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Project barriers to Green Belts through critical success factors

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Abstract

Purpose – The purpose of this paper is to utilize critical success factors (CSF) and identify items Green Belt (GB) practitioners note as barriers to completion of Six Sigma (SS) projects in a major manufacturer setting.

Design/methodology/approach – The design of this paper is a descriptive study of a single location of a global manufacturer's internal data and survey of accredited GBs who have completed an SS project for company accreditation utilizing company focus on CSFs.

Findings – The results demonstrate the GB practitioners have competing priorities, have time constraints and lack project management skills that reduce timely completion of SS projects. Top management responsibility for SS GB projects are defined through the CSFs of leadership, project management and project selection.

Research limitations/implications – This study pertains to the single manufacturing location of a major, multinational company. The survey of SS GBs is limited to those individuals who have become accredited to company requirements, in the initial stages of strategic implementation, resulting in a small sample size. All GB projects follow the DMAIC (Define, Measure, Analyze, Improve and Control) methodology. The implications may be reproduced in similar environments where GBs conduct SS projects to test the robustness of the study.

Practical implications – This study underscores the importance of proper coaching and mentoring of SS practitioners, especially those who are expected to contribute as GBs in a part-time manner. Implementation of SS goes beyond initial deployment and requires active mentoring of GB practitioners to make sure that SS projects get proper focus. The results are relevant to both researchers and practitioners.

Originality/value – This paper examines SS projects with a GB perspective, an important contribution to SS but lacking in the literature. While GBs are important to SS implementation, and serve as a pathway to fulltime SS personnel, there are few studies that note this work. This study will support practitioners in the importance of wider SS deployment through active support of GBs, where top management responsibility for GB success is defined through CSFs for improvement.

Keywords Critical success factor, Projects, Six Sigma, Green Belt

Paper type Research paper

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1. Introduction

Since the beginning of the 1980s Six Sigma (SS) has been adopted as a way of achieving higher profits by reducing defects and increasing customer satisfaction (Parast, 2011; Tjahjono *et al.*, 2010; Behara *et al.*, 1995). Started at Motorola, SS has enjoyed widespread

adoption, often attributed to early adoption at Allied Signal subsequent by Jack Welch at GE (Pande *et al.*, 2000; Maneesh *et al.*, 2011). Since then, the definition of SS has evolved from a quality engineering initiative devised at Motorola to a holistic methodology that is philosophically based upon total quality (Aboelmaged, 2009). When implemented successfully, the results can be remarkable and show substantial quality improvements. According to the American Society for Quality, 82 of the 100 largest companies in the USA have embraced it (Bloomberg, 2007). SS methodologies are being used in a vast array of organizations and in a wide variety of functions. There are numerous definitions of SS in the literature.

SS may be defined as a methodology for pursuing continuous improvement in customer satisfaction and profit that goes beyond defect reduction and emphasizes business process improvement in general (Breyfogle, 2003). According to Mehrjerdi (2011), the central theme of SS, is that product and process quality may be improved dramatically by understanding the relationships between the inputs to a product or process and the metrics that define the quality level of the product or process: by controlling the inputs, the outputs will be produced in a predictable range.

Approximately based upon two project methodologies inspired by Deming's Plan-Do-Check-Act cycle, SS projects follow two methodologies, composed of five phases each, as DMAIC (Define, Measure, Analyze, Improve and Control) and DMADV (Define, Measure, Analyze, Design, and Verify) (Breyfogle, 2003; Deming, 2000). DMAIC is used when existing products and processes need improvement and when the cause of the problem is unknown or unclear. DMADV is a similar process used when a new product or process is being designed. The DMAIC project methodology has five phases where each project phase ends with a gate review that results in a project either going forward, redoing the phase or being stopped completely (Feo and Barnard, 2005). The project aspect of SS is crucial to efforts for successful SS deployment.

Because SS implementation is primarily conducted through projects, SS success may be defined through managing projects successfully. The various methodologies (DMAIC, DMADV, Design for Six Sigma [DFSS], etc.) all follow a basic template of project management to identify and manage the project constraints (PMI, 2009; Pzydek and Keller, 2003). The basic project constraints include: project scope, time and cost and may be identified and managed to measure project success (PMI, 2009). At the project level, success means the finished project realized the objectives and are sustained in the organization after the project has been completed (Pzydek and Keller, 2003). Jacobsen (2008) states that project success is evident where they are: viable and achievable in a short time through a successful launch, may be quantified and are built on accepted and highly demonstrable successes. Pande *et al.* (2000) provide three categories of project selection criteria: business benefits, feasibility and organizational impact. Financial benefits are also quantified. Antony and Banuelas (2002) gives a similar perspective that every project should be selected so that it will help the company improve competitive advantage, business profitability, process cycle-time and throughput yield.

SS projects are no different where the basic attributes of meeting the project are selected so that it will help the company improve competitive, are met. While all three are inclusive and should not be separately managed, project managers may find that it is easier to manage the constraint of time, instead of reducing a project's scope to meet the project's goals (PMI, 2009). Basic SS projects function in the same manner where project completion varies. The expert opinion states that SS projects should take

approximately three to six months (Arumugam *et al.*, 2013; Ahadian and Abadi, 2012; Lynch *et al.*, 2003) or four to six months (Breyfogle *et al.*, 2001). While projects vary according to scope of work, shorter duration of projects helps avoid waste and added costs as project completion time is related to tangible and intangible costs. Lack of progress can lead to a lack of project focus by stakeholders involved and delay in realizing project benefits (Lynch *et al.*, 2003) and Snee and Hoerl (2003) find that SS success means that a sense of urgency to complete projects within four to six months is needed. Team membership begins to suffer and time is lost as project team effort declines as they encounter serious motivational issues (Mariotti, 2005). The individual who manage the day-to-day work of an SS project may work on SS projects full time (Black Belt [BB]) or part time (Green Belt [GB]) (Pzydek and Keller, 2003). Regardless, a person managing an SS project to its successful conclusion must manage the constraints listed above to be successful in the field.

As many experienced practitioners relate, merely sending an employee to training does not mean that the employee will lead a project successfully. In this study, the problem of project duration (timeliness) is introduced through a review of the literature to understand the significance of the problem in general, and more specifically in part-time work of SS GBs. This organization, a multinational, advanced manufacturer, was in its third year of SS strategic implementation at the time of this study. The planned rollout of SS included benchmarking SS project performance; in particular, project duration was the primary concern of management at this three-year review of implementation. The majority of GBs at this company do not finish within six months, the corporate measure for SS success with regard to this constraint. And while this study focuses on those individuals who do complete an SS project (timely or not), the problem is even larger where a portion of the SS GB trainees never start or conduct a project. Discovering and removing barriers may lead to a larger number of successful GB projects and reduce costs further. The SS duration problem is significant because the full speed of return from process or product improvements is not realized. Customer delivery, improvement in quality and customer satisfaction may follow if GB projects are completed in a timelier manner. As a singular case study, the problem is still significant from a leadership perspective and the ultimate strategic goal is to gain more control of the business costs and improve customer satisfaction through creating a sense of urgency of project completion at one of the multinational's facilities located in the USA. Based upon a strategic viewpoint of the company's SS criterion, or critical success factors (CSFs), a survey of company accredited SS GBs are surveyed to understand the research question: What are the barriers to timely completion of SS GB projects? Recommendations to eliminate and/or mitigate those elements that prevent SS GBs from meeting project goals, in time, are presented. This is one of few studies that has been conducted that focuses on the individual involved in SS implementation, through the strategic viewpoint of CSFs, on the GB, expected to successfully manage SS projects where the individual's focus is also on their functional, regular job description. SS is not limited to full-time BB work. While results are limited to this particular environment, future growth at this company demands a sustainable, stable and robust GB project process to meet the organization and to this particular environment; future growth at this company demands a sustainable without SS GBs; and the positive change that SS potential has requires a broad, in addition to deep, implementation of the methodology.

2. Review of the literature

2.1 Project success

Much as been written about SS project success, particularly in studies on the inputs or proper project selection (Ahadian andAbadi, 2012; Padhy and Sahu, 2011; Ray and Das, 2010; Sharma and Chetiya, 2010; Kumar *et al.*, 2009, 2007; Yang and Hsieh, 2009; Su and Chou, 2008; Antony, 2004a). The literature of SS project success also includes: knowledge management (Arumugam *et al.*, 2013; Easton and Rosenzweig, 2012; Gopesh *et al.*, 2009; Savolainen and Haikonen, 2007), project management (Mandal, 2012; Gray and Anantatmula, 2009), risk management (Tariq, 2013) and team management (Wu *et al.*, 2012). Finally, a review of SS project research based upon GB perspective is done (Ho *et al.*, 2008; Green, 2006; Green *et al.*, 2006).

A review of the literature of SS projects was done to understand how SS success is defined through a project perspective. Validation of the effectiveness of SS programs is critical to the credibility and continued success of process improvements, as the methodology has gained wide application. SS, like other strategies, is easier to start than validating effectiveness. Thus, empirical study is recommended to measure SS success to mitigate subjective interpretation (Zhang *et al.*, 2011). The addition of increased bureaucracy, lack of leadership, problematic project definition and selection and ineffective project management support a project-based assessment of SS effectiveness based upon constraints noted above (Snee, 2010; Antony, 2004b). Utilizing an overall process perspective, study of inputs or antecedents are part of SS project assessment.

2.2 Project selection

A focus on selection methods as a predecessor to SS project-based research is well developed in the literature for the result of successful SS projects (Aboelmaged, 2009). Ahadian and Abadi (2012) present a model for identifying SS projects that may be completed successfully, including duration, based upon the multiple criteria decision making (MCDM) mathematical approach (Ahadian and Abadi, 2012). While a rationale for comparing projects is presented, the characteristic of pilot, or test, projects is the focus. In addition, human elements, such as BB or GB roles, are not included (Ahadian and Abadi, 2012). Padhy and Sahu (2011) also study SS project selection through inputs. Conducted as a case study, Padhy and Sahu (2011) study project success through improved flexibility in managing constraints utilizing a real option model; a two-stage decision-making approach and model to evaluate value and risk (Padhy and Sahu, 2011). The results suggest that SS projects using real options can provide flexibility in managing projects and meet project success (Padhy and Sahu, 2011). However, risk and value are the primary factors contributing to project definition and success rather than a systematic approach. Ray and Das (2010) use a more comprehensive approach where they study SS project identification for subsequent success. The authors establish a model for project selection where the data availability, management commitment, project selection and project control skills are all evident through a top-down management and balanced scorecard approaches (Ray and Das, 2010). However, project success was not defined with time duration but primarily customer satisfaction. Sharma and Chetiya's (2010) study project success through factor analysis find that management commitment, good communication, existence of process/workflow techniques, availability of data, existence of measurement systems and resource availability are required antecedents for an SS project success (Sharma and Chetiya,

2010). Conducted through a study of 13 manufacturers, the primary criterion for project success was financial, not time. Project selection studied by Büyüközkan and Öztürkcan (2012) focused on enabling practitioners in determining priority and impact of SS projects using a combined two multi-criteria decision-making methods, Decision Making Trial and Evaluation Laboratory (DEMATEL) and analytic network process (ANP) decision-making approach (Büyüközkan and Öztürkcan, 2012). Results demonstrate that this combined approach is viable; based upon risks of delay, budget and project, the study is limited to a single Turkish logistics company with data collection (Büyüközkan and Öztürkcan, 2012). Yang and Hsieh (2009) study project selection based upon national quality award criteria for a hierarchical evaluation process, utilizing a Delphi fuzzy criteria decision-making methodology by management (Yang and Hsieh, 2009). The results demonstrate successful adoption in a case study of a component manufacturer where the more crucial the project priority, the greater the financial impact. Project duration is not part of the study criterion. In an empirical study, investigators studied the importance of project selection on SS project success utilizing a combined analytic hierarchy process and project desirability matrix (Kumar *et al.*, 2009). The results demonstrate the importance of project selection to ultimate success through a more objective, comprehensive and combined methodology (Kumar *et al.*, 2009). The study is also limited to a single case study of a UK small and medium enterprise (Kumar *et al.*, 2009). In another empirical study, Su and Chou (2008) sought to identify SS projects for selection and report on prioritization with regard to company strategy and customer satisfaction. Implemented through a case study of a semiconductor foundry, the results demonstrate an empirical approach that incorporates where SS projects may be classified as low-hanging fruits, GB or BB projects (Su and Chou, 2008). While SS roles (GB and BB) are incorporated, the approach requires implementation to evaluate SS projects at completion (Su and Chou, 2008). Banuelas *et al.* (2006) study criteria for SS project selection in a national survey of SS practitioners consisting of BBs, GBs and others involved in the SS methodology (quality managers, champions, etc.) (Banuelas *et al.*, 2006). Results shown that customer satisfaction, financial benefits, linkage to business strategy and top management commitment were the main SS project criteria. Survey response rate was low, approximately 8 per cent, but similar to related studies (Banuelas *et al.*, 2006). The study was also geographically bound to the UK. In addition, the constraint of time, as a performance metric, was not noted as significant (top ten factors) by survey participants. Shanmugaraja *et al.* (2012) created an SS project selection model through quality function deployment (QFD). Through a case study using Indian small and medium enterprises, the researchers replaced the Define phase to create a QFDMAIC and applied the methodology to the business. While the organization vision was primarily through satisfying customer service, results demonstrate that technical improvement projects should be the focus through QFDMAIC application (Shanmugaraja *et al.*, 2012). While connecting to company strategy, limitations to this approach included a single organization, at the beginning of an SS implementation (Shanmugaraja *et al.*, 2012). Kumar *et al.*'s (2007) study is based upon improving SS project completion through improved selection utilizing data envelopment analysis (DEA) techniques. In a theoretic study, DEA was demonstrated to be a viable SS selection methodology where hypothetical inputs and outputs are tested for robustness (Kumar *et al.*, 2007). Application to real SS projects would mitigate the limitations of the

study, although several factors contributing to SS project setbacks are integrated into the model (Kumar *et al.*, 2007). While the majority of recent research of SS projects has been based through project selection, other studies have been based upon learning in the SS process.

2.3 Project leadership

Studies of project success may be based upon the principle of the learning organization (Senge, 1990), and, in this section, SS project-based research may be seen through the learning perspective. A study by Arumugam *et al.* (2013) investigates how organizational inputs, technical resources and team socialization impact SS project success. In a survey of SS team members participating in 110 projects of a single Fortune 500 firm, Arumugam *et al.* (2013) found that SS resources are related to know what (knowledge about facts and concepts) and psychological safety (team socialization) is related to know how (competence and skills); know how also mediates project performance through know what (Arumugam *et al.*, 2013). Although limited in project number (52) and to a single firm, this study demonstrates for practitioners to support a positive team climate for project success. In another study, experience, individual, team and organizational, Easton and Rosenzweig (2012) analyzed both SS project successes and failures in a Fortune 500 firm. While a single organization of SS projects is studied after the fact, Easton and Rosenzweig (2012) find that team leader experience is most strongly related to project success, followed by organization experience. In contrast to Arumugam *et al.* (2013), SS project success is not dependent upon individual knowledge or socialization. However, other works (Anand *et al.*, 2010) are in line with previous works (Arumugam *et al.*, 2013). In a study of SS project success, Anand *et al.* (2010) study explicit and tacit knowledge. In a survey of BBs across five firms, it was found that knowledge-creation practices, through individuals on SS team, are related to success. This result is important even though SS projects are limited in duration and team members contribute only a portion of their time to projects, and their individual knowledge is important for project success through explicit knowledge creation from tacit knowledge of team members (Anand *et al.*, 2010). Savolainen and Haikonen (2007) study SS implementation through organizational learning and continuous improvement. The results that the authors find (Savolainen and Haikonen, 2007) is that SS implementation (project implementation and personnel learning) is based upon problem-based (project) learning through SS framework that supports continuous improvement. The study is limited to five Finnish firms. While not defined through explicit SS project success, this study incorporates principles of project-based SS research (Savolainen and Haikonen, 2007).

2.4 Other project-based research

Recent SS project research may be categorized broadly upon business process management principles (Mandal, 2012; Vom Brocke and Sinnl, 2011; Gray and Anantatmula, 2009; Kumar *et al.*, 2007; Wu *et al.*, 2012; Tariq, 2013). While originally focused on information technology adoption, current business process management principles may be more holistically applied where processes are the core from which business is executed and supported (Vom Brocke and Sinnl, 2011). SS implementation also shares process focus and the management thereof. SS project management is found in a couple of studies (Mandal, 2012; Gray and Anantatmula, 2009). Mandal (2012) takes

a different approach to SS project research through improving the DMAIC process. By modifying the improve and analyze phases to incorporate more design of experiments, Mandal (2012) suggests that SS may be more effective in application (Mandal, 2012). While a strategic relationship to SS is described, there are several limitations: the study is based upon a single case, two applications of the proposed model (ease of control and process knowledge leap) are theoretic by classifying 17 DMAIC projects after the fact; and more study would be required for confirmation (Mandal, 2012). In a study to improve SS projects, Gray and Anantatmula (2009) propose a framework for DMAIC application utilizing standardized project management implementation (PMI) principles. Based upon the variation of SS implementation, Gray and Anantatmula (2009) state that project management principles, defined by time/resources (efficiency) and goals/impact (effectiveness), a revised framework of Six Sigma Project Management would improve project initiation, execution and completion. In a survey of 24 SS project leaders, the results demonstrate that SS and project management are complementary, and the ultimate success of SS projects relies primarily upon execution (Gray and Anantatmula, 2009); this study diverges with those above that rely upon project selection. However, the survey defines SS project success through a project management approach (time/scope, budget and results) with a limited sample size, even though BBs and GB perspectives are included (Gray and Anantatmula, 2009). Tariq (2013) was concerned about project completion delays by focusing on execution, rather than selection, in an SS project study. Utilizing risk management principles, the purpose of Tariq (2013) was to create a framework for minimizing project duration delay through combination of SS and risk management principles (Tariq, 2013). Applied to a case study, the results demonstrate improvement in an SS DMAIC project applied to a health-care production company. There is not a comparative study to further validate the model and is limited to a single project. Finally, Wu *et al.* (2012) study how leadership impacts SS project success. Through a survey of Taiwanese individuals involved in SS (BBs, GBs, etc.), member cohesiveness, similar to team approaches described above, mediates leadership and overall SS project success (defined as meeting goals, on time, within budget) (Wu *et al.*, 2012). As one of few studies to include leadership, this study included several national industries, in a snapshot. Furthermore, while individuals surveyed reference their own particular SS project experience, factors of SS success are not particularly noted with regard to the role individuals play in those projects (Wu *et al.*, 2012). This may be true of GBs who are able to devote only part of their time to projects because of their other managerial duties, to SS project success. In the next section, studies of how SS GBs impact project success are reviewed.

2.5 Six Sigma GBs

A study of SS projects should consider the impact of GBs. As part of a comprehensive strategy, GBs serve as the professional force that fill in between full-time project managers (BBs) and the functional workforce by serving as part-time practitioners who fulfill SS projects themselves, serve as team members on larger projects and serve as a pool from which to draw full-time BBs (Snee and Hoerl, 2003). As important as the function GBs serve, they often get less dedicated training and are expected to conduct SS projects in addition to their regular duties (Pzydek and Keller, 2003). There are few studies dedicated to the perspective of the GB. In an initial review, Green (2006) studies the impact of GBs at five companies through in-depth interviews of selected individuals. Through structured

interview and questionnaire, Green (2006) researched actual GB performance at these organizations. Individuals selected or volunteered for GB were highly educated (Green, 2006). Training time and pedagogy varied considerably; from multiple weeks to a few days utilizing classroom-based to more recent electronic-based training. Regardless, project completion was required for certification (Green, 2006). Most GBs stated that they competed projects on their own with little BB mentorship and felt that they did not have the time to complete their projects due to completing regular duties (Green, 2006). Most importantly, GB project duration varied considerably from three months to two years with an average of nine months, much longer that recommended (Pzydek and Keller, 2003; Green, 2006). Common barriers mentioned were lack of data, unclear goals and improper scope (Green, 2006). While illuminating, the study contains few individuals ($n = 14$) from which to draw more general conclusions and does not take strategic objectives, such as CSFs, into account. In another study, Green *et al.* (2006) takes a more detailed approach of how to implement an improvement program at a small company primarily utilizing GBs. In this case study, individuals are either selected of volunteered, take a training program of approximately 24 hours of classroom instruction to apply and complete a GB project in 12-18 months, receiving compensation through a skills reward-based program (Green *et al.*, 2006). GBs are mentored one-on-one by BBs and are expected to complete an additional GB project per year to maintain certification, while completing regular duties (Green *et al.*, 2006). Thus, the time dedicated to GB projects remains low (2-3 per cent of time) (Green *et al.*, 2006). However, a major project barrier was a lengthy project duration (12-18 months), followed by data collection issues and team direction (Green *et al.*, 2006). As a result, GB projects are designed to be of shorter duration through the adoption of lean tools toward more lean-oriented SS projects (Green *et al.*, 2006). While project selection was always a top-down approach, GBs conduct projects based upon strategic company initiatives through a balanced scorecard (Green *et al.*, 2006). Limiting these results is the singular case of a small manufacturer. Finally, a study that has similar research objectives as the study conducted here is one by Ho *et al.* (2008), where the researcher asks what the key success factors that enable GBs to successfully complete projects and reach certification. While these factors are defined as crucial to GB certification, they are based upon strategic indictors or CSFs. Based upon a review of CSF's, individuals who had completed GB certification, or failed to obtain it, were asked in a survey to identify factors that are crucial to project success (Ho *et al.*, 2008). In detail, CSF's critical to GB project success were: top management commitment and participation, business strategy (i.e. SS projects) tied to customer demands, use of data with data that are easily obtainable, investment of essential resources (i.e. time for GB to complete project) and investment/reward system for employees (Ho *et al.*, 2008). Results from this study are interesting where strategy (CSF's) is compared to GB project success, with regard to the limitations that the study is a single case within an Asian aircraft maintenance company (Ho *et al.*, 2008).

A majority of previous work in the area of SS project research has been based upon the inputs, such as: proper project selection or process, such as learning (individual and/or team) or project management. Many studies explicitly study the SS GB, or the successful output of the SS process, as defined by successful project completion. It has been noted above that crucial to SS success is the linking of SS projects to business strategy (Ho *et al.*, 2008). This study connects company focus on CSF's to GB projects. In the next section, a review of CSFs to define SS success is given.

2.6 CSFs for projects

For successfully implementation of SS into a business strategy, the focus on CSFs is recommended (Achanga *et al.*, 2006). Several publications note where CSFs may be translated into a successful project strategy such as executive and active management support, an effective organizational structure, proper project selection, project management, availability of data, bottom-line review and effective coaching and mentoring (Pande *et al.*, 2000; Breyfogle, 2003; Bisgaard, 2007; Jacobsen, 2008; Snee, 2010). With this linkage, managing projects that focus on key core issues may be done for evaluating project success (Sharma and Chetiya, 2010). Projects with no linkage to strategic goals or financial backing are likely to fail and produce a negative precedent for future projects (Ramu, 2007). Table I summarizes findings into six categories of CSFs:

(1) leadership commitment and participation;
(2) projects aligned with business strategy and voice of the customer (VOC);
(3) a consistent SS framework;
(4) project management and execution;
(5) utilization of SS tools; and
(6) project selection.

The question studied in this research is:

RQ1. What are the barriers to timely completion of Six Sigma Green Belt projects?

Few studies evaluate personnel success in project completion through a company's CSFs (Ho *et al.*, 2008; Su and Chou, 2008). As noted above, SS success includes a

CSFs	Reference
Leadership commitment and participation	Antony and Banuelas (2002), Pande *et al.* (2000), Snee and Hoerl (2003), Desai *et al.* (2012); Dobbins (1995), Coronado and Antony, 2002, Breyfogle, 2003, Mehrjerdi, 2011, Zhang *et al.* (2011), Jacobsen (2008), Pande *et al.* (2000)
Projects align to business plans and VOC	Harry and Schroeder (2006), Antony and Banuelas (2002), Pande *et al.* (2000), Desai *et al.* (2012), Coronado and Antony, 2002, Mehrjerdi, 2011, Jacobsen (2008), Sharma and Chetiya (2010)
Six Sigma framework	Antony and Banuelas (2002), Snee and Hoerl (2003), Desai *et al.* (2012), Breyfogle, 2003, Zhang *et al.* (2011), Sharma and Chetiya (2010)
Project management/ execution	Harry and Schroeder (2006), Antony and Banuelas (2002), Pande *et al.* (2000), Snee and Hoerl (2003), Coronado and Antony (2002), Bisgaard (2007)
Utilization of SS tools	Pande *et al.* (2000), Antony and Banuelas (2002), Desai *et al.* (2012), Coronado and Antony (2002), Breyfogle (2003), Jacobsen (2008), Sharma and Chetiya (2010)
SS training	Harry and Schroeder (2006), Antony and Banuelas (2002), Snee and Hoerl (2003), Coronado and Antony (2002)
Project selection	Desai *et al.* (2012), Coronado and Antony, 2002, Breyfogle, (2003), Jacobsen (2008), Sharma and Chetiya (2010), Ramu (2007), Pande *et al.* (2000)

Table I.
Critical success factors for SS implementation summary

project-based perspective. This case study was conducted in a global manufacturing company to understand what the barriers are to successfully completing GB SS projects through a survey of personnel that have completed GB training. This survey incorporates the organization's CSFs in an effort to identify barriers through a CSF framework. While this study is specific to one manufacturing plant, there may be lessons learned that could apply to other process improvement projects.

3. Methodology

To answer *RQ*1, this study utilized internal company data of completed SS GB projects and surveyed company GBs as well; specifically, information came from both database review and individual GB training records. The company under study is in the initial stages of implementing SS at this facility utilizing full-time BBs and part- time GBs. Project information was collected from an internal project database utilized for continuous improvement. This database is utilized to track SS projects and for this study provided: a basis of DMAIC projects for the study sample and to corroborate findings in a subsequent survey noted below. Clear operational definitions were created for how long GB projects were taking to complete (project duration) by project gate reviews to communicate consistently how project time was defined by personnel involved in the study (Deming, 2000). From the database and records, time between gate reviews was collected within projects. Project duration was defined through time taken between DMAIC gate reviews. Actual project duration time, defined by gate reviews, was compared with the overall planned project duration from the original project charter vs the actual project duration. In addition to the charter revisions collected from the database, project folders were evaluated for project duration times to verify actual vs planned duration time. The sample size of gate review projects represented 29 GBs. After removing incomplete project data, a final sample size of GB projects was 18. As a result, company data of completed GB projects demonstrated that the majority of GB projects were taking over nine months to complete instead of the company goal of six months. After confirmation of the lack of progress of timely completion of GB projects, a survey was administered to company GBs.

An electronic survey was administered to GBs to gather feedback utilizing CSFs noted above for timely completion of GB SS projects. The survey sample of GBs included company-accredited GBs who had gone through GB training for a total of 50 individuals in this convenience sample. This represents all of the GB's at this particular company locationnience samplehrough GB Belts included feedback ojects, a survey was administered to company GB's was to corrobon of a SS DMAIC project. Survey guidelines followed Sekaran and Bougie (2009). For cogency, the survey underwent a subjective analysis by subject matter experts (SME) within the organization. This analysis included the researchers and process excellence team. The survey was then pre-tested using a sample of the SME group before distribution to reduce bias and improve consistency. A debrief of the pretest results was done with the SME group to address the reaction to the survey and identify recommended changes. The survey was reviewed by the management team for stakeholder agreement and awareness. The survey was administered electronically through Survey Monkey (1999) anonymously. This study was focused identification of barriers the GB encountered (defined through CSFs listed for GBs in Table I). The survey also collected information on: subject completion of an accredited GB project, project duration, project focus (in GB functional

area), project timeline, if the GB t accreditation was also accounted on the individualccounted on the listed for GB's in Table I above)er agreement and awa, and the level of engagement with the Black Belt coach/sponsor. The final question on the survey was open ended to identify additional improvements to the GB accreditation process. The results to these questions will be answered in subsequent publications. Table II displays the survey questions and the original research purpose after coding. Full survey questions are provided in Appendix 1.

The e-mail requesting participation included an introduction to the project and a link to the survey Web site. This was sent to 50 subjects with one reminder sent later. At the end of the survey period, 29 of the 50 GBs responded, at a response rate of 58 per cent, meeting minimum requirements for this type of survey (Sekaran and Bougie, 2009).

3.1 Limitations and delimitations and assumptions

Reducing the general nature of this study were delimitations and limitations of the study. The basis of delimitations of why the researchers focused on the particular research question is formed from the organizational goal-improved timeliness of GB project completion at this location. Thus, delimiting this study is that it pertains to one manufacturing location of a large, multinational company, located within the manufacturing sector in the Midwest region of the USA. Also delimiting this study is the sample size: the scope of this study consisted of GBs initial project for getting SS GB accredited. An assumption is that the historical data collected on project duration in this study are accurate. Thus, project performance was delimited to those that met project goals and included by the researchers. Finally, limiting this study was sample size: based upon research goals, it was a small convenience sample, although, consisting of all GBs at this particular location accredited since 2009. Other limitations include the fact that all projects are DMAIC in methodology, completed by an individual leading a team while in GB training.

Question	Purpose
1. Is your project currently active, or has it been completed?	Determine demographic
2. Once the GB workshop training was complete, when did you complete the project?	Compare the observed proportion with the survey proportion
3. Was the focus of the project within your functional area?	Determine demographic
4. How closely did you follow your project timeline?	Project management abilities
5. What type of roadblocks did you encounter? (Please select all that apply)	Identify the critical success factors
6. Was completing GB accreditation on your PDR?	Determine demographic
7. Select the main reason for starting the GB accreditation process	Is the subject directed or driven?
8. How would you describe the BB coach's engagement on your project?	Coaching engagement into project
9. How would you describe the Sponsor's engagement on your project?	Leadership engagement into project
10. How can we improve the GB accreditation process?	Gather feedback, textual analysis

Table II.
Survey questions and purpose

4. Data collection and analysis

4.1 Reliability and validity

Reliability and validity of the GB survey were validated through "goodness of data" and by tests of validity and reliability. Validity establishes how well a technique, instrument or process measures a particular concept, and reliability indicates how stably and consistently the instrument taps the variable (Sekaran and Bougie, 2009). Cronbach's alpha is a reliability coefficient that indicates how well the items in a set are positively correlated to one another. Cronbach's alpha is computed in terms of the average intercorrelations among the items measuring the concept (Sekaran and Bougie, 2009, p. 324). The closer Cronbach's alpha is to 1, the higher the internal consistency reliability (UCLA, 2007). The results here demonstrate that Cronbach's alpha = 0.4396; however, although this value is low, it is acceptable due to Cronbach's alpha sensitivity to the number of items in a survey, as in this survey, and may underestimate the internal consistency reliability (Hair *et al.*, 2014).

4.2 Survey results

According to Sekaran and Bougie (2009), the sample must be representative of the population for it to provide useful and accurate answers to the research questions. Of company-accredited GBs, approximately 55 per cent of GBs had active projects. Of those, GBs with completed projects, over 33 per cent took six months or more to complete. To verify results, 24 per cent of respondents completed projects on time or sooner according the scheduled timeline on the original charter. Concerning the nature of GB SS projects, 97 per cent of respondents focused on projects within their personal, functional area.

Survey responses from company GBs were categorized according to company CSFs. From the expert internal review, the factors of leadership, project management and project selection were noted as most critical to understand with regard to barriers that company GBs and related to the CSF categories previously. The results of the survey note the frequency of GB barriers categorized by CSFs below (Table III).

The largest roadblock noted by GBs was "Priorities". The term "Priorities" was defined as: precedence, established by order of importance or urgency. "Time Constraints" was the second highest response and similar to "Priorities". The next three responses scored the same percentage (15 per cent): "Team Involvement", "Data Availability" and "Process Owners". "Planning" and "Project Scope" both had 11 per cent, and "SS Tools" and "Other" had 7 per cent. A chi-square test was performed to determine if a difference between the proportions of survey responses for Question 5 existed.

Survey responses	Leadership	Project selection	Project management	% of respondents
Priorities	×	×		59
Time constraints	×		×	41
Team involvement			×	15
Data availability		×	×	15
Process owners	×	×		15
Planning			×	11
Project scope		×		11
Other	×	×	×	7
Six Sigma tools		×	×	7

Table III.
Project roadblocks through CSF perspective

A chi-square test was performed to determine if a difference between the proportions of survey responses for Question 5 existed which are noted in Figure 1:

H0. There is no difference between the proportions of survey responses for Question 5.

H1. There is a difference between the proportions of survey responses for Question 5.

With a p-value < 0.05 (0.000), a significant difference exists between the CSF roadblocks identified by the subjects. A comparison of the contribution to chi-square is in Figure 2 below.

The top two contributors to the chi-square value were "Priorities" and "Time Constraints". The third, "Six Sigma Tools" had the least amount of responses but scored significantly because it was statistically significant with regard to expected count. The following observations come from the survey data noted below:

Category	Test Observed	Contribution Proportion	Expected to	Chi-Sq
Data Availability	4	0.111111	5.55556	0.4356
Planning	3	0.111111	5.55556	1.1756
Priorities	16	0.111111	5.55556	19.6356
Project Scope	3	0.111111	5.55556	1.1756
Team Involvement	4	0.111111	5.55556	0.4356
Process Owners	4	0.111111	5.55556	0.4356
Time Constraints	11	0.111111	5.55556	5.3356
Six Sigma Tools	2	0.111111	5.55556	2.2756
Other	3	0.111111	5.55556	1.1756

N	DF	Chi-Sq	P-Value
50	8	32.08	0.000

Figure 1.
Chi-square goodness-of-fit test for Question 5

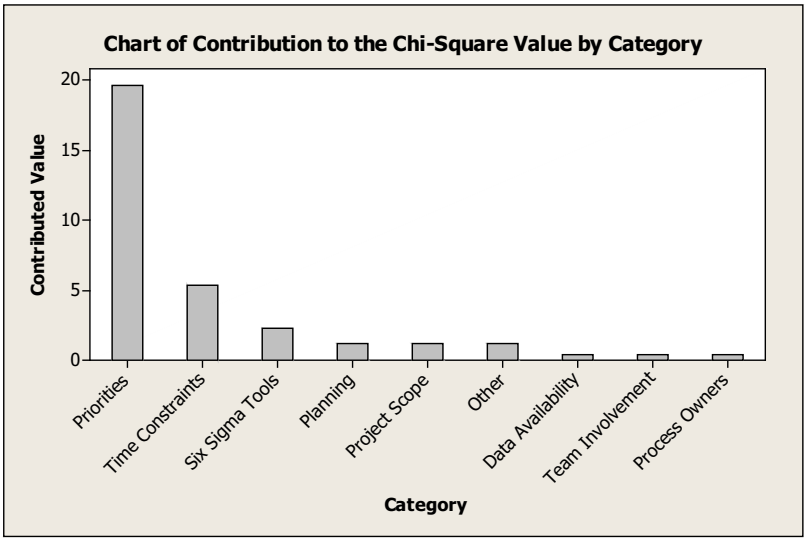

Figure 2.
Chi-square contributors to CSF barriers

- Subjects that have completed projects with a project duration of 6+ months, responded to Question 5 (roadblocks) that "Priorities" were a barrier the most frequently at 71 per cent.
- Subjects that had completed projects and were told by their manager to become accredited responded to Question 5 (roadblocks) with "Priorities" as a barrier at 80 per cent.
- Subjects that completed the project 30+ days to the timeline, 70 per cent responded to Question 5 (roadblocks) with "Priorities" as the main barrier.

Priorities was the most frequently cited roadblock across all demographics. Barriers signal that time management and priorities from local manager were a major concern.

4.3 Qualitative results

Qualitative data are data in the form of words (Sekaran and Bougie, 2009). The analysis of qualitative data aimed to make valid conclusions from comments, recordings, transcripts or answers from open-ended questions in a survey for validation (Miles and Huberman, 1994). Triangulation is a technique that is also often associated with reliability and validity in qualitative research (Sekaran and Bougie, 2009). The data collected from the open-ended question and performed by the research team at several different times throughout the months of January and February in 2013. The study survey contained one open-ended question: How can we improve the Green Belt accreditation process? Of the 29 subjects, 18 responded to the question with a 62 per cent response rate. The research team reviewed and categorized all of the responses to the question into three major themes: Time, Improvement and Leadership. A complete division may be found in Appendix 2. The theme of "time" was the most frequently mentioned barrier outside of "project(s)", and a constraint on the GB accreditation process. The next highest frequently mentioned theme, "make", suggests improvements to the process were recommended.

5. Discussion

Project management is a critical skill for every business, function and individual. SS GBs need to consider basic elements of time, cost and quality with regard to project management, and these elements will support SS teams with scope, aim and resources (Coronado and Antony, 2002). Success in SS projects is well defined through the literature, especially with regard to inputs such as project selection, project leadership and management. This study is in line with previous research as defining SS projects through leadership, project management and project selection. Fewer studies focus on the process of executing SS projects; little is stated concerning GBs, those individuals serving the vast middle of SS implementation between full-time SS personnel and the functional operators. Recent literature stated that a weakness of SS is that as a top-down management approach, it requires sustained and long-term commitment to achieve success (Antony, 2011).

The sustainability aspect is crucial in this study, as top management needs to provide the planning and control through an SS project, not just in selecting the proper project ingredients. The results above show that GBs' greatest barrier to timely project completion is priorities of personnel. As part-time practitioners, this study demonstrates that GBs' understanding how to personally manage time on SS projects require upper-level support and understanding of personnel duties at a strategic level. Regular communication between the SS and regular business functions should support GB success, especially important, as

GBs conduct SS in an occasional manner, juggling multiple priorities. Without more inclusive personal direction, a whim may drive GBs' project work and extend duration.

In this study, the results demonstrate that projects are scoped and defined without proper knowledge of timeline utilizing basic project management techniques. Beginning with charters or baselines are assumptions based upon previous work, or guesses, and do not incorporate basic project management concepts such as sufficient slack time (Lambrechts *et al.*, 2011). GBs in this study note that constraints on time are significant factors influencing project timeliness. For the majority of projects in this study, GBs and their team members had a strong motivation to complete projects and took only optimistic accounts of project duration, creating aggressive timelines. GBs in this study noted that time constraints, rather than proper project planning, such as optimistic and pessimistic durations, accounted in the duration. As GB projects progress, roadblocks start to occur with data collection or determining a root cause and the attention to the project timeliness begins to diminish. Defined at the project start, these time constraints become more limiting due to the arbitrary nature of the planned timeline. Establishing an initial, rational timeline is critical, and previous literature notes that it requires team commitment, clear leadership and lessons learned to be incorporated into calculating accurate project timelines. However, from this study, historical data should be used with caution as the project durations varied widely, making accurate time estimates of future projects based upon similar projects difficult. In addition, GBs noted that teamwork, data availability and SS tools were all factors contributing to a lengthy project duration. GBs noted that teamwork, more precisely, team commitment through time contribution as a significant factor: GBs leading more involved teams noted more project timeliness, in line with previous literature. Also note, previously, especially in the area of GBs, there was the availability of data; teams that had ready data were more efficient where collection of accurate data is a time-consuming activity (Green, 2006). Finally, analysis of results show that GBs felt that requiring the same tools, regardless of the nature of the project they were leading, was onerous. This is similar to previous work where the heavy commitment to the SS DMAIC process reduces its effectiveness (Antony, 2011).

6. Conclusions and recommendations

This study was conducted to understand GB project barriers through a CSF framework. The significant factors that contributed to a lack of GB timely project completion were categorized by: project selection, project management and leadership. The primary factors noted by GBs themselves were priorities, time constraints and SS tools. Top management understanding of SS strengths and weaknesses should support the nature of SS projects and be included in initial selection and design, especially as SS spreads across the enterprise and project applications become more diverse, even with GBs working on SS within their functional areas, as demonstrated here, requiring attention to the problem statement, scope and goals at project selection and not relying as heavily on GB process knowledge. As in previous work, the GBs included in this study were experienced and educated in their chosen area of expertise but note that a barrier to completion noted was SS tools. This also means that the individuals who become GBs (or BBs) need more than the technical competence to be successful in their role in SS implementation.

While GBs described the prescriptive nature of DMAIC, a lack of applying project management was noted by GBs. This organization, like many others, outsources GB training. This curriculum is predominately online. A review or insourcing GB training could

support better project management and leadership in SS to support GB time constraints. GBs have strong motivations to successfully complete projects and may exhibit a strong start. But as the time progresses, barriers start to occur and attention to the project timeliness diminishes to meet projected goals. The inclusion of established project management principles in GB training to support all overall project management principles (scope, time and budget) is important, and it requires commitment and acceptance from both project and functional leadership to support GB priorities, both in temporary (SS) and functional duties.

Due to the nature of GB work, priorities between SS and functional duties may become an issue without proper project planning and control. After initial gate review, GBs often interact with their functional managers and their SS coach or trainers. Of these competing commitments, prioritization of duties may result in SS work being subsumed by regular job duties. Governance at the strategic level between functional managers and SS personnel could minimize confusion as to competing commitments. Better coordination of a GBs time between SS personnel and functional managers, and better management of SS projects, such as project portfolio management, is encouraged. But this means that top management must lead beyond strategic levels to operations transparent to all employees.

To lead with SS means going beyond lip service. Top management plays an active role in not only introducing SS but also demonstrating a visible role for all employees to see. The "sense-making" of the professional roles within the SS framework increases; a principle of a learning organization (Senge, 1990). To support organizational learning, top management should review projects regularly to understand project progression and fulfill the role of leading SS efforts. Frequent interaction between the GBs and top management is encouraged. Without understanding, the roles that upper management plays in supporting SS efforts is limited: while GBs (and BBs) follow a strong roadmap (DMAIC), top management often does not have standardized work at the strategic level that follows best practices. Use of CSFs to actively management SS projects, in addition to implementing SS strategy, may prove useful.

A majority of SS inquiry is based upon industrial research. This study is based upon a single manufacturer with strong engineering knowledge. Expanding upon this case to other industries with GBs would improve the general impact. This study indicates that there is further research potential into project management and SS. While there has been much research on CSFs and projects, especially with regard to selection, the use of CSFs to evaluate the SS project management through top management of SS has potential. In addition, the methods and practice of teaching and learning SS in the industrial environment became evident but was not explored. Research in this area holds promise. While the organization under study contains strong functional knowledge in its employees, SS tools remained a barrier; recent developments with regard to maturity models should be explored.

GBs play an important function in SS success. They provide the critical mass to support the widespread change needed. Without GBs, there are too few personnel, operating as BBs, to have a broader impact. SS is an expensive endeavor and the training and application of BB projects takes much investment. However, with effective GBs conducting projects, an organization may improve the payback of such efforts and improve SS application to a wider spectrum of organizations, especially among the vast number of enterprises that have the will, but not the resources to take full advantage of SS benefits.

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Appendix 1. Survey questions

1. Is your project currently active, or has it been completed?

- ◯ Currently active
- ◯ Completed

2. Once the GB workshop training was complete, when did you complete the project?

- ◯ 1-3 months
- ◯ 3-6 months
- ◯ 6-9 months
- ◯ 12+ months
- ◯ N/A (Project is not complete)

3. Was the focus of the project within your functional area?

- ◯ Yes
- ◯ No

4. How closely did you follow your project timeline?

- ◯ Completed project faster than timeline
- ◯ Completed project per the timeline
- ◯ Completed project within 30 days after timeline
- ◯ Completed project 30+ days after timeline

5. What type of roadblocks did you encounter? (Please select all that apply)

- ☐ Data Availability
- ☐ Planning
- ☐ Prioirities
- ☐ Project Scope
- ☐ Team Involvement
- ☐ Process Owners
- ☐ Time Constraints
- ☐ Six Sigma Tools
- ☐ NONE

Other (please specify)

6. Was completing Green Belt accreditation on your PDR?

- ◯ Yes
- ◯ No

7. Select the main reason for starting the Green Belt accreditation process.

- ◯ Development reasons
- ◯ My manager told me
- ◯ I like challenges
- ◯ Separator for promotion
- ◯ Other (please specify)

8. How would you describe the BB coach's engagement on your project?

- ◯ Level of support accelerated project
- ◯ Level of support did not affect project
- ◯ Level of support hindered project

9. How would you describe the Sponsor's engagement on your project?

- ◯ Level of support accelerated project
- ◯ Level of support did not affect project
- ◯ Level of support hindered project

10. How can we improve the Green Belt accreditation process?

Appendix 2. Qualitative results

Category	Sub category	Comment
Time	Time management, priorities	Nothing the GB team can do. It was just a matter of finding quality time to devote to the project. I was not prepared for the extended amounts of time I would need to dedicate to complete the project and had to work hard to dedicate
	Time management, priorities	Consider a required separation from day-to-day business (perhaps physical separation) that would allow for regularly scheduled time for Green Belt activities. Day-to-day business requirements easily and often receive higher priority than Green Belt projects. Formalizing time away could be very effective towards ensuring timely completion
	Time management, priorities	GB candidates seem to be shying away from the efforts involved with getting certified due to the added time constraints/ expectations. We ought to ensure at least some part of a work week to the candidates (and support teams) to execute the improvement efforts
	Time management, priorities	Provide more pressure to meet the project timeline and force projects to be small
	Non-value-added activity	How can I get rid of my GB certification
	Non-value-added activity	Get rid of the entire thing, the amount of money wasted by me spending time on the GB project and not on my actual job is insane. Class for a week, 60 hours of training online, then the test, then working on the project itself. Over 1 1/2 months of actual work time has been dedicated to the project, and it is not finished. To be honest, it is finished, just spending hours upon hours working on the paperwork to get it accredited. Complete waste of money, and I will NOT be doing another project, I don't have
	Non-value-added activity	My first GB project was meaningful and still useful, my second GB project (In my opinion was a waste of time) had to be completed because of the mandatory requirement to complete a project once a year. I feel that these types of time and money consuming projects should only be assigned as needed
	Non-value-added activity	Don't require them. If the company is serious about changing the culture and changing the way people view there job's and the role we all play in continuous improvement then push yellow belts as an active requirement for their day-to-day activities. It is a hindrance to improvement to use such a cumbersome process that requires special funding, a dedicated team, and a significant time investment that takes employees away from their jobs and ultimately thier families. Make it simple and make it part of the job. We should all be thinking about how we make our jobs better everyday and GB just doesn't help that
Improvements	Budget	Aid the GB applicant in establishing a budget within
	Budget	Dedicated budget for these, so don't need to scratch around
	Improve class material	The book that we get from class of all the class material was impossible to go back and reference later. I couldn't find anything. Doing it in the DMAIC order and adding tabs would be helpful. Otherwise, it is wasted printed paper
	Improve the process	Streamline the gated review process. Should complete this electronically to avoid delays, wasted time waiting for personal schedules to align. Documentation requirements seem excessive. IPP workbooks, Excel files, seemed redundant. Perhaps final approver can approve each project phase just after reviews rather than waiting to the end of the project to grant

(*continued*)

Table AI. Qualitative results

Category	Sub category	Comment
	Improve the toolset	Streamline the toolset (decision tree on what tools to use in specific cases) and make clear that the sponsor has to be engaged
	Project selection	This may already be in place but if not [. . .] Generate a pool of corporate GB projects which people can take on as projects. It can be difficult to identify suitable projects when working at deployed sites and getting buy-in from the customer
Leadership	Governance meeting	Perhaps having some sessions at the end of the year to go over some GB projects would be beneficial for read across
	Leadership	I would like to see the senior leadership engage in more substantive projects. I've noticed that project complexity (and benefit) seems to be inversely proportion to rank in the company. Very senior folks are doing GB projects that feel more like YB projects (e.g. 5S, L: drive cleanup, etc). For Belt skills to be taken more seriously, we really need the seniors to be taking on major, transformational projects using the GB tools. In my view, projects like our re-orgs should be addressed using Belt tools, rather than by the seat of the pants

Table AI.