

## A framework for effective Six Sigma implementation

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In this paper, we introduce a framework for implementing Six Sigma. We utilise the PDCA cycle (Plan-Do-Check-Act) to operationalise Six Sigma implementation. By defining Six Sigma as projects aimed at achieving specific goals, we address the importance of executive commitment and the role of Black Belts in effective implementation of Six Sigma projects. In addition we link implementation of Six Sigma with quality management and the PDCA cycle. Several propositions have been developed and key areas of research have been identified.

**Keywords:** Six Sigma; PDCA; quality management; process improvement

### Introduction

As competition gets more intense, customers demand higher quality products and/or services organisations look for ways to improve their operational performance to address customer expectations (Hammer, 2002). In the pursuit of improved operational performance and higher customer satisfaction, Six Sigma has been recognised as a systematic and structured methodology that attempts to improve process capability through focusing on customer needs (Dasgupta, 2003; Harry, 1998; Linderman, Schroeder, Zaheer, Choo, 2003). It has been described as an approach for organisational change, which incorporates elements of quality management and business process re-engineering (Quinn, 2003).

There has been a significant increase in the application of Six Sigma in industry over the past decade. According to Hoerl (1998) GE's operating margins increased from 13.8% to 14.5%, an increase valued at about \$600 million, which stemmed from Six Sigma quality initiatives. In 2002, at least 25% of Fortune 200 companies claimed they have the Six Sigma programme (Hammer, 2002). By focusing on customer needs and defining quantifiable measures for achieving specific goals, Six Sigma projects result in greater customer satisfaction, and enhance organisational performance and profitability (Blakeslee, 1999; Goh, Low, Tsui, & Xie, 2003; Harry, 1998; Kondo, 2001).

The implementation of Six Sigma has produced mixed results. While companies such as GE and Motorola report huge savings from their Six Sigma initiatives (Pande, Neuman, & Cavanagh, 2000) critics of Six Sigma argue that many quality-based initiatives (such as Six Sigma) will fail because of the intense business competitiveness (Stebbins & Shani, 2002). As organisations are looking towards Six Sigma programmes, there is a need to address the issue of effective implementation of Six Sigma projects. We believe

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developing a framework for Six Sigma implementation will help scholars and practitioners to gain insight into effective implementation of Six Sigma projects. It also helps organisations to effectively utilise their resources so that they can benefit from their Six Sigma initiatives.

The purpose of this paper is to present a framework for implementation of Six Sigma projects. We will begin by defining Six Sigma methodology using DMAIC or DMADV which are popular frameworks for Six Sigma projects (Breyfogle, 2003; Pyzdek, 2003). We will utilise the PDCA cycle to relate Six Sigma initiatives to process improvement. We identify key variables that affect successful implementation of Six Sigma. In reference to the organisational context, we identify factors that are crucial in effective implementation of Six Sigma. We believe the proposed framework can be used as a guideline for further research in implementing Six Sigma while helping organisations to oversee their Six Sigma programmes.

### Six Sigma methodology

According to Feld and Stone (2002) Six Sigma is a data-driven philosophy used to drive management decisions and actions across an organisation. Caulcutt (2001) indicates that Six Sigma reduces waste, increases customer satisfaction and improves processes with a considerable focus on financially measurable results. For the purpose of this paper, Six Sigma is defined as a set of methodologies and techniques used to improve quality and reduce cost utilising a structured and disciplined methodology for solving business problems. Our definition is consistent with that of Hammer (2002).

A popular framework for implementing a Six Sigma methodology is the DMAIC process. DMAIC, or Define, Measure, Analyse, Improve and Control are key processes of a standard framework for a Six Sigma project and are shown below in Figure 1.

According to Jing and Li (2004) the psychology of this approach is that key process input variables are narrowed down to a vital few with the idea that having control of the vital few will allow for good control of the whole process. DMAIC is widely used when a product or process is already in existence but performing inadequately. DMAIC focuses on eliminating unproductive steps, developing and applying new metrics, and using technology to drive improvement (De Feo & Barnard, 2004). Another popular approach associated with Six Sigma projects, DMADV or Define, Measure, Analyse, Design and Verify is used for developing new products/services (Figure 2). While the focus of DMAIC is on eliminating waste and improving an existing process, DMADV is primarily utilised to develop new products/services.

Six Sigma has a strategic component aimed at not only developing commitment to it, but also active involvement of higher management (Snee, 2000). That strategic component is the responsibility of management to identify key processes of their organisation,



Figure 1. DMAIC framework.



Figure 2. DMADV framework.

measure their effectiveness and efficiency, and initiate improvements of the worst performing processes. It is suggested that firms should implement their Six Sigma initiatives via integrating them with their business strategy (Cheng, 2007).

### Literature review

As evidenced by Linderman et al. (2003) academic research in Six Sigma is lagging behind its practice in the industry. While empirical research is needed to fill the gap between the theory and practice of Six Sigma few studies have been carried out to understand the effective implementation of Six Sigma projects.

Most studies on Six Sigma have been primarily focused on anecdotal evidence and case studies. Academic research on Six Sigma has been accelerated in recent years (Linderman et al., 2003; McAdam & Lafferty, 2004; Schroeder, Linderman, Liedtke, & Choo, 2008). McAdam and Lafferty (2004) argue that successful implementation of Six Sigma requires attention to both process perspective (methodology) and people perspective (behaviour). While early research on Six Sigma has been focused on the technical side of Six Sigma in terms of tools, techniques and methodologies, recent studies have paid attention to the psychological, contextual and human side of Six Sigma such as reward systems for Six Sigma (Buch & Tolentino, 2006), goal setting (Linderman, Schroeder, & Choo, 2006), organisational context (Choo, Lindermann, & Schroeder, 2007a) and psychological safety (Choo, Lindermann, & Schroeder, 2007b). Six Sigma has been traditionally focused on cost reduction and efficiency; however, recent studies show that it could be used as a methodology to increase profitability (Sodhi & Sodhi, 2005), and it could drive creativity (Biedry, 2001), enhance organisational learning (Wiklund & Wiklund, 2002) and facilitate innovation (Byrne, Lubowe, & Blitz, 2007). In terms of performance variation, the human side of Six Sigma exhibits the highest level of variation between different groups in a company (Fleming, Coffman, & Harter, 2005). In addition, it requires top management commitment, a highly disciplined approach and training (Hahn, Doganaksoy, & Hoerl, 2000).

Different theoretical frameworks have been used to understand Six Sigma implementation. Building upon goal theory literature, Linderman et al. (2003) address the role of specifying challenging goals for Six Sigma projects, where Six Sigma projects with challenging goals result in a greater magnitude of performance. They also indicate that the use of a structured method (in Six Sigma projects) increases performance. In another study, Linderman et al. (2006) empirically show that goals can be effective when Six Sigma projects employ Six Sigma tools and methods. However, specifying unrealistic and very challenging goals is counterproductive, resulting in frustration and lack of motivation for team members.

From a knowledge management perspective, Choo et al. (2007a) develop a knowledge-based framework for Six Sigma projects. By focusing on two complementary sources of knowledge creation in Six Sigma projects – prescribed methodology and organisational context – they argue that Six Sigma projects that can maintain a balance between the effective implementation of prescribed methodology (e.g. tools and techniques such as quality control) and context (e.g. leadership, organisational culture and Black Belt roles) can generate higher levels of knowledge. To the extent that organisations can manage such a balance, a sustainable quality advantage will be achieved.

With reference to Six Sigma implementation as a structured and systematic process improvement methodology, little has been said on the design and structure of Six Sigma projects. While companies implement Six Sigma in a variety of ways, it is important to determine how much of those efforts are done in a systematic and structured way.

According to Mader (2002) structured application of tools and techniques increases the rate of success in process improvement. Standardisation of methodologies reduces variability in the processes so it is crucial for organisations to implement Six Sigma in a structured and systematic way so that they can benefit the most from their efforts (Choo et al., 2007a). It is important to note that the success of any quality improvement project (including Six Sigma) requires the coexistence of both attention to detail and innovation (Naveh & Erez, 2004). While a structured method (such as PDCA) facilitates attention to detail, contextual variables such as the role of Black Belts and executive commitment are the key in providing a culture of innovation.

Previous research on Six Sigma has paid little attention to the role of Black Belts in Six Sigma projects and how they can facilitate successful implementation of Six Sigma. Linderman et al. (2003) argue that improvement specialists such as Black Belts serve as role models for Six Sigma improvement projects where their effective involvement increases the success of Six Sigma projects.

To address the above shortcomings in the literature, we have employed the Plan-Do-Check-Act (PDCA) framework to relate Six Sigma implementation to process improvement. The steps in Six Sigma projects (DMAIC or DMADV) are similar to PDCA (Choo et al., 2007a; Shewhart, 1931, 1939). The PDCA cycle is a well-established framework for process improvement where it focuses on continuous learning and knowledge creation (Deming, 1993), which is the key in the success of any quality improvement initiative (Karlsson & Sandvik Wiklund, 1997; Wiklund & Wiklund, 2002). While companies may use different terminologies for their Six Sigma projects, by adhering to a unified and well-established framework such as PDCA we attempt to integrate Six Sigma projects under the PDCA cycle. We believe framing Six Sigma projects within a PDCA cycle provides a more comprehensive view of Six Sigma implementation in organisations.

### **Development of constructs and their relationships**

Eight constructs have been defined for Six Sigma implementation. The constructs have been developed based on the review of the literature (Breyfogle, 2003; Pyzdek, 2003) along with other constructs developed by the researchers after observing several Six Sigma organisations. These constructs investigate variations in implementing Six Sigma. Choo et al. (2007a) argue that the quality of improvement projects is affected by both methods and psychological variables. In another study the effect of contextual variables on Six Sigma implementation has been addressed (Choo et al., 2007b). Our instrument addresses both the methods aspect of Six Sigma as well as the financial and organisational aspect. The following is a list of the constructs along with a brief description of each.

- (1) *Black Belt roles*: Black Belts are used differently across organisations. The purpose of this construct is to measure the degree to which the roles of Black Belts are dedicated to Six Sigma or if they have to split their time between their Six Sigma responsibilities and other day-to-day management activities. The role of Black Belts in effective implementation of Six Sigma projects has been addressed in previous studies (Choo et al., 2007a; Hammer, 2002; Linderman et al., 2003). Black Belts bridge the gap between the top management and Six Sigma project team (Schroeder et al., 2008).
- (2) *DMAIC v. DMADV*: These two Six Sigma processes are designed to be used for specific types of projects. The purpose of this construct is to measure whether they are used according to their intention as recommended by Breyfogle (2003).

- (3) *Plan:* Deming (1986) describes how quality projects are managed in the following process; Plan, Do, Check, Act. It is sometimes referred to as a PDCA cycle (Arveson, 1998). For both DMAIC and DMADV, this is the 'define' step. This construct contains the first steps to start a project such as project selection, project planning, and project scope and metrics. The purpose of this construct is to compare how organisations actually start projects with how DMAIC and DMADV recommend starting projects (Breyfogle, 2003; Pyzdek, 2003).
- (4) *Do:* The purpose of this construct is to measure how companies perform the second step in the PDCA cycle. For both DMAIC and DMAVD this is the 'measure' stage in the Six Sigma process. Experiments and tests are performed to evaluate current performance and improvements on a project. Examples of these tools are design of experiments (DOE) and failure modes and effect analysis (FMEA) (Breyfogle, 2003).
- (5) *Check:* The purpose of this construct is to measure the third step in the PDCA cycle to see if the new ideas will perform as expected. Both DMAIC and DMADV have 'analyse' as the third step. The purpose of this construct is to determine whether the organisations check the data with statistical tools to determine which sources of variation are critical to the process. Another purpose is to determine whether judgements are made on the data before the statistical analyses are performed.
- (6) *Act:* The purpose of this construct is to measure the last step in the PDCA cycle which encompasses the last two steps in the Six Sigma processes. Although they are different in nature the last two steps are used to set and implement plans to make sure that the changes or new ideas are successful.
- (7) *Financial responsibility:* The purpose of this construct is to measure how leaders of the project are held accountable for the reported benefits as well as the benefits to the leaders when the project goes well.
- (8) *Executive support:* The purpose of this construct is to measure how involved the executives are with the projects. The role of executives in supporting Six Sigma projects has been addressed in the literature (Byrne et al., 2007; Linderman et al., 2006; Schroeder et al., 2008). Executives not only need to support Six Sigma projects in terms of providing resources and their commitment but they also need to make a balance between Six Sigma projects and operational activities of the firm. It is believed that the balance between innovation projects (such as Six Sigma) and the operational activities of company is the key to the success of the firm (Gottfredson & Aspinall, 2005).

The above constructs capture both the methodological elements (e.g. PDCA) and the context element (e.g. executive commitment) of Six Sigma projects. From the knowledge-based view of quality improvement, creation of knowledge in Six Sigma projects requires the coexistence of both methodological and context elements (Choo et al., 2007a). Accordingly, we believe the variables and the proposed framework are capable of addressing both aspects of knowledge creation in Six Sigma projects.

### **The conceptual model for Six Sigma implementation**

Figure 3 shows the conceptual framework for Six Sigma implementation. The proposed framework for Six Sigma implementation has been developed with reference to both the contextual elements (e.g. leadership) and the methodological techniques (e.g.

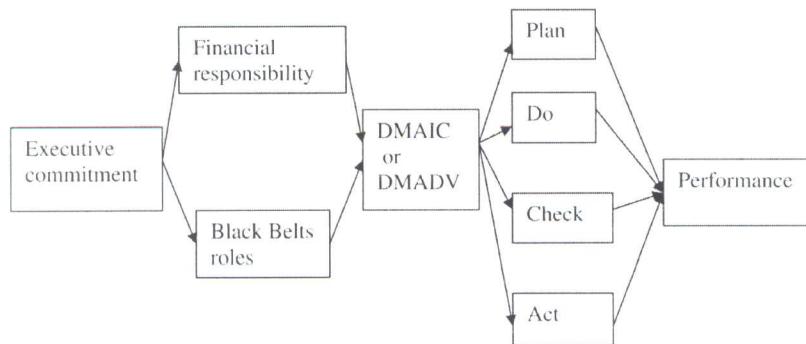


Figure 3. Conceptual framework for Six Sigma implementation.

PDCA). In terms of the contextual variables, it has been argued that the existence of a clear vision about Six Sigma projects is the key to the success of Six Sigma initiatives, where by relating these improvement projects to the business strategy management can enhance the effectiveness of Six Sigma projects (Larson, 2003).

It should be noted that the role of executive support for Six Sigma projects is facilitated by Black Belts, where Black Belts are champions (or improvement specialists) that direct and manage Six Sigma initiatives (Schroeder et al., 2008). While top management is not directly involved in Six Sigma implementation, it is believed that through supporting and empowering Black Belts top management can accelerate the progress of Six Sigma implementation. Accordingly, we hypothesise that:

$H_1a$ : Executive support significantly affects the role of Black Belts in Six Sigma implementation.

The availability of the resources for Six Sigma projects is a key in the success of such initiatives (Choo et al., 2007a). It is a driving force for creativity and innovation for those who need to use resources for any improvement projects (Amabile & Gryskiewicz, 1987). Executives not only need to provide adequate resources for Six Sigma projects but they also need to empower Six Sigma project team members to take responsibility for the initiative. From the goal theory perspective specifying monetary goals (cost saving or revenue) motivates team members to achieve the desired outcome (Linderman et al., 2003). Accordingly, empowering Six Sigma project team members enables them to take necessary actions so that they can meet the goals. In that regard, the executive team needs to empower Six Sigma team members while making them financially responsible for their actions and/or decisions regarding Six Sigma projects. Therefore we hypothesise that:

$H_1b$ : Executive support significantly affects the financial responsibility of team members in Six Sigma implementation.

It has been argued that the success of Six Sigma projects requires utilising specific tools and techniques (Choo et al., 2007a). Team members should be empowered to select the best methodology for dealing with Six Sigma projects. On the other hand, the autonomy of (Six Sigma) team members in making appropriate decisions in Six Sigma projects encourages them to select the best methodology for their process improvement initiative. If Six Sigma team members are held accountable financially, they will be motivated to utilise the appropriate methodology for their project. Accordingly, we hypothesise that:

$P_2$ : Financial responsibility of Six Sigma team members positively affects the selection of the appropriate methodology (DMAIC or DMADV).

Taking into account that Black Belts are the champions that lead Six Sigma initiatives who have extensive training and knowledge in process improvement tools and techniques (Schroeder et al., 2008), it is apparent that they can influence the selection of the appropriate methodology for Six Sigma projects. Therefore, we hypothesise that:

$P_3$ : The role of Black Belts positively affects the selection of the appropriate methodology (DMAIC or DMADV).

Six Sigma is a structured methodology that attempts to achieve specific performance goals using statistical tools and techniques. Six Sigma is a systematic process where its success is contingent upon the existence and utilisation of a disciplined approach towards process improvement (Choo et al., 2007a, 2007b; Linderman et al., 2006). Since Six Sigma originated from the quality management field (Linderman et al., 2003; Schroeder et al., 2008) organisations can benefit from their Six Sigma initiatives if they frame it within the quality improvement paradigm. The Plan-Do-Check-Act (PDCA) cycle is well established within quality management (Choo et al., 2007a; Deming, 1986; Shewhart, 1931, 1939). While firms have the option to use any framework such as DMAIC or DMADV for their Six Sigma initiative, the selection of these initiatives has a significant effect on planning, managing and organising their process improvement efforts. In other words, to integrate Six Sigma projects within the quality improvement programmes, firms should align their Six Sigma initiatives with the PDCA process cycle because of the link between Six Sigma and process improvement, and PDCA. Regardless of the particular Six Sigma methodology utilised by the firm (either DMAIC or DMADV) the effectiveness of Six Sigma projects is contingent upon integrating them with the PDCA cycle. In that regard, if organisations fail to effectively define their Six Sigma methodology (i.e. DMAIC or DMADV) this will result in failure in the PDCA cycle while selection of the appropriate methodology facilitates the sequence of activities that need to be performed to improve quality. Therefore, we hypothesise that:

$P_{4a}$ : The selection of the appropriate methodology (DMAIC or DMADV) has a significant effect on the Plan phase of the PDCA cycle.

$P_{4b}$ : The selection of the appropriate methodology (DMAIC or DMADV) has a significant effect on the Do phase of the PDCA cycle.

$P_{4c}$ : The selection of the appropriate methodology (DMAIC or DMADV) has a significant effect on the Check phase of the PDCA cycle.

$P_{4d}$ : The selection of the appropriate methodology (DMAIC or DMADV) has a significant effect on the Act phase of the PDCA cycle.

It is believed that process improvement initiatives do not provide the desired results unless they are framed within a systematic process improvement structure. Elements such as vision, skills, resources, action plans and incentives are necessary in effective Six Sigma implementation (Larson, 2003). The lack or deficiency in any stages of the process improvement will have a negative effect on the desired outcome of the project. In the context of Six Sigma projects within the PDCA cycle, different phases of the PDCA cycle influence the outcome of the projects. Therefore, we propose that:

$P_5$ : The Plan phase in the PDCA cycle has a significant effect on the performance of Six Sigma projects.

$P_6$ : The Do phase in the PDCA cycle has a significant effect on the performance of Six Sigma projects.

$P_7$ : The Check phase in the PDCA cycle has a significant effect on the performance of Six Sigma projects.

$P_8$ : The Act phase in the PDCA cycle has a significant effect on the performance of Six Sigma projects.

The proposed framework for Six Sigma implementation takes into account both the methodological aspect of Six Sigma as well as the organisational and contextual variables. In addition, it has the advantage of relating Six Sigma projects to the quality programmes in an organisation, where it relates Six Sigma initiatives to the PDCA quality improvement cycle.

As indicated by Sinha and van de Ven (2005) understanding Six Sigma concerns the integration of both the micro and macro level of analysis within a firm. The success of Six Sigma projects requires multiple level understanding within an organisation – a concept that is referred to it as Meso theory in organisational design (Daft, 2001). In that regard, the proposed framework is capable of addressing both the macro (i.e. executive commitment) and micro (e.g. PDCA cycle) level of analysis within a firm.

### Summary

The main purpose of this paper was to develop a framework for effective Six Sigma implementation. Building upon previous studies in Six Sigma, we addressed the need for the utilisation of a structured methodology for Six Sigma implementation. We also asserted the need for addressing contextual variables (e.g. executive commitment) in Six Sigma. With reference to the above findings, we specifically recognised the role of Black Belts in Six Sigma as well as the financial responsibility of the Six Sigma team. That, we believe, is the key in effective Six Sigma implementation. Six Sigma team members need to be empowered while held financially responsible. Our proposed framework can help the executives and managers to look at their Six Sigma initiatives from a broader perspective, linking the organisational variables with the methodological approach to Six Sigma.

Further research is needed to operationalise the constructs we have proposed in this study and test them using empirical data. Evidence from the industry shows that Six Sigma can be implemented to improve the performance of supply chain projects (Yang, Choi, Park, Suh, & Chae, 2007). Therefore, future research needs to address the implementation of Six Sigma in a supply chain environment.

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