A Review of Six Sigma Implementation Frameworks and Related Literature

Kifayah Amar and Douglas Davis

***Abstract*—This paper presents a review of Six Sigma focusing on implementation frameworks/models in the literature. The work is a part of a research project aimed at developing a Lean Six Sigma implementation framework for Indonesian SMEs. Most implementation frameworks examined used the concept of critical success factors in their development. In this paper, the authors examine four implementation frameworks found in the literature from two perspectives. Firstly, from a critical success factor perspective and secondly from the perspective of Rogers' diffusion of innovations theory. None of the frameworks examined comprehensively address issues suggested by Rogers' diffusion of innovations theory. The most robust framework appears to be the one developed by Burton and Sams. Our research suggests a customized implementation framework needs to be designed for Indonesian SMEs based on Rogers' diffusion of innovations approach, but also drawing from literature on critical success factors.**

***Index Terms*—Implementation Frameworks, Innovation, Lean Six Sigma, SMEs**

I. INTRODUCTION

The research reported here is part of a project which aims to develop a framework for implementing Lean Six Sigma in Indonesian SMEs (Small and Medium Sized Enterprises). In particular, we review four Six Sigma implementation frameworks found in the literature.

These frameworks will be examined using two perspectives:

a) the critical success factors perspective and
b) from the broader perspective of Rogers' diffusion of innovations theory.

Six Sigma, like other approaches to business improvement e.g. TQM and ISO 9000, has a strong customer focus, and contains key concepts related to strategy, organisational change, training and setting stretch objectives [1]. The central idea of the Six Sigma approach is to design processes, or improve existing processes, to obtain very high process capability and hence defect rates that are close to zero.

Manuscript received January 15, 2008.

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The Six Sigma concept was first introduced by Motorola Company in the mid 1980s. Since its inception a number of variants on the original concept have been developed, often combining Six Sigma with ideas from other improvement approaches. Lean Six Sigma is one of variant of Six Sigma which integrates Six Sigma with Lean principles [2]. Lean Six Sigma is claimed to have some advantages over Six Sigma and is aimed at improving quality, reducing processing time and reducing production cost [3].

Six Sigma and Lean Six Sigma implementations are associated mainly with large manufacturing organizations. Lean Six Sigma use has however been growing in popularity in service and government sectors. However, the use of Six Sigma generally is still mostly in large organizations which have good resources and technology in place. This does not mean that Lean Six Sigma has no possibility to be implemented by small organizations. For example, TQM first became popular in large manufacturing organizations and subsequently was widely adopted in non-manufacturing organizations and by SMEs.

A systematic literature search was carried out to find publications on implementation frameworks for Lean Six Sigma and Six Sigma. Data bases of journals and dissertations were used in the search and an effort was made to locate specialist text on Six Sigma. Specialist journals in the area of Six Sigma and quality management were particularly targeted. No frameworks specifically for implementing Lean Six Sigma in SMEs were found. However, four less specific frameworks for the implementation of Six Sigma and Lean Six Sigma were found and these are examined below.

II. THEORETICAL BASE OF FRAMEWORK DEVELOPMENT

In this section, we discuss two approaches that useful for designing or critiquing Six Sigma implementation frameworks. These approaches are Critical Success Factors approach (CSFs) and the diffusion of innovations theory developed by Rogers.

A. Critical Success Factors (CSFs)

A common approach used in developing Six Sigma, Lean Six Sigma or other quality improvement framework is to identify factors/elements that are believed to be critical to the successful implementation of these concepts. For example, top management support is usually included on a

list of CSFs for an improvement initiative.

We found several studies on critical success factors related to the success of Six Sigma and Lean Six Sigma implementation [4], [5], [6], [7]. The studies are discussed below.

Coronado and Antony [4] empirically investigated critical success factors in UK SMEs in order to determine the implementation status of Six Sigma in that country. There were eleven CSFs identified in the study; these were: management involvement and commitment, cultural change, communication, organization infrastructure, training, linking Six Sigma to business strategy, linking Six Sigma to customer, linking Six Sigma to human resources, linking Six Sigma to suppliers, understanding tools and techniques within Six Sigma, project management skills, project prioritization and selection.

In their book, Burton and Sams [5] listed sixteen key requirements, which were said to be critical factors in implementing Six Sigma successfully. These are: establish recognition of the need, provide leadership commitment and support, develop Six Sigma strategy and a deployment plan, incorporate enterprise wide scope, mandate linkage to the business plan, make proper investment in resources, develop communication and awareness effort, focus on customer and results, structure around the organization's needs, implement regulated program management, build a teaming and employee involvement culture, manage controversy and confrontation, demand frequent measurement and feedback, implement a structured project closeout process, provide recognition and rewards and leverage successes and stay the course. They believe that these factors have to be in place in order to implement Six Sigma successfully, not just the DMAIC methodology and use of Six Sigma tools.

Hayes [7] identified that success of Six Sigma implementation is based on executive engagement, management involvement, communications, resources, projects, disciplines and consequences.

Furterer [6] mapped the success factors of Lean Six Sigma implementation based on her framework components (see Figure 4). Her success factors were developed mainly from the literature.

B. Diffusion of Innovation Theory

Rogers' diffusion of innovations theory, has been refined over many years and its application extended from focusing on adoption of new ideas by individuals to adoption of new ideas by organizations [8]. Consideration of the culture (e.g. at national, local, industry and individual levels) into which an innovation is introduced is a strong aspect of the theory. Rogers argues that to enable successful adoption innovations should be suitably modified when they are transferred from one cultural setting to another. Problematic innovation experienced in the past, including the diffusion of TQM in Indonesian SMEs seem to have lacked consideration of the cultural aspect. To support further discussion, Rogers' ideas on diffusion of innovation are listed and explained. According to Rogers [8] there are five main constructs that combine to determine the adoption success innovations:

1. Perceived attributes of the innovation:
   a) Relative advantage;
   b) Compatibility
   c) Complexity
   d) Trialability
   e) Observability

Relative advantage is "the degree to which an innovation is perceived as better than the idea supersedes" [8]. Compatibility focuses on how compatible an innovation is with social and cultural values and beliefs, previously introduced ideas or client needs for the innovation [8]. Complexity is "the degree to which an innovation is perceived as difficult to understand and use" [8]. Trialability is "the degree to which an innovation may be experimented with on a limited basis" [8]. Observability is "the degree to which the results of an innovation are visible to others" [8].

2. Type of innovation decisions
   a) Individual-Optional
   b) Collective
   c) Authority

This typology is based on who makes decisions to adopt an innovation; individuals, members of the system and people who have power and status, etc. It is important to identify and understand these decision makers.

3. Communication channels e.g. mass media or interpersonal

These are "the means by which messages get from one individual to another" [8].

4. Nature of the social system e.g. its norms, degree of network interconnectedness.

5. Extent of change agents' promotional efforts.

Change agents' promotional efforts are important because attitudes and behaviors towards change may depend on effective promotion. A change agent is "an individual who influences clients' innovation decision in a direction deemed desirable by a change agency" [8].

III. SIX SIGMA AND LEAN SIX SIGMA FRAMEWORKS/MODELS

Three frameworks for implementing Six Sigma were found from our literature search [5], [10], [11] and one framework for implementing Lean Six Sigma [6].

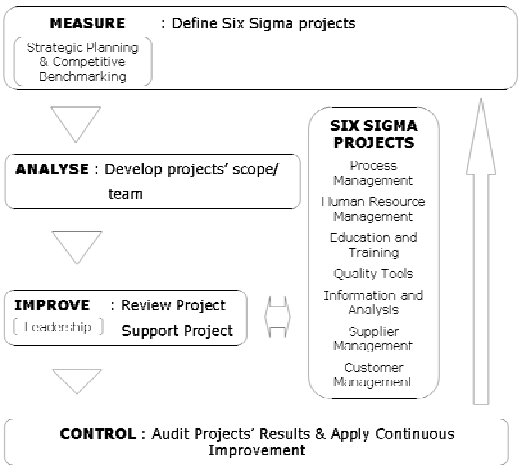

Figure 1. Chang's Six Sigma framework for SMEs. Source: Chang (2002, p. 152)

Chang [10] developed his framework (see Figure 1) based mainly on the MBNQA (Malcolm Baldrige National Quality Award) model which contains TQM elements such as strategic planning, leadership, process management, human resource, education and training, quality tools, customer management, supplier management and information and analysis. Chang claimed these elements are critical factors for SMEs to adopt Six Sigma. His framework is built around the idea of continuous improvement following MAIC (Measure-Analyse-Improve-Control) steps. Chang's development of his framework is rather lacking in discussion about culture consideration related to implementation and the limitations that SMEs can have compared to large organizations. He did not explain how to bring these factors into implementation. For instance, for education and training in Six Sigma projects, he did not suggest what is the best type of training for SMEs. SMEs may find it difficult to follow the common training scheme of Six Sigma (green belt, black belt, etc.) because they have limited funds. Generally speaking, for SME which have limitations on resource and technology, an ideal framework should give guidance on how to deal with issues like limited resources and expertise. This argument is in line to Yusof [12] who stated that "small organization needs a clear and less complex framework" that can assist them towards the implementation of concepts/approaches.

The framework, developed by Park [11] (see Figure 2) and based on his experience as a consultant, is believed to be more suitable to large organizations. The explanation and justification of the model is rather unclear and it does not provide specific guidance related to implementation of Six Sigma in SMEs.

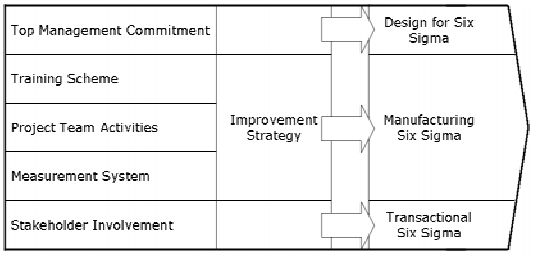

Figure 2. Park's Six Sigma framework. Source: Park (2005, p. 30)

A framework developed by Burton & Sams [5] (see Figure 3) appears to be more suitable for SMEs. They suggest a Six Sigma pilot project as the first stage when SMEs plan to implement this concept. The purpose of the pilot project is to demonstrate the applicability of its concept and as a way to help convince skeptics of the benefits of the new program and gain their acceptance or at least reduce their resistance to it.

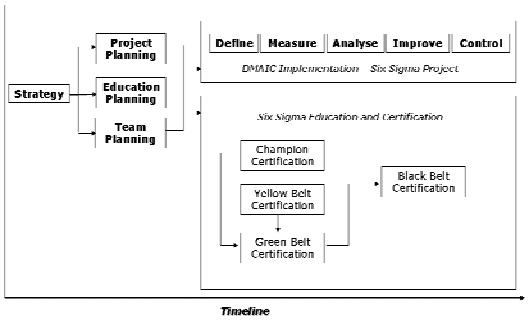

Figure 3. Six Sigma implementation framework for SMEs. Source: Burton & Sams (2005, p. 38)

Burton and Sams' framework emphasises education and certification (i.e. Champion, Yellow Belt, Green Belt and Black Belt certification) as an important aspect of their implementation model. It can be argued that certification cannot assure the success of Six Sigma implementation. Six Sigma teams should have enough understanding to use basic and advanced quality tools to solve organizational problems. It is not difficult task since these basic and advanced tools of Six Sigma are not new tools, they have used in the TQM or other improvement programs in the past.

Also, in situations where SMEs are starting from a relatively low educational base and may be short of resources the conventional "belt" training programs (yellow,

green, black) may not be the most appropriate. To cater for these situations Harry and Crawford [13] have introduced the 'White Belt', a new generation of belt system in the Six Sigma infrastructure which is of shorter duration than the green belt program. This 'White Belt' is another training alternative for small and medium enterprises that have limitations sending their employees for Six Sigma Green Belt training. Harry and Crawford [13] also suggest online Six Sigma training for SME who have difficulty in releasing employees for face-to-face training.

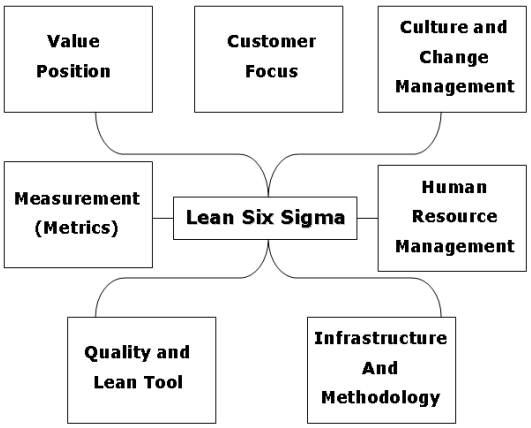

Figure 4. Lean Six Sigma framework. Source: Furterer (2004, p. 41)

A Lean Six Sigma framework developed by Furterer [6] (see Figure 4) is specifically aimed at the needs of local government. This framework together with its elements was developed from the literature and from Furterer's experience as a consultant. It can be seen that majority of the framework's elements are based on quality award models e.g. Business Excellence Model and MBNQA.

IV. ANALYSIS

Table 1 provides an analysis of the four Six Sigma frameworks discussed above in relation to a number of the key constructs that Rogers' diffusion of innovation approach suggests should be considered in an implementation framework. An evaluation of the degree of emphasis and clarity of each framework relations to Rogers' constructs is also provided. A blank cell indicates that the construct does not seem to be included in a framework. It can be seem that the frameworks of Chang [10] and Park [11] are particularly weak in their alignment. The frameworks of Burton and Sams [5] and Furterer [6] are stronger in alignment, but still relatively weak.

Table 1. Examination of existing frameworks based on Rogers' diffusion of innovations

FRAMEWORKS	Rogers' constructs							
	relative advantage	compatibility	complexity	trialability	observability	communication channels	nature of the social system/culture	extent of change agents' promotion
Chang (2002)	unclear	unclear	unclear			emphasised	less emphasised	less emphasised
Park (2005)	emphasised	emphasised	unclear	unclear	emphasised	unclear	less emphasised	
Burton & Sams (2005)	emphasised	emphasised	unclear	emphasised	emphasised	emphasised	emphasised	less emphasised
Furterer (2004)	emphasised	emphasised	unclear	emphasised	emphasised	emphasised	emphasised	unclear

Table 2 below analyses the four frameworks against five key critical success factors related to implementation. An evaluation of the degree of emphasis and clarity of each framework relations to CSFs is also provided. A blank cell indicates that the CSF is not included in a framework.

Table 2. Examination of existing frameworks based on CSFs

FRAMEWORKS	CSF item				
	management commitment	training	communication	employee involvement	customer focus
Chang (2002)	emphasised	emphasised	emphasised	emphasised	emphasised
Park (2005)	emphasised	emphasised	unclear	emphasised	emphasised
Burton & Sams (2005)	emphasised	high emphasised	emphasised	emphasised	emphasised
Furterer (2004)	emphasised	emphasised	emphasised	emphasised	emphasised

V. DISCUSSION AND CONCLUSION

Lean Six Sigma is a new integrated concept that has objectives to improve quality, reduce processing time and reduce production cost [3]. However, one needs to be careful when implementing Lean Six Sigma concepts into small organizations. There is a need to think about SME characteristics as highlighted by Rogers' theory on diffusion of innovations. Rogers' framework for analysis based on his theory represents a practical and theoretically sound approach to designing a implementation program for an improvement methodology like Lean Six Sigma where the objective is to spread the innovation within an industry. Identifying critical success factors for implementation is useful. But CSFs in themselves do not represent a coherent implementation framework, they need to be integrated into an implementation plan.

As was stated earlier the broader aim of the research is to develop an implementation framework to implement Lean Six Sigma into Indonesian SMEs in the manufacturing industry. A temporal dimension is an important feature of an effective implementation plan aimed at introducing an innovation at an industry level. Thought should be given to how different phases of such an innovation should be conducted. For example, how should innovation diffusion be started? A feasible approach that has been used, is to introduce the innovation into a small number of targeted organisations whose success would encourage other organisations to follow their example.

The research into CSFs and existing implementation frameworks for Six Sigma and its variants shows that relatively little seems to have been published. What has been is of some use in developing an implementation framework. However, it is evident from Rogers' ideas that although there may be common general issues in implementing innovations it is essential to customise the implementation for the intended situation. This means that a thorough study of the innovation itself and the situating for which it is intended should be carried out. If the innovation is not likely to be valued or if support for its introduction cannot be organised then it is unlikely to succeed.

Some limitations in the analysis carried out in this paper need to be acknowledged. The four Six Sigma frameworks were analysed from two perspectives a CSFs perspective and Rogers' diffusion of innovations perspective. Other approaches contained in the literature on organizational change were not used and may be of some relevance in formulating a implementation framework. Also, although the importance of the temporal perspective was mentioned there is a body of knowledge within the domain of project management that would be relevant to formulating time based implementation plans.

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