A STUDY OF KNOWLEDGE CREATION IN SIX SIGMA DMAIC PROJECT SUCCESS AND ITS IMPACT ON ORGANIZATIONAL PERFORMANCE

by

ANG BOON SIN

Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

Jun 2015

ACKNOWLEDGEMENT

The path taken to complete this piece of works was longer, bumpier and curvier that I initially anticipated. Along the way, I was fortunate to receive guidance, insights, and support from a large group of people. Their helps were not limited to my dissertation work but often touched other aspect of my life. With a grateful heart and sincere appreciation, I take this time and opportunity to say thank to all of them.

My dissertation committee members have assisted me in numerous ways. First and foremost, I must thank my both supervisors, Prof. Suhaiza Hanim Dato Mohamad Zailani and Prof. Ramayah, has been my endless source of support and guidance. Their sharp mind, compassion, nurturing and constant encouragement buoyed me many time, and provided me a much-needed anchor during time of uncertainty.

In addition, I am very grateful to the directors, managers and Six Sigma professional from my anonymous case study research sites, who opened many kinds of doors for me, let me join into their Six Sigma project meetings and lives unstintingly. They spent countless hours sharing with me on the Six Sigma project activities and patiently answering my questions. I consider it an honor and a privilege to have worked together with them. Special thanks also go to all the Six Sigma firms who participate in the survey and make this research success.

Last, but most certainly not least, I thank my family and friends. To my father, Ang Swee Seng, you are a man of few words, but such a big heart. I absolutely appreciate your prayers, your humor, and your loving kindness. To my mother, Teoh Kim Hooi, you are the one that kept me grounded, inspired me, prayed for me, and helped me until the very end. All you have done for me in my life, and during the studying for and writing of this dissertation, will never be forgotten.

To my marvelous friends for insisting I get out of the house to have some fun so that I could relax, refocus, and continue. Of course, I had also learned a lot from my PhD friends. They were always being very helpful and willing to share her experiences in doing good research.

All…..Thank you so much! I will always remember, with a humble spirit, the continuous guidance, help and support you have given as I continue my journey of life. I am thankful for that and I thank God for putting all of you in my journey of life.

DEDICATION

To my beloved parents Teoh Kim Hooi and Ang Swee Seng

whose loves and supports continue to be my inspiration

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

SATU KAJIAN PENCIPTAAN PENGETAHUAN DALAM KEJAYAAN PROJEK SIX SIGMA DMAIC DAN KESANNYA TERHADAP PRESTASI ORGANISASI

ABSTRAK

Terdapat banyak penyelidikan empirikal yang mengkaji hubungan antara Six Sigma dan prestasi organisasi. Walau bagaimanapun, kebanyakan penyelidikan ini memberi tumpuan kepada hubungan terus antara Six Sigma dan prestasi organisasi. Tidak ada siasatan terperinci bagaimana Six Sigma boleh menyebabkan peningkatan prestasi organisasi. Kajian ini mencadangkan bahawa dengan mengintegrasikan proses penciptaan pengetahuan organisasi, hubungan antara Six Sigma dan prestasi organisasi dapat dijelaskan dan dibangunkan. Kajian ini mengkaji kewujudan hubungan antara proses penciptaan pengetahuan organisasi dalam projek Six Sigma DMAIC, pengetahuan, Six Sigma kejayaan projek dan prestasi organisasi. Penyelidikan ini dijalankan terlebih dahulu dengan menggunakan kaedah kajian kes dan diikuti oleh kaedah kajian selidik. Empat kajian kes telah dijalankan untuk mengesahkan sama ada terdapat bukti-bukti process penciptaan pengetahuan organisasi wujud dalam projek Six Sigma DMAIC. Hasil kajian kes menunjukkan bahawa terdapat bukti-bukti yang berkaitan dengan proses penciptaan pengetahuan organisasi wujud dalam setiap fasa Six Sigma DMAIC. Kajian selidik dijalankan untuk menguji model-model penyelidikan dengan menganalisis data daripada 225 syarikat Six Sigma elektrik / elektronik di Malaysia. Hasil kajian selidik menunjukkan bahawa proses penciptaan pengetahuan organisasi mempunyai kesan positif ke atas pengetahuan. Pengetahuan mempunyai kesan positif ke atas kejayaan projek Six Sigma dan kejayaan projek Six Sigma membawa kesan kepada peningkatan prestasi organisasi.

A STUDY OF KNOWLEDGE CREATION IN SIX SIGMA DMAIC PROJECT SUCCESS AND ITS IMPACT ON ORGANIZATIONAL PERFORMANCE

ABSTRACT

There are number of empirical researches that are studying the relationship of Six Sigma and organizational performance. However, most of them are focusing on direct relationship of Six Sigma and organizational performance. There is no detail investigation how Six Sigma can lead to the improved organizational performance. This research suggests that by integrating organizational knowledge creation processes the link between Six Sigma and organizational performance can be explained and developed. This study investigates the existence of a relationship between organizational knowledge creation processes in Six Sigma DMAIC project, knowledge, Six Sigma project success and organizational performance. The research is conducted by using case study first then followed by the survey study. Four case studies are conducted to validate if there are evidences of the theoretical construct of organizational knowledge creation processes exist in Six Sigma DMAIC project. The case study finds relevant evidences of organizational knowledge creation processes exist in Six Sigma DMAIC phases. The survey study tests the theoretical research models by analyzing data from 225 Six Sigma manufacturing companies in Malaysia. The findings reveal that organizational knowledge creation processes has positive effect on knowledge. In turn, the knowledge has positive impact on Six Sigma project success and Six Sigma project success leads to improve organizational performance.

CHAPTER 1 INTRODUCTION

1.1 Introduction

In today's competitive business environment leaves no room for error. Businesses are not only to provide high quality and innovative products and services at competitive prices (Souza et al., 2013; Slack et al, 2010; Jugulum & Samuel, 2008; Chinho & Chang, 2006; O'Rourke, 2005; Ahmed, Yang, & Dale, 2003). They must delight customers and relentlessly look for new ways to exceed customer's expectations (Sarkar et al., 2013; Van Der Wiele et al., 2010; Abas & Yaacob, 2006; McAdam & Lafferty, 2004; Huarng & Chen, 2002; Li & Collier, 2000). The ability to reach to these challenges is crucial not only to remain relevant in the marketplace but the adverse impact that these changes could have on business performance if they failed to respond accordingly (Souza et al, 2013; Garza-Reyes et al. 2010; Dale et al., 2007; Ho & Chuang, 2006; Mahanti & Antony, 2005; McAdam, Hazlett, & Henderson, 2005; Gowen & Tallon, 2005). Many organizations are increasingly aware and concerned about these challenges. The challenging question is: how a company should improve business processes efficiency, cost reduction, improved bottom lines benefits and still remain competitive players in the stressful environment. For many companies, Six Sigma is one of the initiatives that can help organization to meet these challenges and deliver those results (Pyzdek & Keller, 2009; Garza-Reyes et al. 2010; Van Der Wiele et al., 2010; Kumar et al., 2008; Dale et al., 2007;Brue & Howes, 2006; Banuelas et al., 2005; McAdam, Hazlett, & Henderson, 2005)

Six Sigma has emerged as one of the most successful business improvement model of the latter 21st century (Padhy and Sahu, 2011; Garza-Reyes et al. 2010; Basu, 2009). Six Sigma process is customer-oriented, structured, systematic, proactive and quantitative approach for continuous process improvement in the business processes of an organization to ensure improved quality, low cost and fast delivery and drive out waste from business processes using statistical tools and techniques (Laureani et al., 2013; Harry et al., 2010; Naslund, 2008; Van

Der Wiele et al., 2010; Chiarini, 2011). After Motorola's creation of Six Sigma, AlliedSignal and GE popularized it in the 1990s. Today it has become widely recognized as an effective method for improving business performance. These successes have encouraged many other companies such as Ford, DuPont, 3M, Dow Chemical, etc to undertake Six Sigma initiatives. Many small and mid-size companies are also using the Six Sigma approach. Six Sigma has its roots in manufacturing and has been very successfully applied in manufacturing. Today Six Sigma has proved to be successful in marketing, finance, healthcare, banking and many other business process (Souza et al, 2013; Falcon et al., 2012; Gijo et al., 2011; Firka, 2010; Mahanti & Antony, 2009; Markarian, 2004)

Most company today, view Six Sigma as a business strategy and methodology for improving process performance in such a way that customer satisfaction is increased and the bottom line is improved (Laureani et al., 2013; Snee, 2010; Nonthaleerak & Hendry, 2008; Wu & Lin, 2009). The bottom line focus attracts the attention and support of corporate executives and financial analysts, and makes Six Sigma different from many earlier improvement approaches, such as statistical process control (SPC), total quality management (TQM), and ISO 9000, none of which have the explicit bottom line focus (Chiarini, 2011; Schroeder et al., 2005; Wu & Lin, 2009). Success stories of big corporations that have adopted Six Sigma, such as Motorola, General Electric (GE), and Allied Signal/Honeywell have been reported in various papers claiming that Six Sigma implementation result in high financial saving (Hendricks & Kelbaugh, 1998). For instance, in 1999, GE spent $600 million and saved over $2 billion (Watson, 2003). Allied Signal, from 1992 through 1996, reduced costs by $1.4 billion (Brue & Howes, 2006).

Success stories of big corporations that have adopted Six Sigma, such as Motorola, General Electric (GE), and Allied Signal/Honeywell have been reported in various papers claiming that Six Sigma implementation result in high financial saving (Keller, 2010; Brue & Howes, 2006; Aghili, 2009; Antony, 2007). Many industries have an increased interest in Six

Sigma. There is a wider acceptance, growth and investment of Six Sigma in industries. There are many publications such as articles and books about Six Sigma. Current concepts in the field of Six Sigma are largely descriptive and based upon the prescription of leading 'gurus' who worked in major companies using Six Sigma, such GE, Motorola, Honeywell, etc (Pyzdek & Keller, 2009; Zu et al., 2008). It provides detailed about Six Sigma concepts, methodology, tools and techniques and implementation strategy. The practitioner literatures primarily provide prescriptive guideline and procedures needed for Six Sigma implementation. There is little on theory development. In spite of considerable discussion of Six Sigma and organizational performance, there is no detail empirical discussion on the phenomenon how Six Sigma leads to the organizational performance.

Given this situations, Six Sigma and organizational performance is an interesting issue to study. This study proposes that the knowledge-based theory of the firm and Nonaka's (1994) organizational knowledge creation theory are useful approach in explaining the phenomenon Six Sigma leads to the organizational performance. According to the knowledge-based theory of the firm, knowledge is a strategic resource that the firm uses to develop sustained competitive capability (Davenport & Prusak, 1998; Grant, 1996; Kogut & Zander, 1996; Spender, 1996) and the firm's practices that toward the generation of knowledge can have substantial effects on the organization performance. According to Nonaka's (1994) organizational knowledge creation theory, the conversion between tacit and explicit knowledge allow knowledge to be created through socialization, externalization, combination and internalization processes. From these two theoretical perspectives, if Six Sigma practices lead to knowledge creation then the link between Six Sigma and firm performance can be explained. That is, Six Sigma becomes a source of knowledge creation that results in a competitive advantage that leads to the improved organizational performance.

1.2 Background of the Study

1.2.1 Six Sigma Literature in Malaysia

There are seven Six Sigma empirical researches found in the literature. Majority of the research are focused on identifying critical success factors for Six Sigma implementation as (Supremanian & Muthusamy, 2011; Zailani & Sasthriyar; 2011; Jayaraman, et al., 2012; Leong & Teh, 2012; Nurul & Sha'ri, 2013) do. There are two studies that investigate the impact of Six Sigma to organizational performance as (Ang, et al., 2010; Yusra, et al., 2012) do.

Supremanian and Muthusamy (2011) study examined Critical Success Factors (CSFs) of Six Sigma methodology implementation in Malaysian Multinational Corporations (MNCs). This research used the method of exploratory survey conducted via online questionnaire. Five CSFs identified: management commitment, absorption, project /process assessment, training& awareness, cultural influence. The study results concluded that CSFs that have direct impact in Six Sigma implementation are management commitment, absorption, project/process assessment and training & awareness. Cultural influence does not have significant impact on Six Sigma implementation.

Zailani and Sasthriyar (2011) performed correlation study to examine critical success factors of Six Sigma towards Six Sigma success to the organizations. Ten CSFs are identified: management involvement and commitment, project prioritization and selection, reviews and tracking, understanding the Six Sigma methodology tools and techniques, linking Six Sigma to business strategy, linking Six Sigma to suppliers, training, company infrastructure, project management skills, linking Six Sigma to human resources and linking Six Sigma to customers. The study also reveals that all ten dimensions of critical success factors of Six Sigma (independent variable) as a group explained 45%, in order to perceive Six Sigma success. This reveals that there must be more these 10 independent critical success factors. So, it can be concluded that all the independent effects of critical success factors of Six Sigma were collectively predicting the perceived Six Sigma success. However, individually somehow,

factors for management involvement and commitment, and linking with supplier management could not explain the relationship with perceived Six Sigma success at the significance level of $p < .05$.

Jayaraman, et al. (2012) conducted research to analyze the critical success factors (CSFs) for Lean Six Sigma (LSS) implementation and its impacts towards company performance in multinational electronic manufacturing service (EMS) industries. The study identified nine CSFs: management engagement and commitment, reward and recognition system, competency of Master Black Belt / Black Belt, company financial capability, frequent communication and assessment on LSS result, project selection, review and tracking, sharing of project success stories and best practices, effective LSS training program and establishment of LSS dashboard. The results indicated that out of these CSFs, management engagement and commitment, effective LSS training program, established LSS dashboard, frequent communication and assessment on LSS results were found to be statistically significant and they affect operational performance and organizational performance.

Leong and Teh (2012) study examined the five critical success factors (i.e., top management involvement and commitment, training and education, teamwork, cultural change, and organizational infrastructure) on Six Sigma implementation in the Original Equipment Manufacturer (OEM) industry. The results show that top management involvement and commitment, as well as training and education are independent and positively related to six sigma implementation. However, teamwork has a negative relationship with Six Sigma implementation.

Nurul and Sha'ri (2012) study identify and evaluate the critical success factors (CSFs) affecting Lean Six Sigma (LSS) implementation in the Malaysian automotive industry. The study identified seven CSFs: Leadership, Structured improvement procedure, Quality information and analysis, Supplier relationship, Just in time, Customer focus and Focus in metric. Data for the study were collected from a sample of 252 Malaysian automotive suppliers

and the research model was tested using SEM. Based on the empirical data survey, the two factors of “leadership” and “customer focus” have been shown to be the extremely important factors for LSS implementation in Malaysian automotive industry.

Ang, et al. (2010) had conducted the first empirical research in Malaysia that is linking Six Sigma to knowledge creation and organizational performance. This study focuses on the antecedents and outcomes of organizational knowledge creation in Six Sigma organization. Specifically, the study focuses on how Six Sigma practices can lead to organizational knowledge creation capability and how this capability can lead to improved organizational performance. Six Sigma practices included in the study were top management involvement & support, customer focus, role structure, use of metrics, project selection, tools & technique, team, DMAIC, DFSS, process management and training. The organizational performance was measured in four balanced scorecard perspective which were customer satisfaction, internal business process performance, employee learning & growth and financial performance. Overall, the study’s results show that process improvement through Six Sigma practices involves the creation of knowledge, knowledge creation has direct positive impact on customer, internal business process, employee learning and growth and indirect positive impact on financial. Overall, this study provides a more comprehensive understanding of how Six Sigma practices can lead to improved organizational performance and enhancing organizational capabilities.

Yusra, et al. (2012) study attempted to figure out the relationship between Six Sigma and innovation performance, and examine the mediating role of absorptive capacity (AC) in this relationship. The findings of the analysis show that Six Sigma has a significant and positive influence absorptive capacity. Also, the results indicate that absorptive capacity positively affects innovation performance. The mediating effect of absorptive capacity has also been proved by the findings of this study, where 73% of the effect of Six Sigma on innovation performance is explained through absorptive capacity. However, the direct relationship between Six Sigma and innovation performance was substantially reduced to be insignificant when the

mediating relationship was introduced, which refers to the full mediating effect of absorptive capacity in the relationship between Six Sigma and innovation. Therefore, it can be concluded that absorptive capacity as capabilities are very crucial to enhance and develop innovation performance. Hence, companies which tend to be innovative are recommended to build its absorptive capabilities as the basis or first step towards innovation. Further studies should be done to determine the factors that affect on absorptive capacity in order to get more understanding regarding how to improve the absorptive capabilities in the organization level.

1.2.2 Six Sigma Research Issue in Malaysia

Six Sigma research territories in literature are mostly focus in United States and Europe (Nonthaleerak & Hendry, 2006; Ang et al., 2010). Ang et al. (2010) highlighted that empirical research of Six Sigma in Malaysia context is limited. Majority of the research done in Malaysia are focused on identifying critical success factors for Six Sigma implementation. There is no any research been done for studying the relationship of Six Sigma and organizational performance in Malaysia context. As a result, there is not much solution offers to Six Sigma companies in Malaysia in explaining how the Six Sigma can lead to improved organizational performance. Therefore, there is a need to investigate the relationship of Six Sigma and organizational performance.

1.3 Research Problems

There are number of empirical researches study on the relationship between Six Sigma and organizational performance in the literatures. However, the research has yielded mixed results. Some empirical researches as done by Lee (2002); Ayeni (2003); Lee & Choi (2006); Zu et al. (2008) and Braunscheidel et al. (2011) found that Six Sigma has positive effects on organizational performance. Others as done by Goh et al. (2003); Foster (2007) and Gutierrez et al. (2009) found that there is no significant relationship of Six Sigma to organizational

performance. Thus, this topic needs further investigation. For those studies that found that Six Sigma has positive effects on organizational performance, the studies were focused on direct relationship between Six Sigma and organizational performance (Lee, 2002; Ayeni, 2003; Lee & Choi, 2006; Zu et al., 2008; and Braunscheidel et al., 2011). There is no detail discussion on the phenomenon how Six Sigma leads to the organizational performance. The link between Six Sigma and organizational performance has not been clearly explained and fully developed. Linderman et al. (2003) and Antony (2004) remark that theory about the link of Six Sigma lead to organizational performance is lacking and the academic community lags behind in understanding this relationship. Nonthaleerak and Hendry (2006) comment that theory development of Six Sigma lead to organizational performance that is of use to academic scholars and business organization is required. Therefore, systematic and rigorous research is needed to determine components that make up of Six Sigma can lead to organizational performance.

In existing literature, there is no empirical research being done on how application of Six Sigma DMAIC methodology can lead to knowledge creation. However, there are few empirical researches that relate and study knowledge creation in Six Sigma as Choo et al.(2007); Chuni & Chinho (2009); Anand et al.(2010) and Ang et al.(2010) do. Choo et al. (2007) developed method and context perspectives of learning and knowledge creation for quality improvement program such as Six Sigma. These two perspectives reflect the dual emphasis of quality practices as technical and social that can complement each other in maintaining sustainability of quality advantage that finally lead to learning and knowledge creation. Chuni and Chinho (2009) conducted interview case study in two manufacturing companies in Taiwan to identify how the Six Sigma program facilitates the knowledge creation process. The focus of their study was on general Six Sigma program practices. Both research even though related to knowledge creation in general Six Sigma program but none of them focus on the relationship of Six Sigma DMAIC methodology and knowledge creation. Anand et al. (2010) developed a

conceptual model for predicting success of Six Sigma process improvement projects as a result of knowledge-creation practices employed in the projects. The study was focused on the relationship of knowledge-creation practices on the Six Sigma project performances. Ang et al. (2010) had conducted the first empirical research in Malaysia that is linking Six Sigma practices (e.g. top management involvement & support, customer focus, role structure, use of metrics, project selection, tools & technique, team, process management and training) to knowledge creation and organizational performance. Both studies focus on general Six Sigma practices and knowledge creation. However, there is no investigation of Six Sigma DMAIC methodology lead to knowledge creation. Above review of the literature suggested that previous studies for instance (Choo et al., 2007; Chuni & Chinho, 2009; Anand et al., 2010; Ang et al., 2010) did not only show little interest in examining the relationship of Six Sigma DMAIC methodology and knowledge creation.

To the researcher knowledge there is no empirical research being done on the relationship of knowledge created in Six Sigma DMAIC methodology and Six Sigma project success. However, there is one empirical work noted in the extant literature that relates the relationship of knowledge creation process and Six Sigma project performance in Six Sigma context. Anand et at. (2010) developed a conceptual model for predicting success of Six Sigma process improvement projects as a result of knowledge-creation practices employed in the projects. In this study Anand classified Six Sigma practices into Nonaka's four knowledge creation mechanism: socialization, externalization, combination and internalization. The model was empirically examined in the context of Six Sigma black belt projects. Data was collected from 98 projects from five companies. The results support the notion that knowledge-creation practices influence the success of process improvement projects. The research done by Anand et at. (2010) was focused on the relationship of knowledge creation practice on the Six Sigma project performances. However, there is no investigation if the knowledge creation process lead to knowledge creation and finally knowledge creation leads to Six Sigma project performances.

Therefore, this study tries to find out the relationship if the knowledge created in Six Sigma DMAIC methodology would have an effect on Six Sigma project performances.

Six Sigma is project driven approach to process and product quality improvement (Ray & Das, 2010; Gitlow et al., 2006). Projects are the means by which Six Sigma converts quality improvements into bottom line financial benefits (Gulcin & Demet, 2010; Kubiak & Benbow, 2009). Six Sigma projects must be linked with business strategy, meet the requirements of the customer and provide maximum financial benefits to the organization (Breyfogle, 2010; Ray & Das, 2010; Russell & Tippett, 2008; Sanchez, Benoit, & Pellerin, 2008). In the literatures, there is also limited empirical research that investigates the relationship between Six Sigma project success and organizational performance. Although scholars and practitioners cite numerous examples on the positive effect of Six Sigma projects on firm performance (e.g. Foster, 2007; Johnson, 2005; Roberts, 2004; Hoerl, 1998; Rucker, 2000), there is little theoretical support on the effectiveness of Six Sigma projects on organizational performance. The existent literatures are mostly employs descriptive research method based upon anecdotal evidence (Brady, 2005). There is one conceptual paper by Mahour (2011) identified in the literatures that discuss the effect of Six Sigma projects organizational performance. Mahour (2011) developed a theoretical base framework for the effect of Six Sigma projects on innovation and firm performance. The framework was built upon theories from process management and quality management. The paper proposes several propositions to address the effect of Six Sigma projects on innovation and firm performance. However, empirical research is needed to further validate the propositions.

Six Sigma research in Malaysia context is rather limited. Ang et al. (2010) highlighted that Six Sigma research territories in literature are mostly focus in United States and Europe. There is little research done in Malaysia context. Majority of the research done in Malaysia are focused on identifying critical success factors for Six Sigma implementation (e.g. Supremanian & Muthusamy, 2011; Zailani & Sasthriyar; 2011; Jayaraman, et al., 2012; Leong & Teh, 2012;

Nurul et al., 2012). There is limited research been done for studying the relationship of Six Sigma and organizational performance in Malaysia context. As a result, there is not much solution offers to Six Sigma companies in Malaysia in explaining how the Six Sigma can lead to improved organizational performance. Therefore, there is a need to investigate the relationship of Six Sigma and organizational performance.

1.4 Research Questions

The problems identified in the literature has lead to the development of a several research questions that are worthy of investigation.

1. Does application of Six Sigma DMAIC methodology for business process improvement facilitates knowledge creation?
2. Does knowledge created in Six Sigma DMAIC methodology has an effect on Six Sigma project success?
3. Does Six Sigma project success has an effect on organizational performance?
4. Does each of the Six Sigma DMAIC phases (e.g. Define, Measure, Analyze, Improve, and Control) facilitate knowledge creation?
   (a) Does Define phase facilitate knowledge creation?
   (b) Does Measure phase facilitate knowledge creation?
   (c) Does Analyze phase facilitate knowledge creation?
   (d) Does Improve phase facilitate knowledge creation?
   (e) Does Control phase facilitate knowledge creation?

1.5 Research Objectives

This study will be conducted at Six Sigma electrical/electronic companies in Malaysia. The objectives of this study are as below.

1. To examine if application of Six Sigma methodology facilitate knowledge creation

2. To examine if knowledge created in application of Six Sigma methodology have an effect on Six Sigma project success.
3. To examine if Six Sigma project success have an effect on organizational performance.
4. To examine if each of the Six Sigma DMAIC phases facilitate knowledge creation in business process improvement.
   (a) To examine if Define phase facilitate knowledge creation.
   (b) To examine if Measure phase facilitate knowledge creation.
   (c) To examine if Analyze phase facilitate knowledge creation.
   (d) To examine if Improve phase facilitate knowledge creation.
   (e) To examine if Control phase facilitate knowledge creation.

1.6 Scope of the Study

The study focus on electrical and electronic manufacturing companies that has implemented Six Sigma program in Malaysia. The manufacturing sector was selected because majority of Six Sigma companies in Malaysia are from electrical and electronic manufacturing companies (Ang, et al, 2010). According Ang, et al. (2010), 96.7% of Six Sigma companies in Malaysia are from electrical and electronic manufacturing companies and the remaining 3.3% represent services industries. This is understandable, since Six Sigma started in manufacturing and is strongly embraced by this sector. The manufacturing sector was selected also because it is the largest sector in terms of sales, employment and contribution to the economy (MIDA, 2011; Department of Statistic Malaysia, 2011). Thereby, any effort to improve the performance of this sector can produce substantial benefits. Since the research studies knowledge creation in Six Sigma organizations, the companies selected must with knowledge intensive activities. Based on this goal, manufacturing companies is selected because these companies tend to have a greater intensive of knowledge work due to their emphasis on process improvement as their key source of competitive advantage.

Six Sigma methodologies being established by Motorola is amongst the popular business improvement strategies today. Six Sigma methodologies are one of the highly controlled management approaches that enable companies to increase their profitability and reduce costs (Brussee, 2010; Karbasian & Aghadaee, 2006). As a result, they are able to deliver best products and services, higher profits and retain happier customers (Owens, 2011; Jacob et al, 2009; Trusko et al., 2007). There are two types of methodologies followed in all six sigma projects. These are Six Sigma DMAIC methodology and DMADV methodology (Mehrjerdi, 2013; Yang & El-Haik, 2008; Gitlow et al, 2006). The DMAIC methodology is used for those projects that are targeted to improve the existing business processes (Keller, 2010; Reidenbach, 2009; Goldsby & Martichenko, 2005). The DMADV type of Six Sigma methodology is also known as Design For Six Sigma (DFSS), it targets those projects in an organization that creates new products or process designs (Ginn & Varner, 2011; Yang & El-Haik, 2008; Watson, 2005). According Ang, et al. (2010), 88.9% of Six Sigma companies in Malaysia are using Six Sigma DMAIC methodology as their process improvement initiative. It is appropriate that the study focuses on manufacturing companies that adopted Six Sigma DMAIC methodology as their process improvement initiative.

1.7 Significance of the Study

This research is significance in several ways and makes a meaningful contribution for research as well as for practice.

There are number of empirical researches study on the relationship between Six Sigma and organizational performance in the literatures. However, the research has yielded mixed results. For those studies that found that Six Sigma has positive effects on organizational performance, the studies were focused on direct relationship between Six Sigma and organizational performance (Lee, 2002; Ayeni, 2003; Lee & Choi, 2006; Zu et al., 2008; and Braunscheidel et al., 2011). There is no detail discussion on the phenomenon how Six Sigma

leads to the organizational performance. The study results make a significance contribution to the literature on explaining empirically the phenomenon of how Six Sigma can lead to organizational performance. The research findings reveal that application of Six Sigma DMAIC methodology facilitate knowledge creation through knowledge creation processes and knowledge created has positive effect on Six Sigma project success and finally Six Sigma project success leads to improve organizational performance.

There are few empirical researches that study knowledge creation in Six Sigma quality improvement program such as Choo et al. (2007) and Chuni and Chinho (2009) do. Both research even though related to knowledge creation in Six Sigma but none of them focus on the relationship of Six Sigma DMAIC methodology and knowledge creation. The results of the study contribute to Six Sigma body of knowledge that integrating knowledge creation processes such as Socialization, Externalization, Combination and Internalization (SECI) can lead to knowledge creation. From a practical point of view, the study results reveal that the important role of knowledge creation processes in the relationship of Six Sigma and organizational performance. Awareness of this finding can help Six Sigma project leaders target appropriate points to facilitate the spiral of knowledge creation by taking a leading role in managing the SECI processes. Each process of knowledge conversion requires different approaches for organizational members to create and share knowledge effectively (Nonaka and Konno, 1998; Nonaka et al., 2000b; Becerra-Fernandez and Sabherwal, 2001; Anand et al., 2010; Ang et al., 2010).

Based on existing literature, there is no empirical research being done to study the relationship of knowledge created in Six Sigma DMAIC methodology and Six Sigma project success. The results of this study add in the body of knowledge that application of knowledge creation processes in Six Sigma DMAIC methodology allows knowledge to be created and knowledge created has positive effect on Six Sigma project success. In practice, the result implies that knowledge of Six Sigma project team member is critical and forming an effective

Six Sigma project team for driving improvement projects is essential to Six Sigma project success. Six Sigma project team should comprise of a diverse group of individuals with diverse, complementary skills and knowledge. Interaction among Six Sigma project team members with multidiscipline knowledge and experience can create organizational knowledge more efficiently and effectively (Ang et al, 2010; Linderman, 2004; Sabherwal & Becerra-Fernandez, 2003; Anand, et al., 2010).

In the literatures, there is also limited empirical research that investigates the relationship between Six Sigma project success and organizational performance. The existent literatures are mostly employs descriptive research method based upon anecdotal evidence (Brady, 2005). This research studies the relationship between Six Sigma project success and organizational performance empirically. The result of the study adds in the body of knowledge in Six Sigma literature that Six Sigma project success has positive effect on organizational performance. In practice, the result of the study can help organization to understand that Six Sigma project selection is critical. Six Sigma project selections must be aligned with the business strategies, organization's goal /objectives and meet customers' requirements. Six Sigma projects will not likely be supported if they do not simultaneously provide greater customer satisfaction and make progress toward achieving the organization's strategic goals. Six Sigma projects must be prioritized which provide maximum financial benefits to the organization.

There is little research done in Malaysia context. Majority of the research done in Malaysia are focused on identifying critical success factors for Six Sigma. There is little research been done for studying the relationship of Six Sigma and organizational performance in Malaysia context. As a result, there is not much solution offers to Six Sigma companies in Malaysia on how the Six Sigma can lead to improved organizational performance. The results of this study will help organizations to understand that the important role of knowledge creation processes (Socialization, Externalization, Combination, Internalization or SECI) in the

relationship of Six Sigma and organizational performance. Awareness of this finding can help Six Sigma project leaders target appropriate points to facilitate the spiral of knowledge creation by taking a leading role in managing the SECI processes. Each process of knowledge conversion requires different approaches for organizational members to create and share knowledge effectively.

1.8 Definitions of Key Terms

Six Sigma: Six Sigma is defined as a structured management system to continuously improve organizational processes to achieve the strategic business goal of increasing bottom line benefits and enhancing customer satisfaction through collaboration of the organization's employees, customers and suppliers (Zul et al., 2008).

DMAIC: The systematic approach to reducing process variation and achieving improvement utilized in Six Sigma. DMAIC is an acronym for Define, Measure, Analyze, Improve, and Control – the five phases of a Six Sigma improvement project (Pyzdek & Keller, 2009).

Design for Six Sigma (DFSS): The approach used to design a new process rather than improving an existing process (Pyzdek & Keller, 2009).

Black Belts (BB): Specially trained individuals responsible for leading Six Sigma team through the DMAIC process. They usually occupy full-time positions. Training in statistical methods and quality improvement techniques are prerequisite (Pyzdek & Keller, 2009).

Master Black Belts (MBB): Individual who train and mentor Black Belts. They are highly trained in statistics and quantitative analyses, possess excellent leadership skills, and usually occupy full-time position (Pyzdek & Keller, 2009).

Green Belts (GB): Similar to Black Belts; however, they may possess less statistical expertise and usually occupy part-time positions (Pyzdek & Keller, 2009).

Defects per million opportunities (DPMO): The number of defects out of one million opportunities for defects (Pyzdek & Keller, 2009).

Socialization: Process of conversion from tacit knowledge to tacit knowledge through share experience and joint activities (Nonaka & Takeuchi, 1995).

Externalization: Process of conversion of tacit knowledge into explicit knowledge (Nonaka & Takeuchi, 1995).

Combination: Process of conversion from explicit knowledge into more complex and systematic sets of explicit knowledge (Nonaka & Takeuchi, 1995).

Internalization: Process of conversion from explicit knowledge into tacit knowledge through learning by doing (Nonaka & Takeuchi, 1995).

Knowledge

Knowledge has been defined as "justified true belief" that increases an organization's capacity for effective action (Nonaka, 1994; Nonaka & Takeushi, 1995).

Tacit Knowledge: Tacit knowledge is personal knowledge based on individual experience, action, commitment, and involvement in a specific context (Nonaka, 1994). It is difficult to articulate, express, and formalize to others, so it is often transmitted to others in informal and subtle ways.

Explicit Knowledge: Explicit knowledge is often categorized as codified or visualized knowledge, which is transmitted in the form of formal and systematic language (Nonaka, 1994). It is often referred to as information.

Six Sigma Project Success: The extent to which the improvement goals of the project were achieved, performance of the process improved and project results to organizational benefits Anand et al. (2010).

Organizational Performance: Organizational performance is an extensively utilized dependent variable for organizational research. Arawati (2005) reported that customers satisfaction, internal business processes, innovation and learning, and financial perspectives, have been used to measure organizational performance.

1.9 Outline of the Thesis

The organization of the thesis follows the logic of the business research process. The thesis is organized into seven chapters. Each of the chapter contents are briefly explained and provided. It is summarized as below.

Chapter 1 Introduction

This chapter starts with introduction to the study which gives general idea about the research topic under study. It provides an overview of the background of the research that includes Six Sigma initiatives, its success stories and benefits of implementation. Then, it explains the scope and problem of the study followed by research questions and objectives. Next, it portrays the significance of the study and its expected contributions. The chapter ends with defining key terms used in the study and outline of the thesis.

Chapter 2 Literature Review and Theoretical Research Models Development

This chapter provides a theoretical basis of Six Sigma DMAIC methodology include activities, tools and techniques of each phases. The next section discusses the literature on knowledge management such as knowledge and it classification, knowledge-based view of the firm and theory of organizational knowledge creation process. The literature of relationship of Six

Sigma, knowledge management and organizational performance are discussed. Finally, theoretical research models are proposed based on literature review.

Chapter 3 Research Methodology

This chapter discusses the research design strategy and methodology employed in this research, which consist of both qualitative (case study) and quantitative (survey study) methods. The next section will describe the case study method which includes data collection, research protocol, data analysis procedure and validity and reliability. The last section will detail the research setting (population and sample size), questionnaire development and construction, data collection and analysis procedures for survey study.

Chapter 4 Case Study Findings and Analyses

This chapter describes result of case study data collection and analysis. First, the individual case study results are systematically reviewed according to each element of the research protocol. Then, it will be presented, analyzed, and interpreted according to Six Sigma DMAIC methodology sequence. A tabular presentation will be adopted to ease understanding at the end of each case study analyses. Finally, a cross-case analysis will be presented to view the differences and similarities between the cases.

Chapter 5 Research Model and Hypothesis

This chapter focuses on theoretical research models and its associated hypotheses. Research hypotheses about relationship between the variables of research models are established. A brief literature is also provided to support the formulated hypotheses.

Chapter 6 Survey Study Findings and Analyses

This chapter presents the results of survey data analysis. First section the sample description, characteristics and response rate are discussed. Second section will share the survey data screening and cleaning assessment results. Then, testing for non-response bias result is

presented. Next, measurement and structural model analysis for each research models are discussed. The chapter ends with the analysis and result of hypothesis testing.

Chapter 7 Discussion, Conclusion and Implication

The purpose of this chapter is to discuss the results of the study. The organization of the chapter will be as follows. The first section will discuss the results of the study, both case study and survey study. The second section will identify theoretical and managerial implications of the study. Next, limitation of the study and direction for future research will be discussed. Finally, conclusion of the study will be presented.

CHAPTER 2 LITERATURE REVIEW AND THEORETICAL RESEARCH MODEL DEVELOPMENT

2.1 Introduction

This chapter provides a theoretical basis of Six Sigma DMAIC methodology include activities, tools and techniques of each phases. The next section discusses the literature on knowledge management such as knowledge and it classification, knowledge-based view of the firm and theory of organizational knowledge creation process. The literature of relationship of Six Sigma, knowledge management and organizational performance are discussed. Finally, theoretical research models are proposed based on literature review.

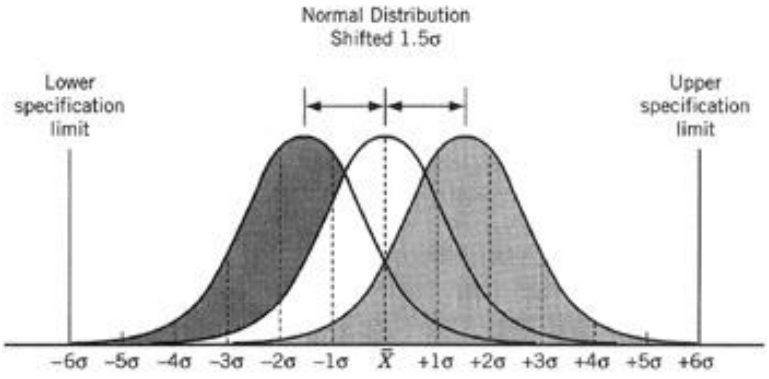
2.2 Six Sigma Basic and Concepts

2.2.1 What is Six Sigma?

Six Sigma concepts was pioneered by Motorola in the 1980s and boosted by the efforts of GE, Allied Signal, and others in the late 1990s (Braunscheidel et al, 2011). Today Six Sigma is one of the primary quality initiatives that have been billed as a critical business tools for the 21st century (Pepper & Spedding, 2010; Mader, 2008). In a fast changing business environment, companies have used Six Sigma initiatives to gain improvements in process and product quality (Biranvand & Khasseh, 2013; Gulcin & Demet, 2010; Snee, 2010; Kwak & Anbari, 2006). The success that companies have enjoyed is the results directly to improved customer satisfaction ratings and bottom line savings (Tjahjono et al., 2010; Zu et al, 2008).

Brue (2006) views Six Sigma has three meaning depending on the context. It is a level of quality (Pyzdek & Keller, 2009; Montgomery & Woodall, 2008); it is a problem solving methodology (Tjahjono et al., 2010; Antony et al., 2008) and it is a management philosophy (Summers, 2011; Kwak & Anbari, 2006; Antony & Banuelas, 2002). *Sigma* is Greek letter σ is used as a statistical measure of variation in a process (Chakraborty & Leyer; 2013; Gillett et al.,

2010; Omachonu & Ross, 2004). A stated sigma level is used to describe how well the process variation meets the customer's requirements (Pyzdek & Keller, 2009). Achieving a six-sigma level (6σ) of quality means that processes are producing only 3.4 defects per million opportunities (DPMO) with 1.5σ allowable shift under the normal distribution or practically it is corresponding to 99.999770% yield (Saghaei et al., 2012; ASQ, 2010; Raisinghani et al., 2005; Antony, 2004), refer to Figure 1.1. In other words, they are working nearly perfectly.



Spec. limit	Percent	Defective ppm
±1 σ	30.23	697700
±2 σ	69.13	308700
±3 σ	93.32	66810
±4 σ	99.3790	6210
±5 σ	99.97670	233
±6 σ	99.999660	3.4

Figure 2.1: Six Sigma Quality Level (Source: Breyfogle et al., 2003)

Most companies operate in three to four sigma ranges. As sigma level is increased, the defect per million opportunities decreases exponentially (Souza et al., 2013; Summers, 2011). For example, the sigma level is moving from three sigma (3σ) to four sigma (4σ), the DPMO drops from 77810 to 7210, then to just over 233 at five sigma (5σ). At three to four sigma, where most organizations operate, an organization spends about 15% to 25% of its sales on fixing problem (Pyzdek & Keller, 2009; Shah et., 2008). This is known as the cost of poor quality. As an organization moves to a five sigma level of performance, its cost of poor quality

drops to around 5% of sales (Pyzdek & Keller, 2009). The Six Sigma organization can expect to spend between 1% and 2% of sales on non-value-added activities (Pyzdek & Keller, 2009).

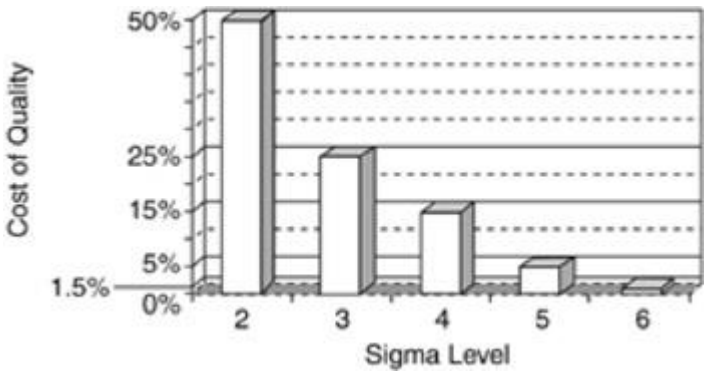


Figure 2.2: Sigma Level vs Cost of Quality (source from Pyzdek, 2003).

The cost of poor quality also drops quickly as dollar that go to waste in a three sigma organization (due to failure costs) go directly to the bottom line in a Six Sigma organization, to be reinvented in value-added activities which boost revenue (Souza et al., 2013; Garza-Reyes et al. 2010; McCarty et al., 2004). This is where the cost savings come from.

From this concept and statistical underpinning, Six Sigma has been developed into a disciplined and structured process problem solving methodology which is DMAIC (Dale et al., 2007; McCarty et al., 2004). Within each phase of DMAIC are specific Six Sigma process requirements and the deployment of various statistical tools and techniques (Garza-Reyes et al. 2010; Tang et al., 2007; Antony et al., 2005). DMAIC methodology is used to help an organization to identify and evaluate a defect, analyze root causes, make improvement and then control those improvements in order to deliver near-perfect products and services to customer (Tjahjono et al., 2010; Pande et al., 2002).

Six Sigma concepts has then moved from concentrating on improving existing manufacturing processes and services to design/redesign of product, process and services (Aboelmaged, 2011; Watson & Deyong, 2010). This is a Design for Six Sigma (DFSS) concept. In DFSS process the DMADV methodology is utilized with the aim is to design and engineer Six Sigma quality into the product and process as a proactive approach to defect prevention and elimination (Watson & Deyong, 2010; Antony et al., 2002).

Six Sigma has experienced an evolution since its inception at Motorola in the 1980s. First used by Motorola as a tactical defect reduction quality tool kit, Six Sigma has evolved through its application by other organizations (Hayler & Nichols, 2010; Magnusson et al., 2004). It was AlliedSignal that first began to use Six Sigma as a strategic enabler to achieving business objectives and also initiated the use of managing by process (Aboelmaged, M.G, 2011; Gulcin & Demet, 2010). Finally it was GE that not only added the strategic element of Six Sigma but also made it a cultural phenomenon (summers, 2011; Sarkar et al., 2013). Today, Six Sigma is a management philosophy (Firka, 2010; Mahanti & Antony, 2009; Markarian, 2004). It is customer-based approach that link and align the key business processes with the strategic business objective of an organization to continuously drive business processes efficiency and effectiveness and allow for innovation (Ray & Das, 2009; Kwak & Anbari, 2006).

2.2.2 Six Sigma Roles Structure

Six Sigma projects are at the heart of the Six Sigma methodology. These projects are carried out by a group of improvement specialists, typically referred to as champions, master black belts, black belts, and green belts (Morgan & Brenig, 2012; Gitlow, 2009; Schroeder et al., 2008; Linderman et al., 2003). A champion is an executive who is acting as the sponsor of a Six Sigma project and responsible to ensure that resources are available for training and projects; participating in project selection, scoping and review (Evans & Lindsay, 2005). Master Black Belts are the highest level of technical and organizational proficiency. They are technical