and TQM or a variation of TQM in the past. All these companies had used quality as a strategic tool to develop their distinctive competencies, and they made the transition to LSS when they realized that it is more structured and profit oriented. The successful companies received higher scores on the LSS leadership structure because the executive suite was not only involved with the program, but it also focused on coalition building with the informal leaders of the workforce. Executive leadership coupled with transactional forms of leadership at the lower echelon of the hierarchy helped shape the quality culture in these companies. In the successful companies, empowerment was integrated into the organizational culture in a progressive manner through implementation of Lean and other quality programs over time, as a result, when it came time to implement LSS workforce culture was amenable to LSS requirements. In contrast to that, launch of LSS in the four unsuccessful companies were either totally management initiated, or the participative management initiative started by executive suite lacked direction and guidance. The low score and the high coefficient of variation for this dimension for unsuccessful companies testify to this problem in leadership structure. In addition, their marginal or lack of experience with other quality programs failed to create participatory spirit needed for LSS. Many of the LSS teams in these companies failed to realize that LSS not only requires a deep understanding of process for defect reduction, but it also requires innovation for quantum leap into defect prevention. In contrast to the successful companies, LSS teams in these companies had less perceived support from top management to go beyond the call of duty by suggesting ideas for process innovation.

The score on internal marketing for unsuccessful companies stand in stark contrast to the score for successful companies. The performance of the unsuccessful companies is not even half as good as the successful companies. It is an indicator of the management effort put into coalition building with the employees, empowerment, and success in persuading the employees to take initiative. Similar results were obtained for the dimension – performance appraisal system. Three of the four unsuccessful companies still had individual based, activity-oriented performance appraisal system as opposed to black belt/project oriented performance appraisal for successful companies. Performance appraisal in LSS companies should be conceived and patterned to be consistent with the tenets of LSS culture, it should be based on self-evaluations and peer ratings on acquisition of new LSS skills and their successful application on the job. Through commitment to process control and improvement LSS makes its greatest impact on quality performance, it is a fact driven process and requires discipline. For companies with experience in Lean and data driven quality management, i. e. TQM, CQI, making transition to LSS is expected to be smooth. LSS requires one extra step by incorporating an economic justification for each improvement effort, and selecting only the ones that are supposed to have the most significant impact on the company bottom line. All the successful companies scored high (Average: 5.75, CV: 8.69) on this dimension, an indicator of achievement of breakthrough process innovation, while the scores of the unsuccessful companies varied widely with some very poor performers (Average: 2.75 CV: 34.81). The average score of the unsuccessful companies were unduly affected by two companies that scored very poorly on this dimension because they do not even have a data driven decision making process. There was no evidence of application of any statistical analysis tools, e. g., control charts, capability measures, etc., beyond Pareto charts, and fishbone diagrams. By the same token, goal setting for LSS suffered the same fate in unsuccessful companies

(Average: 2.75, CV: 34.81) while performance of successful companies was very encouraging (Average: 5.75, CV: 11.22). The successful companies went through idea generation for process improvement (or improvement of product quality), alternative evaluation through NPV, payback period, and breakeven analysis. This is a critical competency factor for LSS implementation, something that lies at the core of the LSS approach, essential for avoiding estimates of LSS benefits often calculated under untenable assumptions. Although cost benefit analyses were part of all black belt training programs in the studied companies, most of the unsuccessful companies did not use a methodical goal setting approach. The problem was, many of the quality improvement projects at these companies were initiated by top management, and the project selection committee felt obliged to accept these projects based on goals and aspirations put forward by top management. Training of workers in LSS – ones that will get involved with LSS projects – is very important, but it is more important that the CEO's – who have the highest leverage in harnessing the resources for LSS – be trained first. It became obvious during the course of this study that CEOs in the less successful companies had less exposure to LSS compared to CEO's in successful companies, this is consistent with our findings that the successful one's had more implementation experience with other forms of quality programs. This was also reflected in the fact that the control function for selection of LSS projects in unsuccessful companies is more decentralized, i. e., controlled by process staff, as opposed to integration of the decision-making process. In the successful companies the executive suite exercised more control over this to minimize the risk of project misfit with the corporate goals and objectives. It was evident that the executive suite in unsuccessful companies had difficulty in putting together a cohesive team to oversee the LSS activities either because they had inadequate experience and training in LSS, or there were cultural impediments to its implementation. On training most successful companies scored reasonably well (Average: 5.25, CV: 9.52), in most of them the formal training was followed by proactive coaching of the process staff by black belts. In contrast to that (Average: 2.25, CV: 22.22), the training in unsuccessful companies were not followed by proactive coaching.

LSS is a change management practice, although it is not a radical re-thinking approach, it becomes one if the company has no experience with Lean and other quality management practices. It is often characterized as being fixated on meticulous attention to details, application of advanced statistical tools, and mechanistic without regard to needs, desires, and fears of the employees who implement it. In addition, it picks up only the competent people in the workforce to implement it leaving others to feel left out and ostracized, Lean principles moderate that mechanistic outlook. In a pervasive quality culture – companies that have years of experience in Lean and quality programs – such backlash is unlikely to happen. In the absence of a pervasive quality culture the processes that are connected do not support each other, for LSS it is a non-starter. It was interesting to note that in most of the unsuccessful companies studied in this research the evidence of such backlash was minimal, the study teams concluded that the change in the process structure of LSS projects had a positive impact on the employee behavior in the connected processes. The study teams also concluded that the LSS project teams in unsuccessful companies were empowered to make most of the decisions, these teams in addition to focusing on tools and methodologies, emphasized the dynamics of people at work and the whole work system that will increase both organizational performance and individual satisfaction. Observe in table 3 that this is the only workforce competency dimension in which the performance of unsuccessful companies, although far from being ideal, is reasonably well (Average: 3.5, CV: 16.49) in comparison to other competency dimensions. The successful companies scored high on this dimension (Average: 5.62, CV: 8.51). The successful companies applied a two-pronged approach to achieve employee buy-in, in addition to the efforts by the executive suite in coalition building, LSS project members worked with their peers in the connected processes to win their confidence.

CONCLUSION

Successful implementation of LSS appear to hinge on some important workforce competency dimensions. Eight LSS companies were categorized, through a detailed study, into successful and unsuccessful adopter based on their level of experience with quality programs. It was hypothesized, based

on published literature, that only companies that has years of experience with successful implementation of other quality programs, e.g. Lean, TQM, CQI, etc., will have the competency to implement LSS. Study results indicate that companies with limited experience with quality programs performed poorly on the selected workforce competency dimensions, and their performance is significantly different than the performance of companies with years of experience with quality programs. We recognize the limitations of this study, with a sample size of only eight companies it is not generalizable. However, it reveals some important findings that need to be followed-up with a more detailed study.

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