HOW TO IMPLEMENT LEAN SIX SIGMA IN CHINA: A CASE STUDY OF THREE MANUFACTURING COMPANIES

by

Na Li

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THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL

Dr. Chad Laux, Chair

Department of Computer and Information Technology

Dr. John Springer

Department of Computer and Information Technology

Dr. Stephanie Zywicki

Department of Education Curriculum and Instruction

Dr. Jiju Antony

Department of Technology

Approved by:

Dr. Kathryne Newton

I would like to dedicate this thesis to my family-my beloved husband Ke Xu and my parents Mr. Yiqiang Li and Mrs. Qingmei Wu.

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LIST OF ABBREVIATIONS

BAG	Brother Appliances Group
BB	Black Belt
CSF	Critical success factor
DMAIC	Define-Measure-Analyze-Improve-Control
DMADV	Define-Measure-Analyze-Design-Verify
EBHL	Everlasting Battery Holdings Limited
FMEA	Failure Mode Effect Analysis
FPY	First passing yield
GE	General Electric
IMVP	International Motor Vehicle Program
FAW	First Automotive Works
JIT	Just-in-time
HR	Human Resources
LSS	Lean Six Sigma
MSA	Measurement System Analysis
MBB	Master Black Belt
QC	Quality Circle
QMS	Quality Management System
SME	Small and Medium Enterprise
SOP	Statistical Process Control
SS	Six Sigma
TPM	Total Productive Maintenance
TQM	Total Quality Management
WMS	Warehouse Management System
VTCL	Victory Technology Company Limited
VM	Visual Management

ABSTRACT

Lean Six Sigma (LSS) has been implemented worldwide for many years and has been successful in many organizations. Eloot, Huang, and Lehnich (2013) noted that achieving manufacturing excellence by using LSS was an opportunity for many companies. Liker and Rother (2011) pointed out that only 2% of companies successfully achieved the desired results with Lean plans.

The presented dissertation identified the critical success factors of LSS implementation for Chinese manufacturing companies and explored the challenges occurring during the LSS transformations. The objectives of this dissertation were:

i. to understand how the employee training process for LSS can be designed using total quality management (TQM) adoption in private manufacturing organizations in China;
ii. to understand how LSS practices can be adopted successfully in SMEs in China;
iii. to examine and explore the critical success factors (CSF) of LSS implementation;
iv. to discuss the challenges occurring during LSS transformation.

Objective (i) was achieved through a descriptive single case study. This case study showed how to apply a design for Six Sigma methodology (DMADV) for staff training in quality management tools in a private organization in China. The author also discussed the problems occurring during the Six Sigma project and explored how organizational culture impacted Six Sigma implementation. Objective (ii) was achieved through a detailed descriptive single case study which recorded how LSS practices were adopted successfully in a SME-VTCL in China using DMAIC methodology. Survey data was collected to identify and explore the critical success factors of LSS implementation in SMEs, by querying the voice of top, middle, and frontline management, as well as frontline workers of these companies. Objectives (iii) and (iv) were realized utilizing descriptive, exploratory, and multi-case studies designed to gather and analyze observational and interview data. The resulting interview data, and the key factors for successful LSS transformation of these three companies were discussed from the perspective of senior management and LSS promoters within the companies. Based on interview data and the Lean iceberg model, a new LSS transformation model was proposed. The author also developed 6 propositions based on the findings from the interviews.

In summary, the results of this study provided value and references for LSS practitioners to expand the body of knowledge on the strategies used to implement LSS successfully inside organizations. The findings of this research may potentially lead more Chinese organizations to successfully adopt LSS to provide customers with high-quality products. The three LSS implementation cases described critical success factors (CSFs) and challenges that occurred during the transformation, may improve the success rate of implementation, help enterprises achieve the desired results through LSS, and enhance the sustainability of LSS implementations.

CHAPTER 1. INTRODUCTION

In the era of globalization, an increasing number of companies are realizing the importance of eliminating waste in the process and implementation of continuous improvement initiatives in their organization. LSS, the integration of two process improvement methodologies – Lean manufacturing and Six Sigma, is a systematic problem-solving technique and business improvement strategy. Lean manufacturing has been widely adopted by many companies all around world in order to remain competitive. LSS originated from the automotive industry and has now been adopted in manufacturing, service and healthcare.

However, Lee, Wong, and Yeung (2011) pointed out that many researchers and practitioners have criticized the Six Sigma (SS) methodology for being difficult to implement and integrate into the existing quality management system. Thomas and Barton (2006) also pointed out that the effective implementation of Six Sigma in manufacturing industries was relatively poor, especially in small and medium-sized enterprises (SMEs). During the period of widespread adoption of LSS, the two main obstacles faced by the company are high cost and complexity of implementation. Six Sigma is recommended only for large enterprises with adequate human and financial resources.

By analyzing three case studies, the author of this dissertation described how LSS was implemented in three manufacturing companies in China. The author organized the research into three individual articles. The introduction begins with a brief overview of what LSS is and the current and historical status of implementation. The following is an overview of LSS history, research objectives, research questions, dissertation format, overall study design and conceptual framework. At the end of the introduction, the author gives a brief summary of each article.

1.1 Brief History of LSS

Since the early 1970s, heightened challenges from global competitors have urged the adoption of new manufacturing approaches by many manufacturing firms in US (Hall, 1987; Meredith & McTavish, 1992). Among all the emerging manufacturing methods, Lean production was considered the most salient (Womack & Jones, 1996; Womack et al., 1990). Since then, scholars have been involved in the research of Lean in order to better understand and predict the

outcome of the transformation and have actively applied Lean philosophy in business and process improvement. At the same time, as a new method of organizational change and improvement, Lean was also marketed as a cost-reduction mechanism (Bicheno, 2004; Achanga et al., 2006).

The initial thought of "being Lean" in an organization was often associated with "doing more with less" (Hampson, 1999; Ziskovsky & Ziskovsky, 2007; Radnor & Boaden, 2004). The first known integration of Lean and Six Sigma occurred in American manufacturing in 1986 (Salah et al., 2010). Albliwi, Antony and Lim (2015) stated that recently, the most popular business strategies for deploying continuous improvement (CI) in both manufacturing and service sectors is LSS. Ruben et al. (2017) defined LSS as a systematic data-driven methodology which integrates two powerful business improvement strategies of Lean Manufacturing and Six Sigma with the goal of reducing variation and removing waste in process. Garza-Reyes et al. (2016), Hu et al. (2008) and Snee (2010) defined LSS as a systematic approach that improves system performance through quality, delivery, customer satisfaction, and cost. Snee (2010) identified three features of LSS: (i) integration of the all the employees and all the areas of process for improvement; (ii) focus on the financial improvement of the bottom-line ($); and (iii) a methodology that combines and links different improvement tools into an overall approach, resulting in a more comprehensive deployment approach than the ones used by other improvement initiatives.

Corbett (2011) pointed out that the isolated deployment of Six Sigma could not eliminate waste in the manufacturing process, and the isolated deployment of Lean management could not reduce changes while controlling a process statistically. Corbett (2011) pointed out that the fusion of Lean and Six Sigma was necessary because (i) Lean alone cannot bring a process under statistical control; (ii) Six Sigma cannot dramatically increase the efficiency of a process or reduce capital invested; And (iii) Lean and Six Sigma together can reduce the cost of complexity.

Albliwi, Antony and Lim (2015) presented a systematic literature review of LSS, pointing out that there has been a noticeable increase in academic research papers and journals on the subject of LSS since 2003, the year the first paper was published on how LSS was applied in manufacturing sector. Albliwi, Antony and Lim (2015) summarized the top ten benefits in the LSS application case studies as follows:

1) increased bottom line on financial savings and profits
2) increased overall customer satisfaction
3) reduction in cost
4) reduction in cycle time
5) improved key performance index
6) reduction of defects
7) reduced machine breakdown time
8) reduction in inventory level
9) improved quality level
10) increased production capacity

1.2 Current Status of LSS Implementation in China

Over the past decades, economic growth in China has been phenomenal and it has become the second-largest economy in the world since 2012. Based on the data from the World Bank, China's GDP in 2017 was $12.238 trillion, with an annual growth rate of 6.9 percent.

Due to lower labor rates and outsourcing trends, many multinationals have established production facilities in China. However, as China's economic growth has slowed in the past decade due to fierce global competition, Chinese companies are eager for transformation (Figure 1-1).

Figure 1-1 China annual GDP growth forecast from 2016 to 2021 (World Bank, 2019)

As a pillar industry of Chinese economy, manufacturing majorly relies on labor costs and raw materials to obtain competitive advantages (Zhang et al., 2016). Low costs of raw materials and labor have been key factors in China's emergence as the world's largest manufacturing economy. However, Chinese manufacturing companies are facing many challenges and problems. These include serious overcapacity, unconscionable industrial structure, lack of core technology and low quality (Zhang et al., 2016). Chinese manufacturing companies are under pressure to transfer from labor-intensive to technology-intensive industries. The Chinese government is also motivated to push industry to upgrade its position in the value chain, tapping into new growth patterns based on technology innovation instead of low-cost labor (Adhikari & Yang, 2002).

In the 1990s, many traditional manufacturers in the USA and Europe either transferred to the Lean approach or created new cellular production systems. However, Lean production application in China actually predates European and American manufacturers, starting in the late 1970s.

In 1949, the People's Republic was founded. The first automotive plant, First Automotive Works (FAW) was built in Changchun in 1953. FAW, China's oldest carmaker, was the Chinese prototype for mass production adopting Lean manufacturing. FAW was the largest of the 156 projects of technological and financial assistance that the Soviet Union undertook in China. FAW is the symbol of the birth of the Chinese car industry. In the early 1980s, the Chinese government introduced Japanese management methods to China. China invited Taiichi Ohno as the proponent of Just-in-time (JIT) to conduct on-the-spot technological direction in the factory in 1977 and 1981 (Chen, Lee, & Fujimoto, 1997). The initiative of this transfer was the result of intensified market competition and costly model change.

In China, Six Sigma was first adopted in a few large organizations, such as Haier, TCL, Midea, ZTE, Gree, Chunlan and Hainan Airlines (Lee, Wong & Yeung, 2011). Six Sigma adoption in these companies was relatively easier than in small and medium companies because of the considerable resources available. However, the success rate of Six Sigma implementation is relatively low in China now. Lee, Wong and Yeung (2011) pointed out that the major problems faced by Chinese enterprises in implementing Six Sigma were low education level, lack of intellectual capacity, high staff turnover rate, financial limitations, lack of time resources, lack of strategic vision and long term goals formulation as well as resistance to change.

After joining WTO in 2001, Chinese manufacturing companies have faced fierce international quality competition. A growing number of Chinese manufacturing companies are adopting Six Sigma Management, Total Quality Management (TQM) and Lean principles to improve the quality of their products, aiming to build a more standardized quality management infrastructure (Wang & Hussain, 2011).

The following table is a summary of the timeline of the adoption of TQM, Lean and Six Sigma in United States and China.

Table 1-1 Evolution of TQM in USA and China

	United States	China
1920s	P. Dudding at GE used statistical methods to control the quality of electric lamps. Henry Ford wrote *My Life and Work* with Samuel Crowtha and published it. It focused on elimination of all types of waste and improving process efficiency. This became the basis of Lean principles used today.	N/A
1930s	Walter Shewhart developed a statistical analysis method to control the quality of product during the manufacturing process.	N/A

Table 1-1 continued

1950s	W. Edwards Deming went to Japan and presented statistical analysis method of controlling product quality to Japanese engineers and executives. People now believe that this was the origin of TQM. Controlling quality and managerial breakthrough was taught by Joseph M. Juran. "Total Quality Control" by Armand V. Feigenbaum was published. Feigenbaum is now considered the forerunner for the present understanding of TQM. Philip B. Crosby proposed the concept of zero defects, which paved the way for quality improvement in the future.	The first automobile plant, FAW opened. Mass production was introduced from the Soviet Union to China.
1968	The Japanese named their business strategy Total Quality Control, and the term "quality management systems" arose at that time.	N/A

Table 1-1 continued

1980s	TQM was defined as the philosophy of a broad and systemic business approach adapted to managing organizational quality. The Six Sigma management strategy was proposed by Bill Smith from Motorola in 1986 and was disseminated by GE in the 1990s. Different quality standards such as the ISO 9000 series and quality award programs such as the Malcolm Baldrige National Quality Award and the Deming Prize all specify principles and processes required in TQM.	TQM and Lean production was introduced into China and directed by the Chinese government.
1990s		Chinese enterprises started to be certified by ISO 9000.
2000s-Today		Six Sigma, LSS, Lean Manufacturing, and the Baldrige Excellence framework were introduced and adopted in a growing number of enterprises in China.

In Table 1-1, General Electric (GE) in the US already started to utilize statistical process control (SPC) to control quality in 1920s. 30 years later, China had just built the first automobile plant and started mass production. The development of the manufacturing industry in China was far behind that of the United States and Japan at that time.

In the 1980s, the Lean and TQM philosophies were first introduced in China, while both had been developed and adopted in Japanese manufacturing companies for over 10 years. Six Sigma was proposed by Bill Smith in Motorola in 1986 and became widely internationally known after the 1990s. However, Six Sigma was not introduced into Chinese manufacturing until China joined the WTO in the 2000s. In recent years, Lean and Six Sigma have been widely utilized in both service and manufacturing industries in the US and Japan. The history of LSS

implementation in Chinese companies is far shorter than in the case of the US and Japan. Besides, Six Sigma originated from the US, while TQM and Lean were came from Japan. These management strategies were formulated based on their own culture instead of the culture of Chinese companies. These are the reasons for the low success rate of LSS implementation in China. In this study, the author explored the critical success factor of LSS implementation based on the culture of Chinese companies and help Chinese organizations to better utilize LSS to elevate their performance.

1.3 Research Objectives

The objective of this study is to understand how LSS is implemented in China, the primary barriers and obstacles encountered by manufacturing enterprises, and the CSF of LSS implementation in China. This study is important and timely because the success rate of LSS implementation in China is incredibly low, less than 10 percent. Manufacturing is the mainstay of the Chinese economy, but China relies primarily on low labor and raw materials costs. Currently, these advantages are disappearing as global customer demand is becoming more sophisticated. China's GDP growth forecasts have declined since 2016. A growing number of Chinese manufacturing companies hope to use LSS to improve their business performance, elevate product quality and reduce production costs. However, the success rate of LSS is quite low and very few companies have successfully utilized LSS to achieve their performance improvement goals. The author hopes this research may contribute the knowledge of LSS implementation in China and help practitioners to better implement LSS in Chinese manufacturing.

1.4 Research Questions

By utilizing a case study research approach of three private manufacturing companies in China, this research investigated four primary research questions. These research questions are focused on understanding how to implement and integrate LSS in Chinese manufacturing organizations. The following are the primary research questions being investigated:

1) How may a Lean program be implemented using a DMAIC methodology in SMEs in China?

a. What are the critical success factors (CSF) of Lean implementation in SMEs in China?

2) How can a LSS training program implemented by DMADV in large manufacturing organizations in China?
    a. What are the major obstacles and challenges of LSS adoption in large manufacturing organizations in China?
3) How can LSS be implemented in manufacturing organizations in China?
    a. What are the critical success factors for the successful implementation of LSS in Chinese manufacturing organizations?

1.5 Dissertation Format

This dissertation study combines three case studies conducted in three manufacturing companies in China. Chapter Two and Three are two individual case studies which described how Lean manufacturing and LSS were implemented in two manufacturing companies. One company was a SME and the other was a large manufacturing organization. Chapter Two adopted the method of the questionnaire survey to determine the key success factors of the implementation of LSS. In Chapter Three, obstacles and barriers that occurred during LSS implementation were also discussed based on on-site observation. Chapter four used a multiple case study approach and compared the perspectives and experiences of LSS implementation from employees in different positions, including top management and LSS promoters. This dissertation format can provide practical experience and reflect different perspectives on the subject of LSS adoption by Chinese manufacturers. Multiple results from three studies may provide a more comprehensive understanding of LSS.

1.6 Overall Study Design

In 2019, the author conducted a qualitative case study at Victory Technology Company Limited (VTCL), a vehicle roof handle manufacturing company, Everlasting Battery Holdings Limited (EBHL), a battery manufacturing company, and Brother Appliances Group (BAG), a home appliances manufacturing company in China. The study design consists of three cases and the overall research approach is that of a case study. Before the study started, the author had

spent six months as a part-time LSS consultant at three study sites and worked in the quality control and human resources departments to observe how the HR department at VTCL, the Quality Control department at EBHL, and the LSS steering office at BAG respectively initiated LSS implementation throughout their organizations. As a LSS consultant, the author participated in some of the LSS implementation activities and coached Six Sigma Green Belts, Black Belts, and Lean practitioners. The author was on site for 28 consecutive weeks, 6 days a week, observing for approximately 840 hours. In order to gain access to the participants of the study, the author obtained approval from the quality director of EBHL, the general manager of the EBHL Yongda plant, the HR director of VTCL and the general manager of Shangyong of BAG. The HR departments provided contacts of potential participants in each organization. The author used WeChat, an online chat software, to send participants information about interview and questionnaire requirements with their consent. The author scheduled appointments with each participant and conducted one-on-one online interviews and administered an online questionnaire.

In Chapter Two, the author adopted a single case study approach and collected data from employees involved in Lean production through questionnaires. Participants included the frontline employees, frontline managers, middle managers and senior managers of VTCL. Based on the employees' self-reported judgment and author's observations, VTCL's achievement had reached the initial expectations.

Chapter Three is a published journal article in which the author adopted the single case study approach and collected data from on-site observation, company documentation and reports of LSS implementation in EBHL. EBHL suffered a large failure in its LSS implementation and tried to transfer from LSS to the Lean program.

In Chapter Four, the author adopted the multiple case study approach and collected data through on-side observation as well as interviews from plant managers and LSS supporting personnel of VTCL, BAG and EBHL. In this study, the author used analytical memos to record daily LSS activities and participants' feedback during on-site observation, and recorded audio of online interviews from plant managers and LSS promoters of the three companies. Nevertheless, all three companies encountered countless problems and challenges in their respective implementation processes. However, the author became interested in how these companies' LSS journeys independently progressed and what the critical factors that significantly impacted their

LSS implementation results were. The author also analyzed written documents (LSS implementation reports and Employees' LSS activities feedback notebooks) with the permission of the quality directors and HR directors at VTCL, EBHL, and BAG. The author transcribed and translated all interviews and provided participants with an opportunity to review the findings. The author coded all interview data and proposed a LSS transformation model based on the findings of this dissertation. The following section is a brief introduction of the three companies, as well as an in-depth understanding of the experience of participants in this study.

1.6.1 Research site 1: Everlasting Battery Holdings Limited (EBHL)

The selected study unit in Chapter Three is Everlasting Battery Holdings Limited (EBHL) and its subsidiaries (collectively, the "Group"). It is one of the largest lead-acid storage battery manufacturers in China. EBHL's products are widely used in electric tricycles, electric bikes, and special-purpose electric vehicles, among others. The headquarters of EBHL is located in the Zhejiang province in Southern China, with all 27 manufacturing facilities strategically located in regions that have high demand for lead-acid batteries, such as the Jiangsu and Zhejiang provinces. EBHL was established in 1998 with a total of approximately 20,000 employees.

1.6.2 Research site 2: Victory Technology Company Limited (VTCL)

Victory Technology Company Limited (VTCL) is located in Southern China, in the Zhejiang province. VTCL is a SME, its plant has an annual production capacity of 12 million vehicles, and the company has 150 employees. VTCL, a plastic parts processing company, is affiliated with a state-owned enterprise and was established independently in September 2010. Initially, VTCL mainly focused on hiring technical managers in injection molding. However, as annual sales grew rapidly, the original technical management team was in need of a new production management methodology in response to changing growth, competition, and management needs.

1.6.3 Research site 3: Brother Appliances Group (BAG)

Brother Electronics Group Company Limited, established in 1984, is listed as a Fortune 500 company. BAG is a global customer electronics and home appliance manufacturer in China. The total number of employees is approximately 73,000, with annual sales of 29 billion in 2016. BAG major product lines cover almost the whole home appliances market, including refrigerators, washing machines, TVs, air conditioners, water heaters, and microwave ovens. BAG started to implement LSS in 2005 and is one of the first companies to implement LSS in China. However, they are in an idle period in the LSS journey.

Institutional theory explains the implementation of LSS as a process of institutional isomorphism. The iceberg theory is driven by both visible and invisible variables within an organization.

1.6.4 Conceptual framework

In order to study the process of LSS implementation for the three manufacturing companies, the basis of this study is in Institutional Theory and Iceberg Theory, respectively. LSS is typically adopted to facilitate change within the organization and performance improvement inside an organization. Institutional Theory explains LSS implementation as a process of isomorphic institutional change. Iceberg Theory explains how LSS cultural transformation is driven by visible and invisible variables within an organization.

The Iceberg Model of Culture Theory

The Iceberg Theory, which was also known as the "the theory of omission," is a term used to describe a technique of writing coined by American writer Ernest Hemingway in 1923. Hemingway believed that the deeper meaning of a story should not be superficial but implicit. Edward T. Mall developed the Iceberg Model of Culture in 1976. It was based on the tragedy of the "Titanic," that most of the iceberg that the ship had hit was below the surface of the sea and only the tip of the iceberg was visible. Mall believed that the Iceberg Theory may be applied to culture. The visible aspects of culture are only the "the tip of the iceberg," with most of what drives the cultural transformation being below the surface, unseen and subconscious. In the Iceberg Model of Culture, culture renewal, observable behaviors in the workplace, discourses

and practices are visible above the waterline, while beliefs, values, philosophies, and attitudes, which are below the waterline, are often invisible and taken for granted (Abbasi, 2011).

Braithwaite (2011) pointed out that cultural change can not only influence and shape human behaviors and practices, but also change attitudes and values. Cultural change can be conceptualized as an iceberg. On one hand, physical issue and clinical activity are visible above the waterline, and on the other hand, psychological constructs are invisible (Braithwaite, 2011).

Hines et al. (2008) applied the iceberg model to Lean transformation in his book, called "*Staying Lean, Thriving, Not Just Surviving.*" Hines et al. (2008) concluded that Lean transformation inside an organization was primarily driven by five major variables: "technology, tools, and techniques" and "process management" were the two visible variables above the waterline, while "strategy and alignment," "leadership" and "behavior and engagement" were the three variables below the waterline (Hines et al. 2008). In this study, the author adopted the Hines Lean iceberg model as the framework of interview and analysis.

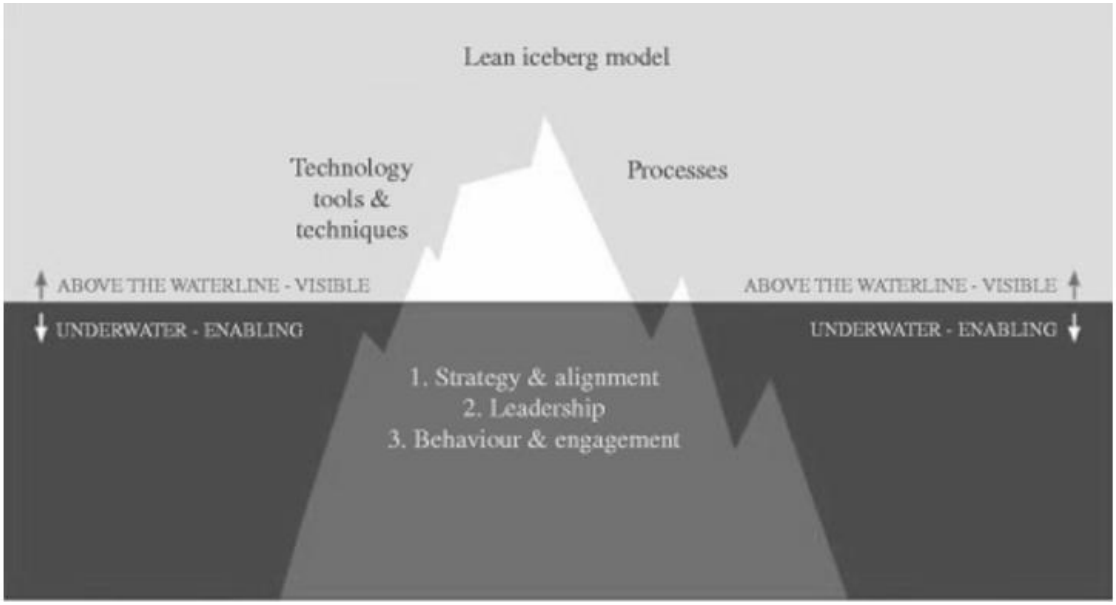

Figure 1-2 The Sustainable Lean Iceberg Model (Hines et al., 2008)

1.6.5 Situating my identity

In this section, the author will situate her identity in this research. The author works as a part-time LSS consultant and participates in some of the LSS promotion activities in each organization. The author situates herself as an insider in this study. Dwyer and Buckle (2009) stated that the issue of the researcher as an outsider or an insider to the group being studied was

an important aspect of the increasing exploration by social scientists. Hayano (1979) initially pointed out that due to the identification between the researcher and the studied group, insiders may ignore and make certain assumptions about the studied group. Kanuha (2000) further writes:

> "Being an insider researcher enhances the depth and breadth of understanding a population that may not be accessible to a nonnative scientist, questions about objectivity, reflexivity, and authenticity of a research project are raised because perhaps one knows too much or is too close to the project and may be too similar to those being studied" (p. 128).

Asselin (2003) pointed out that it was better for researchers who are considered insiders to collect data with their "eyes open," but at the same time, researchers need to assume that they know nothing about the phenomenon being studied. Additionally, he also suggested that the researcher might not be able to fully understand the culture, even if they were part of the culture under study. In this study, even though the author worked as an LSS supporting staff member, the author didn't have a great depth of communication with employees regarding their involvement in the LSS activities under study.

Based upon consulting experience in each of these companies and conversations with employees and other LSS consultants, the author is aware that a LSS program is very hard to implement. However, the author assumes that she is just outside and realizes her biases during interviews, questionnaire development in interpreting manuscripts transcribed, analyzing the results, and formulating conclusions.

1.7 Summary of Research Project

This dissertation is written in the portfolio format. Chapter One is the general introduction of the dissertation. Chapter Two, Three and Four are the manuscripts of the three research studies within the overall domain of LSS implementation in the manufacturing industry in China. Chapter Five is a summary of the general conclusions. Antony, Gijo, and Childe (2012) pointed out that even a single case had limited generalizability and contribution, but the aggregation of three each single case studies may add to the body of knowledge available for future practitioners and researcher by documenting previous case experience in light of existing academic literature.

In Chapter Two, a case research approach was employed to explore the CSFs of Lean implementation in a SME by DMAIC in China (Yin, 1994). In this chapter, the author first

conducted a literature review of the CSFs of LSS, including the CSFs of Lean, Six Sigma and LSS in the USA, the UK, and other western countries. Then the study describes how a Lean program was successfully deployed by using the DMAIC methodology of Six Sigma at VTCL. The CSFs of Lean implementation were analyzed and summarized based on the survey data collected from 36 participants. These were randomly selected from different managerial levels, including senior managers, middle managers, frontline managers, and frontline employees. The results indicate that key success factors for the adoption of Lean production in SMEs include leadership, LSS guiding the organization, employee participation, and organizational culture.

Chapter Three is a summary of a published journal article of a case study on how to design LSS training programs using the DMACV method under TQM in Chinese manufacturing enterprises. In the published study, the author also illustrates the major barriers and obstacles that occurred during this DMADV project. (The main body of this published journal is attached in Appendix C.)

Chapter Four is based on Chapter Two and Three and adopts a variety of case study methods. The research questions of this case are how to implement LSS in manufacturing companies in China and what are the CSFs of LSS implementation in China. The author collected questionnaire data from top management and LSS promoters. A survey with on-site observation was included. Based on qualitative data, an LSS implementation model derived from the Lean iceberg model is proposed. Based on the results, the author also makes five propositions:

1) LSS promoters' soft skills, such as communication, are more important than hard skills, such as knowledge of LSS technology and tools during the LSS promotion.
2) Process management, including supporting process establishment and standardization, will effectively enhance the sustainability of LSS implementation. Process management should be constantly improved based on the progress of LSS implementation.
3) Employees' loyalty and unity is helpful in LSS implementation.
4) It is easier for small companies than large ones to implement true LSS. In large enterprises, LSS implementation tends to become superficial or "fake."
5) LSS implementation will be more successful if done from the bottom up.

Chapter Five is a summary of the overall findings of this dissertation, including a discussion of the limitations, delimitations and future work.

CHAPTER 2. IMPLEMENTING LEAN IN A CHINESE SME: A CASE STUDY

2.1 Introduction

Lean and Six Sigma (LSS) are two widely known process improvement methodologies that focus on achieving significant results in terms of quality, time, and cost (Kumar et al., 2006). These two process improvement methodologies together can bring savings to the bottom-line of organizations, while Six Sigma focuses on reducing variability and Lean Production focuses on eliminating waste and non-value-added activities (Kumar et al., 2006). Currently, there is a great number of large organizations deploying LSS. However, Albliwi, Antony and Lim (2015) pointed out that LSS for small and medium-sized enterprises (SMEs) was the future research direction, because very few studies have been published on LSS application in SMEs. Additionally, the success rate of LSS implementation is very low even in large organizations, not to mention SMEs, which have limited financial capital investment and professionals (Albliwi, Antony & Lim, 2015). Liker and Rother (2011) pointed out that only 2 percent of companies implementing Lean management met the expected results of a survey conducted by Industry Week in 2007. They also stated that the Shingo Prize committee, which assesses Lean implementation and gives awards for excellence in Lean manufacturing, found that many of the past winners had not sustained their progress in the Lean journey after winning the award. Liker and Rother (2011) raised a question about why the pursuit of excellence using Lean methodology is so difficult to sustain.

Like companies in other countries, enterprises in China are also facing the same problem when implementing LSS. A LSS expert at a National LSS conference in China mentioned that currently, the average success rate of LSS implementation is less than 10%. The low success rate of LSS implementation in China then motivated this study. Here, the author presented how a Lean program was adopted successfully in a Chinese SME and discussed the critical success factors for the successful implementation of Lean strategy. The research direction of this study is to explore how the Lean program can be implemented successfully in SMEs in China.

The study unit in this case study is an anonymous company called VTCL here for confidential reasons. VTCL produces vehicle interior decoration in China. Currently, the net profit of VTCL products is continually shrinking because of increasingly fierce competition and

a rapidly changing market. Customer complaints were constantly received in regard to quality issues of products, and the management team hit a bottleneck in resolving the current problems. VTCL was seeking external assistance to find the root causes of their quality problems. An external LSS consultant was hired and LSS practices were adopted after the consultant pointed out that the Lean manufacturing and Six Sigma philosophy could help the company reduce capital investment and eliminate all types of waste in different areas of the value chain, which were the most attractive incentives for the company owner.

2.2 Lean Manufacturing Adoption by DMAIC in SMEs

2.2.1 What is Lean

The term "Lean" was first described by Womack et al. (1990) in *The Machine That Changed the World*. In the book, the results of research conducted by the International Motor Vehicle Program (IMVP) in MIT in 1985 were summarized. A new manufacturing mode developed by the Toyota Motor Company was first defined and described as "Lean production" (Baines et al., 2006; Emiliani, 2006; Holweg, 2007). Womack and Jones (1996) defined Lean as a systematic method aiming to remove different types of waste during manufacturing or the service process by all members in the organization from all areas of the value stream. Lean is often recognized as an effective cost-reduction mechanism (Achanga et al., 2006; Bicheno, 2004). Lean is aimed at strengthening the competency of the organization by increasing efficiency and decreasing cost due to the elimination of No Value-added Activity (NVA) and inefficiencies in the process (Motwani, 2003).

2.2.2 What is Six Sigma

Sigma (σ) is a letter in the Greek alphabet representing the normal density distribution. In industry, achieving a Six Sigma level means the quality of performance is nearly defect-free, which is only 3.4 defects per million opportunities. The definition of Six Sigma varies based on different scholars' perspectives. Tjahjono et al. (2010) stated that there were at least four streams of thought within Six Sigma. Goh and Xie (2004) as well as McAdam and Evans (2004) believed that the basic goal of Six Sigma is process improvement by applying a set of statistical tools that can be adopted in quality management. Chakrabarty and Tan (2007) believed that Six Sigma, as

an operational management philosophy, can be shared by suppliers, customers, employees, and shareholders. However, some scholars defined Six Sigma as a business culture. Commitment of top management is a critical success factor of Six Sigma because it can guarantee the full involvement of all the employees within the organization. Some scholars also referred to Six Sigma as a quality management methodology (Banuelas & Antony, 2004; Thawani, 2004; Black & Revere, 2006). Some of them took Six Sigma as an extension of TQM, because these two methodologies were similar to each other and DMAIC was oriented from Deming's PDCA cycle (Banuelas & Antony, 2004; Thawani, 2004; Black & Revere, 2006).

2.2.3 What are SMEs

The categorizing criteria of large, medium, small and micro-sized enterprises were published in 2017 by the National Bureau of Statistics and sets the guidelines for classifying SMEs in China. The guidelines mainly cover the employment base, business revenue, and total assets. The categorizing criteria are applied to industrial sectors, such as construction, wholesale, retail, transportation, warehousing, post service, hospitality, and restaurants. Based on the industry sector guidelines, the minimum number of SME employees is 20, and the maximum is 1,000. The annual operating income of SMEs should be no less than 3 million RMB and no more than 400 million RMB (See table 2-1).

Table 2-1 Categorizing criteria of large, medium, small and micro-sized enterprises in China

Industries	Index Name	Large	Medium	Small	Micro
Industry	X-Employment Base	X≥1000	300≤X < 1000	20≤X < 300	X < 20
	Y-Business Revenue (¥)	Y≥400M	20M ≤Y < 400M	3M ≤Y < 20M	Y < 300
Construction	Y-Business Revenue (¥)	Y≥800M	60M≤Y < 800M	3M≤Y < 60M	Y < 3M
	Z-Total Assets (¥)	Z≥800M	50M≤Z < 800M	3M≤Z < 50M	Z < 3M
Wholesale	X-Employment Base	X≥200	20≤X < 200	5≤X < 20	X < 5
	Y-Business Revenue (¥)	Y≥400M	50M≤Y < 400M	10M≤Y < 50M	Y < 10
Retail	X-Employment Base	X≥300	50≤X < 300	10≤X < 50	X < 10
	Y-Business Revenue (¥)	Y≥200M	5M≤Y < 200M	1M≤Y < 5M	Y < 1M
Transport	X-Employment Base	X≥1000	300≤X < 1000	20≤X < 300	X < 20
	Y-Business Revenue (¥)	Y≥300M	30M≤Y < 300M	2M≤Y < 30M	Y < 2M
Warehouse	X-Employment Base	X≥200	100≤X < 200	20≤X < 100	X < 20
	Y-Business Revenue (¥)	Y≥300M	10M≤Y < 300M	1M≤Y < 10M	Y < 1M
Post	X-Employment Base	X≥1000	300≤X < 1000	20≤X < 300	X < 20
	Y-Business Revenue (¥)	Y≥300M	20M≤Y < 300M	1M≤Y < 20M	Y < 1M
Hotel	X-Employment Base	X≥300	100≤X < 300	10≤X < 100	X < 10
	Y-Business Revenue (¥)	Y≥100M	20M≤Y < 100M	1M≤Y < 20M	Y < 1M
Restaurant	X-Employment Base	X≥300	100≤X < 300	10≤X < 100	X < 10
	Y-Business Revenue (¥)	Y≥10000	2000≤Y < 10000	1M≤Y < 20M	Y < 1M

2.2.4 SMEs in China

After China's reform and opening up in the 1980s, a growing number of private small and medium-sized enterprises (SMEs) emerged, making great contributions to the development of China's economy (Liu, 2007). Based on a report of Chinese small and medium-sized enterprise development, the value of finished products and services provided by private SMEs in China occupied 60% of the country’s GDP (National Administration for Industry and Commerce, 2014). By the end of 2013, there were 56 million SMEs which accounted for 94% of all enterprises in China (National Administration for Industry and Commerce, 2014). However, even today, SMEs are still continually growing in China while facing many challenges and problems. Liu (2007) pointed out that in the operation of SMEs in China, there are many

problems, such as weak linkage with the external market, weak technological innovation, inadequate financing, poor physical infrastructure and comparatively higher operational cost than in large organizations.

2.2.5 Lean manufacturing implementation in SMEs

SMEs in the manufacturing industry account for 53% of all SMEs in China and were preeminent in multiple industry areas (Liu, 2007). Currently, globalization and emerging technologies continually impact the manufacturing industry in China. Many SMEs find it difficult to survive in a more competitive macro market environment. SMEs operate in a reactive manner in order to adapt to these changing circumstances. Adopting Lean manufacturing, a systematic method, can create a streamlined, high-quality production system which can meet a finished product demand at the pace of the customer, became a breakeven point for Chinese SMEs. The Chinese economy is seeking greater productivity, greater flexibility in responding to changing customer needs, and lower operating costs. A core concept of Lean manufacturing is to minimize "Muda" – waste that exists within any process. In Lean manufacturing, anything but the minimum amount of equipment, materials, parts, space, and workers' time is defined as "Muda," which are absolutely essential for adding value to the product.

2.2.6 Critical success factors of Lean implementation

A critical success factor (abbreviated "CSF") refers to an element that is necessary for an organization or project to achieve its mission. Achanga et al. (2006) concluded that leadership and management, financial capabilities, skills and expertise, as well as organizational culture were the four key fundamental critical factors for Lean implementation within SMEs in the UK. Among these four critical success factors, leadership and commitment of top management support are the cornerstone of the success of Lean implementation in the organization. Shah and Ward (2003) discussed the influence of unionization, the age of the plant and plant size on Lean implementation. The author stated that unionized facilities could resist the adoption of Lean practices because most production practices require change to be negotiated within the organization (Shah & Ward, 2003). The age of the organization can indirectly reflect the

employees' tendency towards liability of newness or resistance of change. Stinchcombe (1965) suggested that the age of an organization had a negative impact on the rate of adoption of innovative or new management philosophies. Since the longer the company had experienced an organizational routine, the harder it was to replace old practices, even if the results of old practices were inferior. Additionally, the author pointed out that management tasks in large organizations tend to be more complex, and managers may not even try to change. This phenomenon is more severe in manufacturing than in service (Stinchcombe, 1965).

2.3 Case Study Research Methodology

In this study, a single case study approach is used as the research methodology. Yin (2009) stated that a case study was an empirical inquiry that investigates a contemporary phenomenon within its real-life context. Bryman and Bell (2006) pointed out that a case study should entail the detailed and intensive analysis of a single case - a single location, a single event, or a single organization. Antony et al. (2012) pointed out that even though each case had limited universality, it can still increase the overall knowledge for future researchers and practitioners by recording different case experiences based on the existing academic literature.

Yin (1994) pointed out that access to information was a critical factor in conducting case study research. In this study, access was gained through top management to middle management and frontline workers. Documents, including Lean implementation project reports and Lean meeting minutes generated from the LSS implementation, were utilized as data sources to assess the Lean implementation project. Surveys, interviews, and on-site observations were utilized to analyze the critical factors that will contribute to the Lean implementation results. Triangulation is a technique that can be used to ensure an account is rich, robust, comprehensive and well-developed. Denzin (1978) and Patton (1999) identified four types of triangulation, including methods triangulation, triangulation of sources, analyst triangulation and theory/perspective triangulation. In this study, the author used methods triangulation, a method of checking out the consistency of findings generated by different forms of data collection, to facilitate deeper understanding of what the critical success factors of Lean implementation in SMEs in China are.

The unit of analysis in this study was a selected SME in China which started to implement Lean manufacturing in 2014. Unlike most SMEs in China, the LSS implementation results in this organization are considered superior. The objective of this research is to present

what LSS practices this SME has adopted, explore how to adopt the lean production plan within the framework of DMAIC, and determine its CSFs through interviews with senior management and Lean production promoters.

2.4 Company Background

The automobile interior decorations SME in this study was established in 2010 as a subsidiary of a state-owned enterprise, which is a plastic parts processing organization. In this study, the author described how VTCL has implemented Lean manufacturing since 2014 and identified the CSFs to successful Lean adoption. VTCL primarily produces a variety of automobile interior decorations, including vehicle air outlet assemblies, vehicle assist handle assemblies, vehicle auxiliary clothing, and cap hook assemblies, etc. The majority (90 percent) of customer orders are vehicle roof auxiliary handles. Currently, VTCL has 27 injection molding machines and 12 assembly lines with an annual production capacity of 12 million RMB.

The total number of personnel includes 170 employees and 30 managerial and technical staff. Based on the SME definition, VTCL is a typical representative of SMEs in the manufacturing industry in China. Figure 2-1 shows the organizational structure of VTCL:

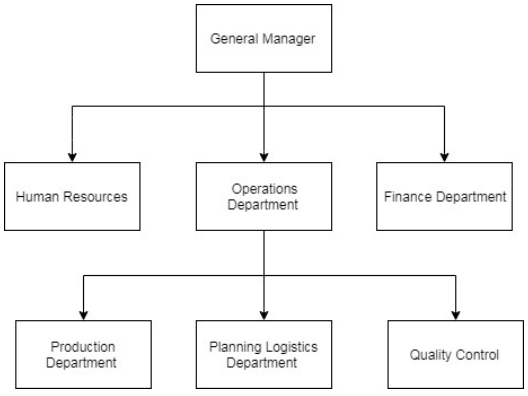

Figure 2-1 VTCL organizational structure chart

The overall organizational structure of VTCL is relatively flat, and the administration tasks are also very simple. As a manufacturing enterprise, the cornerstone of the company is the operations department, including the production department, the planning and logistics department, and the quality control department (Table 2-2).

Table 2-2 Responsibilities of each department

Department	Responsibility
Production Department	Entire production and manufacturing
Planning Logistics Department	Procurement, planning, warehousing and logistics
Quality Control Department	Outsourcing inspection, process inspection, finished product inspection, system maintenance, supply chain quality management, customer quality management, etc.

In the beginning, when VTCL was small-scale, the company owner mainly focused on hiring technical management employees. When the sales increased 100% annually, the existing technical team ran into management constraints, and the company needed a new approach to production management to address the challenges of growth, competition, environment, and management systems. The year 2014 was also a breaking point for VTCL. In 2014, a great number of customer complaints regarding product quality and internal quality issues emerged and VTCL was facing serious challenges. A situation of "either die or change" forced this company to look for external assistance and finally take the initiative to embrace change and start their own Lean journey.

2.5 Lean Implementation: A Case Study

In this section, the author described the Lean program implementation at VTCL based on documents including Lean implementation project reports and Lean meeting minutes in the organization.

This Lean adoption project at VTCL was focused on DMAIC utilization. DMAIC (Define-Measure-Analyze-Improve-Control) is a problem-solving framework used in Six Sigma for improving, optimizing and stabilizing business processes and designs. A startup Lean adoption process following a DMAIC methodology in Six Sigma was designed (see Table 2-3).

Table 2-3 Lean implementation plan

Lean implementation stages	DMAIC Phase	Step
Pre-implementation stage (Preparation)	1. Define	1.1 Voice of customer
		1.2 Lean objective
		1.3 Project charter
		1.4 Process flowchart
	2. Measure	2.1 Assessment before Lean implementation
		2.2 Assessment results
	3. Analyze	3.1 Cause and effect analysis
Implementation stage (Execution)	4. Improve	4.1 Multifunctional team
		4.2 Lean training
		4.3 5S/Housekeeping
		4.4 TPM
		4.5 “Push” to “Pull”
		4.6 Six Sigma
Post-implementation phase (Generalization)	5. Control	5.1 Implementation results review
		5.2 Constant improvement

This Lean adoption process is conducted as a DMAIC project and follows the DMAIC framework, consisting of five phases: Define, Measure, Analyze, Improve and Control. Each phase is described below, along with major milestones.

2.5.1 Define

In the Define step, the team states the problem and goals, identifies the customers served by the process under study, defines customer requirements, and writes a plan for how to complete the project. The goal of this Define phase is to have the improvement team and project sponsor or company owner reach a definition of the project based on scope, goals, and financial and performance targets. The Define stage is influential in aligning the project with the voice of the customer (VOC) from and specific project outcomes. Although the project sponsor identifies

key bottlenecks in the system, improvement areas and project objectives still need to be aligned with the organization's strategic business plan and VOC.

Voice of Customer (VOC)

Complaints and feedback from the customer and company itself were analyzed to identify the voice of both the external customers and internal customers. Severe quality problems existed in the finished products shipped to customers (vehicle manufacturers), resulting in a bad reputation and a lot of compensation. In 2014, VTCL received 60% more customer complaints compared to the previous year. From the business side, the first pass rate (FPR) of finished products was around 89%, with 11% of finished products scrapped and wasted. The inventory level of raw materials, WIP and finished products was also very high due to long production cycles. Before adopting Lean production, the company was financially bankrupt. This caused the owner to seek a new management philosophy and outside assistance, and to finally decide to make a thorough change.

Project Objectives

The general objectives of this Lean program adoption were as follows:

1) Improve the initiative of employee participation and create the atmosphere of Lean manufacturing throughout the company.
2) Reduce operation space and shorten logistics routes through optimization of material flow in order to ensure better control of the number of manufacturing process steps and the quantity of WIP.
3) Significantly improve production efficiency and reduce the need for operational personnel.
4) Significantly improve the quality of products and effectively control the product cost.

Project Charter

In the beginning of the project, its objectives, scope, resourcing, schedule, and team members as needed were confirmed (Table 2-4).

Table 2-4 Project charter

Business Case

Currently, company A is facing the biggest management bottleneck since 2010 as growing up because their customers, which are the vehicle manufacturers, are questioning the process management and complain about the product quality. Complaints appeared once per month and seriously damaged the company's reputation. The top management is seeking breakthrough opportunities and expects to adopt a new management philosophy-Lean production to resolve current problem and break through the bottleneck.

Opportunity Statement

Current, FYP of the finished vehicle handles is around 89%. 11% of finished products are scrapped and wasted. The condition of customer complaints regarding the quality of products received is dire. However, the management team met the bottleneck of reducing the defect rate and management methodology.

Goal Statement

LSS quality circle team building	Monthly defect rate of injection of large handles	PPM	101426	80000	21%
Improvement of production line	Average efficiency of large handle assembly	Unit/ person *hour	52.36	61.09	17%

The objectives of this project are as follows:

Section	Measurement Index	Unit	Baseline	Target	Improvement rate
Production planning model optimization	WIP Inventory	Day	7.43	6	19%
	Achieving rate of assemble plan	%	88%	95%	8%
	Achieving rate of injection molding	%	62%	75%	21%
Overall efficiency elevation of injection equipment	Monthly average OEE	%	64%	75%	17%
Improvement of quality passing rate	Monthly defect rate of finished products for large handles	%	2.87%	2.00%	30%

Project Scope

This project contains four sub-projects and is mainly focused on production planning optimization, overall efficiency elevation of injection equipment, product quality improvement, quality circle (QC) team building, and visual management improvement. The improvement areas were only limited in one selected sample assembly line.

Table 2-4 continued

Project Plan

Activity	Time						
	June	July	August	September	October	November	December
DEFINE							
Form team	■						
Develop charter		■					
Receive chart approval			■				
MEASURE							
Develop staff survey			■	■			
Review proposal types			■	■			
Administer staff survey				■			
ANALYZE							
Analyze survey					■		
Establish proposal categories					■		
Establish skill categories					■		
IMPROVE							
Create skill matrix						■	
Create proposal prioritization						■	
Create training matrix						■	
Validate matrices						■	
CONTROL							
Standardize prioritization matrix							■
Standardize skill matrix							■
Establish training plan							■
CLOSE OUT REPORT							■

Team Selection

Project Sponsor: Owner of company

Project Leaders: External Master Black Belt consultants

Team Members:

HR director

Operational director

Quality managers

Process flowchart

The variety of the products in VTCL is relatively monotonous since 90% of the products are vehicle roof auxiliary handles and the manufacturing process is very simple (see Figure 2-2). The core manufacturing technology is plastic injection molding.

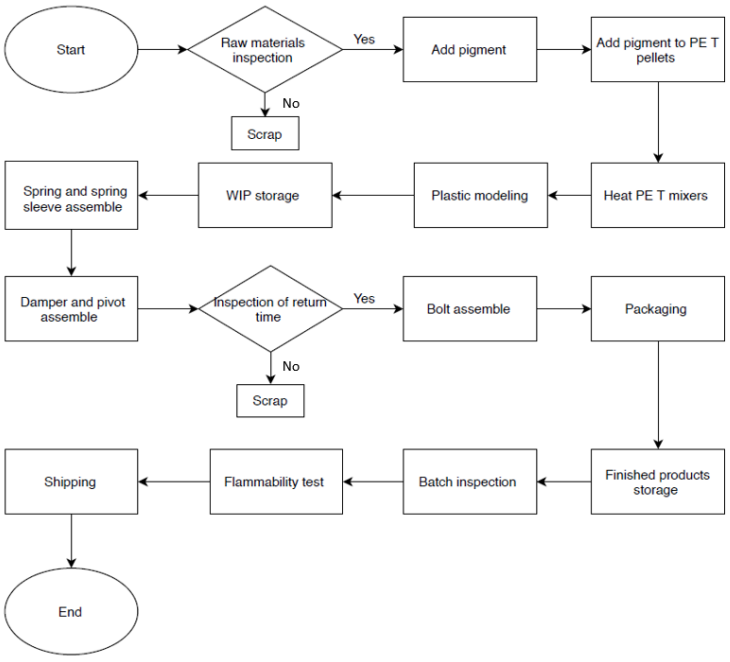

Figure 2-2 Manufacturing process of vehicle roof assistance handles

Before the Lean implementation project, the production plan was primarily based on the confirmed customer orders rather than internal projections of customer orders. This was due to

inadequate forecasting and inaccurate analysis of customer (vehicle manufacturers) demand (see Figure 2-3). The plastic injection molding was out of control. The injection plan was communicated by word-of-mouth and monitoring of yield was absent. The assembly plan was unreasonably based on the yield of plastic injection molding. All these factors lead to the fluctuation of delivery time and seriously affected the on-time rate of order shipping.

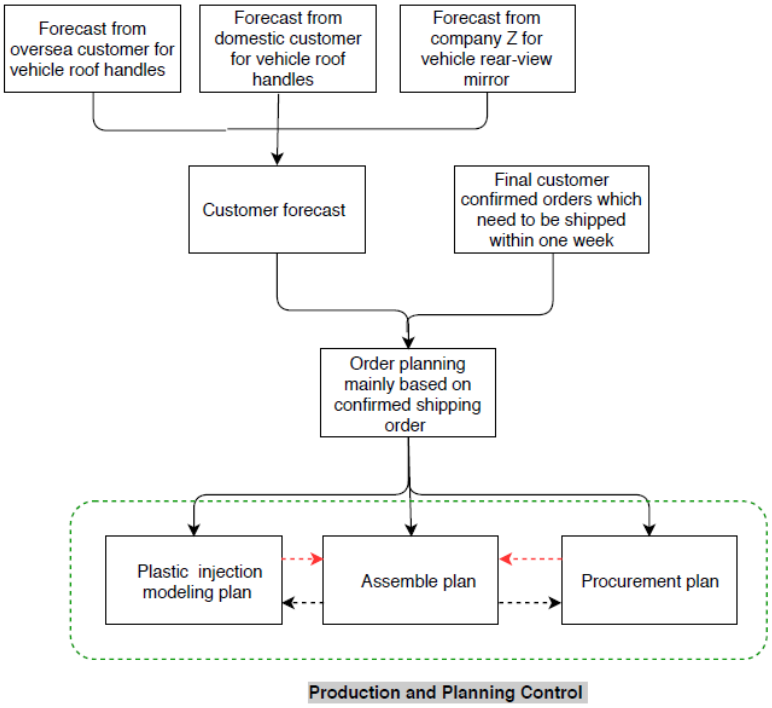

Figure 2-3 Production planning flowchart

2.5.2 Measure

Measurement is a key transitional step in the Six Sigma process that helps the team refine the problem and start looking for the root cause. This is a data collection step, the purpose of which is to establish process performance baselines. In the Measure step, the LSS consultant worked with HR and the operational director, assessing the current status of the company from five perspectives-fundamentals, quality, efficiency, logistics management and production management.

Current status for Ys

"Y" is the major project objective for reducing the defect rate of products and the order lead time by implementing Lean management. In this project, the major objective "Y" was broken into small goals, or "ys" – fundamentals, quality, efficiency, logistics management and production management.

y1: Fundamentals

The fundamentals of the factory included 5S, standard operation procedure (SOP), management principles, visual management, and employee training.

y2: Quality

The quality assurance system, employees' willingness to improve and the application level of effective problem-solving methodology were evaluated with respect to the quality objective.

y3: Efficiency

It was mainly focused on the evaluation of operational improvement, cross-trained workers and teamwork.

y4: Logistics management

The logistics management assessment included four aspects which were delivery/shipping time management, raw materials and WIP storage management, logistics layout, and labor and capital linearity management.

y5: Production management

Manufacturing techniques, constant improvement of daily operations, setup and production batch size selection, and daily maintenance of equipment were appraised as part of the production management objective.

The current status evaluation was conducted by the external LSS consultant and scored on a scale of 1 to 5 (see Table 2-5).

Table 2-5 Lean manufacturing assessment criteria

Score Level	Criteria
1	The principle of Lean Manufacturing hasn't been understood
2	The principle of Lean Manufacturing has been understood but hasn't been implemented in the organization
3	The principle of Lean Manufacturing has been understood and has been implemented partially in the organization
4	The principle of Lean Manufacturing has been understood and has been sophisticatedly implemented in the organization
5	Lean Manufacturing implementation has reached the ideal level

Assessment results

Current status was evaluated by the external LSS consultants and the production manager. The following table shows the assessment results (see Table 2−6).

Table 2-6 Assessment results before Lean implementation

Categories	No.	Item	Score
Fundamentals	1	5S	2
	2	SOP	3
	3	Management principles	2
	4	Visual management	1
	5	Employee training	2
Quality	6	Quality assurance system	1
	7	Problem-solving methodology	1
Efficiency	8	Employees' wiliness to improve	3
	9	Shop floor improvement	2
	10	Multiple-function	1
	11	Teamwork	3
Logistics Management	12	Logistics arrangement, U-line	3
	13	Warehouse management	1
	14	Delivery management	1
Production	15	Manufacturing techniques	1
	16	Improvement of daily working method	2
	17	Setup and batch production selection	1
	18	Machine maintenance	1
		Total score	31

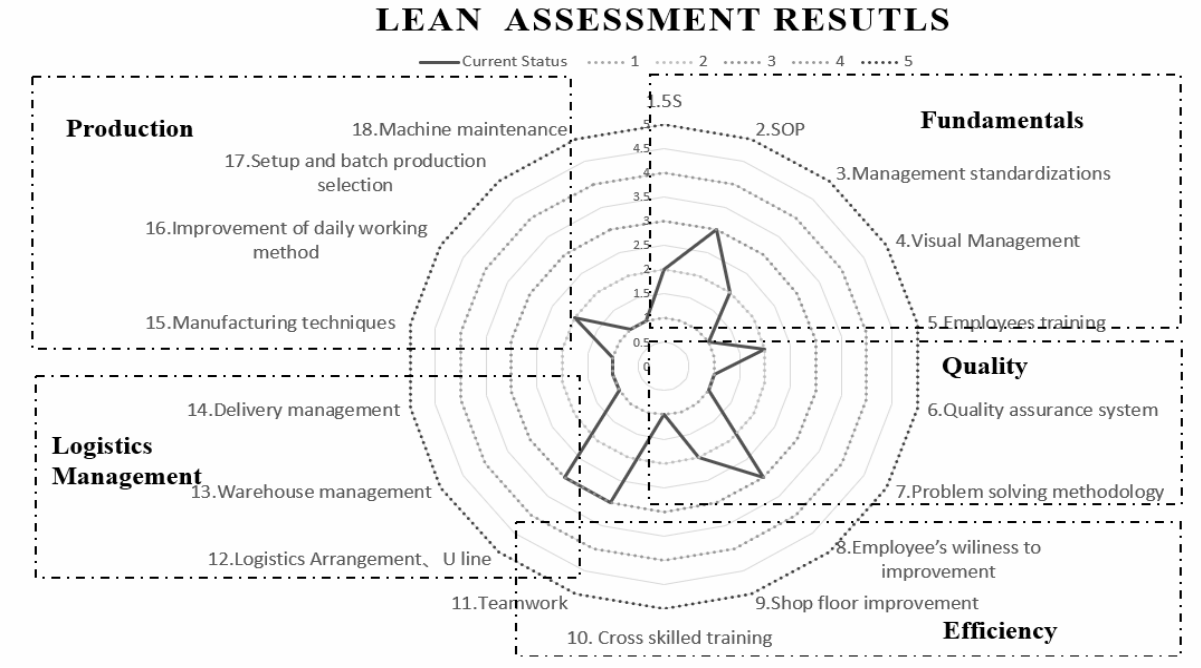

Figure 2-4 Spider chart of Lean assessment results

From Table 2-6 and Figure 2-4, we can see that the overall score of the 17 items evaluated is only 31 out of 85. 5S logistics management has been partially implemented inside the organization. However, there is no foundation in visual management, quality assurance system, problem solving, cross-skill training, warehouse management, delivery management, manufacturing process, setup and batch production selection, machine maintenance, among others, which needs to be addressed.

2.5.3 Analyze

The Analyze phase in DMAIC can be used to identify, validate and explore the root causes for variability in plastic handles manufacturing. Through root cause analysis, process input Xs can be identified as the root cause of project problems. In this phase, the project team analyzed the current major factors that contributed to the defect rate of finished products to set the improvement directions of Lean adoption. This includes logistics management, quality control, production management, efficiency, and teamwork and workshop management (see Figure 2–5).

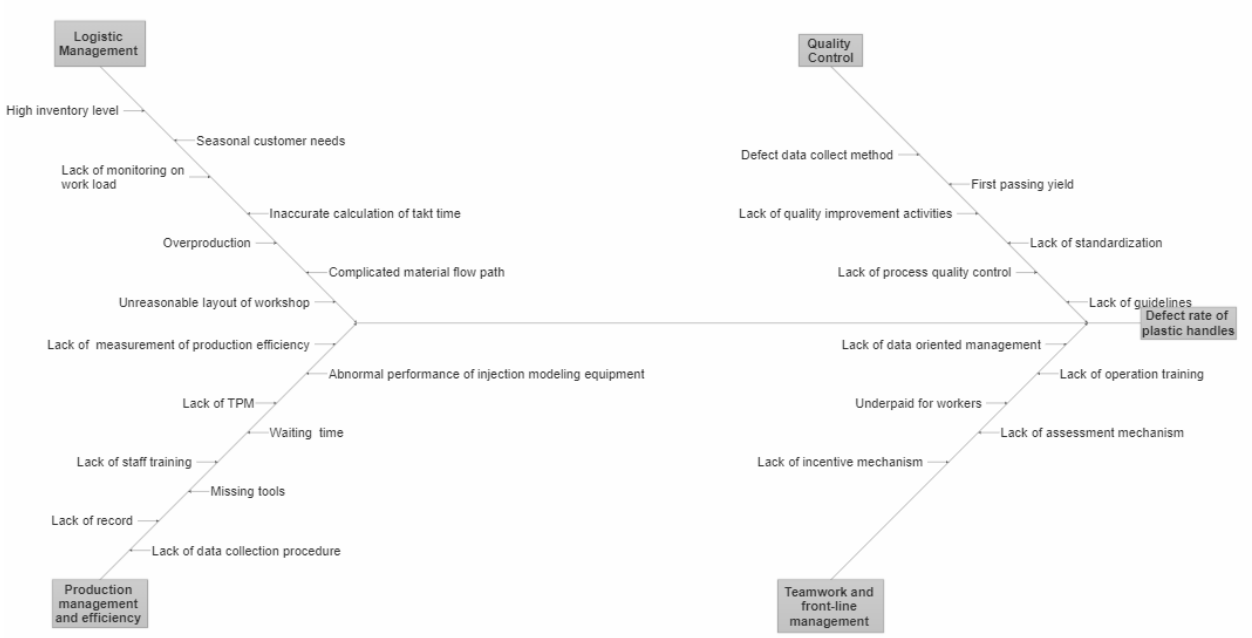

Figure 2-5 Fishbone diagram of Lean adoption in VTCL

Logistics management

The inventory turnover ratio evaluates the effectiveness of a company's management of inventory levels. At VTCL, in order to ensure continued large batch production, inventory levels of raw materials, WIP and finished products became very high, resulting in low inventory turnover. Before Lean implementation, the complementation ratio of production planning was very low and the accuracy was only 90%, which was mainly due to the fluctuation of customer orders in a peak time period. This highly impacted the balanced production. In addition, the lack of detailed monitoring of the working load rate on the shop floor had also impacted balanced production and needed to be further enhanced. The production plan was based on the master plan, but there would always be problems in the on-site manufacturing process, such as sudden changes in customer requirements, materials, production batches, equipment failure, quality, etc. All these factors affect the schedule of production.

In addition, the detailed production of the process and the measurement of the TAKT time were not accurate enough, with the overproduction problem still persisting. All of these factors influenced the progress of production planning. The mode of production at VTCL still needed to be further detail-oriented, including make-to-order, finished products make-to-stock, semi-finished product make to stock, etc. At the time, VTCL had not yet formed an evaluation

and adjustment mechanism for the whole company, and the planned capacity corporation in different assembly lines was irrational and needed to be further improved. After releasing the production demand plan, the following tracking actions were simply descriptive documents, rather than using quantitative metrics and operational metrics.

Due to the limitation of workshop space, the material flow was not reasonable. Systematic process layout planning hadn't been formed in the whole company, and the logistics path had become very complicated by that point, which lead to longer transportation times and waste of logistics and handling costs, thus resulting in lower production efficiency and longer cycle time.

The layout of the production workshop was also inefficient. Each workshop cell was not well connected, resulting in long internal transportation distances and times. The standardization of production lines still needed to be further optimized. The storage of materials also needed improvement. Although certain planning principles had been formed, detailed management of the material transportation mode, frequency, transportation tools, and so on were missing and stricter regulations were needed. The phenomenon of workers searching for materials in the production process still happens occasionally in the workshop. In conclusion, material transportation and storage needed to be further improved, especially the lack of IT operation, for example, although VTCL had simple warehouse management, but corresponding warehouse management system (WMS) was still absent.

Quality control

In order to improve the product quality, VTCL has upgraded the quality management system (QMS), bypassing TS16949 certification. The first passing yield (FPY) of handles manufactured was 90%, assembly line was 97%, and the injection molding process of the main products was 98%. Generally speaking, the quality control of products was acceptable. However, the implementation of Lean production within the company was needed to further improve product quality control.

The data collection procedures for defect rates needed to be improved. At the time of the study, there was a lack of detailed data records on rework, repair and scrap, which made it impossible to conduct systematic analysis. In the manufacturing process, excessive reliance on inspectors was needed in order to ensure product quality. Practical improvement activities such

as standardization, automation, Poka Yoke and the like were not enough. Only a few basic quality analysis tools were utilized. The product manufacturing process was lacking process quality control, such as Measurement System Analysis (MSA), a control plan, Statistical Process Control (SPC), Failure Mode Effect Analysis (FMEA) and so on, which are not applied in assembly lines now. Besides, each individual operation cell lacked process quality control guidelines. Engagement of frontline workers in quality control was also lacking. No quality feedback early warning system based on customer complaints has been established. On the side of suppliers, the quality of raw materials was very unstable. For example, color deviation was a common problem. The quality of raw materials needed to further improve and be controlled.

Production management and efficiency

At the time, there was no systematic method to measure production efficiency, no specific and measurable evaluation method, and no analysis of the process efficiency index. Injection molding equipment sometimes abnormally shut down, affecting the replacement time. Total Productive Maintenance (TPM) hadn't been implemented effectively. Mold and tooling management needed to be further elevated. The efficiency of the production line was low, which was mainly affected by the waiting time in the manufacturing process, the imbalance of TAKT in the processes, and problems of WIP quality, among others. The operation of the staff also lacked systematic training. Unstandardized operation happened all the time. Inefficient production appeared all the time because of a lack of necessary auxiliary tools. Sometimes, the equipment in production lines would also operate abnormally, and the fluctuation of quality level of assembly parts caused the abnormal production. However, detailed records and data collection on these abnormal productions were missing, affecting the product quality improvement in the following manufacturing processes.

Teamwork and frontline management

Although 5S management had been introduced on the shop floor, visual management (VM) had not reached the ideal level in the practical implementation process. For example, product labeling, color coding, function area labeling, among others still needed to be further improved. It was necessary to set up an emergency system for abnormal problems in the

workshop, but VTCL did not have an early warning system at the time. Frontline workers sometimes lacked the tools needed. No room or location was assigned to the QC team, and no information board was provided to display QC activities or Lean evaluation results. Frontline operators didn't accept systematized and standardized training. The process in certification, assessment, rotation, grading, and other details were incomplete. The workers were underpaid compared to the heavy workload. The incentive and assessment mechanism also needed to be further established and improved. Current qualitative assessment was far from enough, and also needed quantitative assessment to motivate employees.

2.5.4 Improve

In the improvement stage, the Six Sigma team must be ready for solutions that can address the root causes of the problem and the goal the team set in the Project Charter.

In this phase, Lean principles and content were introduced by training and the four project teams were established: logistics management, quality control, production management, efficiency, and teamwork and workshop management. Lean principles were adopted in small-scale sample areas at first. Since the current management team was limited in LSS professionals, a professional management consulting team was hired. Through the establishment of multifunctional teams, Lean manufacturing was introduced and implemented in the form of projects.

The Lean production model and measurement system were established, and Lean management was applied to the warehouse area, office area, and assembly lines. During the process of promotion of Lean manufacturing all over the company, all employees of the company were trained in the basic principles of Lean. QC teams comprised of frontline workers were also formed. All the employees were encouraged to participate in quality improvement activities, total production and maintenance (TPM), and daily 5S management work. Staff incentives and assessment indicators were also identified and developed accordingly. At the same time, routine daily inspection, weekly reports, monthly reviews and other procedures of the Lean improvement project were added to the daily tasks of the senior and middle management of the company.

Establishment of multifunctional Lean teams

A steering committee, a Lean promotion office, a project support team, and multifunctional Lean improvement teams were established to initiate Lean practices all over the company (see Figure 2-6).

Lean management steering committee

The Lean management steering committee was headed by the General Manager (GM) of VTCL. The steering committee's responsibility was to set up the strategic direction of the Lean improvement projects, allocate financial and labor resources, solve the problems occurring during implementation, and reward and motivate the improvement project teams.

Lean promotion office

The Lean promotion office was led by the Deputy Chief Operating Officer of VTCL and composed of full-time Lean promoters (project coordinators), and specialist consultants. Their responsibilities were to develop strategic plans for Lean implementation, organizational framework of Lean promotion, and work assignments according to the responsibilities assigned in the organizational structure diagram. They also needed to lay down a Lean production implementation plan and formulate an appraisal system. Lean promotion activities were included in members' daily management, and team meetings were facilitated to analyze and solve problems in the progress of Lean implementation in a timely manner.

Lean project support team

The Lean project support team was composed of staff from the finance and administration departments. They were responsible for project benefit assessment, training project development, activity process tracking, and administrative support for promotional activities.

Lean production improvement team 1

The production plan model improvement team, led by the manager of the logistics planning department, was responsible for the transformation of the production planning model from “Push” to “Pull.” This improved the completion rate of the production plan, and shortened the delivery cycle and inventory turnover days.

Lean production improvement team 2

The plastic injection molding equipment improvement team was led by the production manager and was responsible for the promotion and management of the work that related to total productive maintenance (TPM). They needed to analyze the main failure reasons of plastic injection molding equipment as well as organize relevant staff, frontline managers and workers to maintain the ideal operating conditions of the equipment in order to ensure Lean production can be carried out under optimal equipment conditions. This improved the overall equipment effectiveness (OEE).

Lean production improvement team 3

This team was headed by the director of Human Resources and was responsible for the promotion of 5S and visual improvement. They also needed to motivate frontline workers to form QC teams and promote QC teams to apply 5S and visual management practices on assembly lines and in individual workshops.

Lean production improvement team 4

The quality improvement project team was led by the quality manager and was responsible for utilizing Six Sigma methodology to reduce the variation of product quality, control production process, and formulate production inspection standards. They aimed to reduce the rate of scrap and defective products by using Six Sigma quality tools to ensure customer satisfaction.

Lean production improvement team 5

The assembly line production mode improvement team was organized by the operation deputy head and was responsible for U-line design layout through research, design, and improvement of tooling and workshops. As well, this team cooperated with the planning logistics department for the practical implementation of the “Pull” production mode on assembly lines based on the requirements of the flexible manufacturing system (FMS).

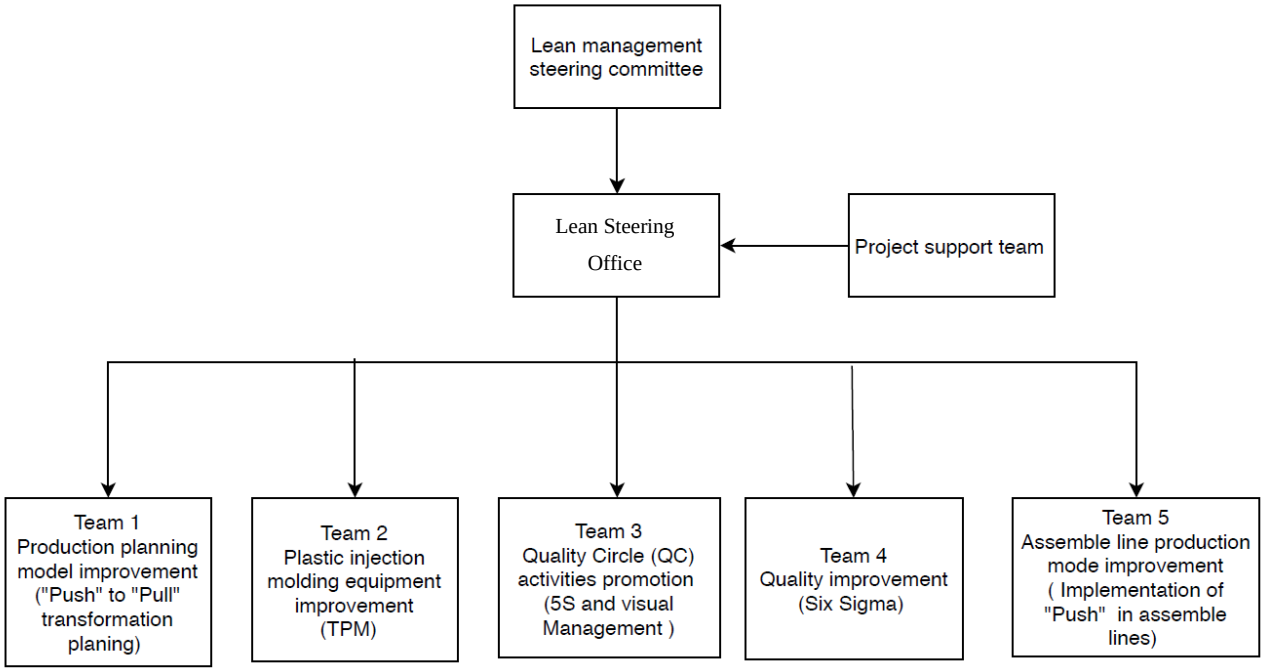

Figure 2-6 Organizational structure of LSS adoption

Establishment of the Lean training program

Before launching the project, all the senior managers of the company were required to participate in a mandatory two-day training by professional training institutions, so that all management was on the same page regarding LSS implementation, as well as establishing a common language for the following actions. Through the analysis of the current value stream flow and the basic status, as well as the ideal blueprint conceived by senior management, the following improvement topics were determined:

1) Can the capacity in key processes be expanded?
2) Can OEE be improved?
3) Can we establish an internal and external “Pull” mode?
4) Where is improvements location?
5) How to set up the project?

The LSS promotion office was established. The Process Improvement Manager (CPO) or lead (Champion), the project management team and the full-time implementation department team, such as the Integrated Management Department among others were all selected and assigned. Under the guidance of the professional consulting team, relevant activity management rules were made. The consulting team and the improvement team (value stream flow analysis group) investigated the situation deeply and formed the following conclusions: factory status analysis, current value stream mapping (VSM), design of future VSM, plan of initial goal of shortening the cycle time, data collection method of standardized working hours, goal of efficiency enhancement of key processes, identification of control points for current and future plans, selection of the right leader for the LSS improvement project.

Establishment of 5S and visual management

The principles of 5S and visual management were introduced to frontline workers by LSS consultants. The whole factory was divided into different areas, and frontline workers were responsible for 5S and visual management adoption on site based on the training progress in the assigned area. 5S demonstration areas were also selected and established in order to play a role of model and motivation for all the employees. 5S management was applied as follows:

S*eiri- Sort*

Frontline workers were required to separate materials or parts, machines or equipment, jigs and tools into two categories- “Unneeded” or “Needed”. Unneeded items were labeled by red tag. Unneeded items were moved from the site on time.

***S**eiton-Set*

The workstations were designed in a U-shape by utilizing Lean tubs to design appropriate working shelves. Tools and jigs were rationally assigned to specific areas based on the usage frequency and convenience level for the workers to take and return. Location indicators and item indicators were attached in order to show which item went to which location or address. Visual management standardization was developed and applied in selected 5S demonstration areas by the LSS consultant in order to set an example for the rest of functional areas.

***S**eiso-Shine*

Floors and machines were cleaned regularly and needed to be free of waste, water, and oil. Cleaning responsibility was assigned to workers overseeing cleaning operations.

***S**eiketsu-Standardize*

Standard procedures, such as equipment inspection and cleaning policy, were documented, and workers were required to follow the procedures under the supervision of frontline managers.

***S**hitsuke-Sustain*

In the morning meeting, frontline managers would spend 15 minutes training the workers in standard procedures. Procedures were reviewed regularly and updated based on the application by the steering organization. A hecking and assessment mechanism was established. The steering organization assessed 5S performance weekly and the performance results added to employees' performance appraisals.

Establishment of the Total Production Maintenance (TPM) system

Maintenance usually has a poorer return rate than other budget items, so the importance of preventative equipment maintenance will be taken for granted by many companies. Equipment management has undergone serious changes over the past decades. The traditional perception of maintenance involves reactive tasks of repair action or replacement for broken items. This is known as breakdown maintenance, reactive maintenance or corrective

maintenance. A more recent view of maintenance includes more proactive tasks such as periodic inspection, preventive replacement, and condition monitoring. VTCL used repair maintenance before TPM implementation, but transferred to preventive maintenance after the project. Additionally, maintenance cost was reduced by almost one third while the level of productivity was improved greatly after the project. Figure 2-7 shows the TPM establishment procedure.

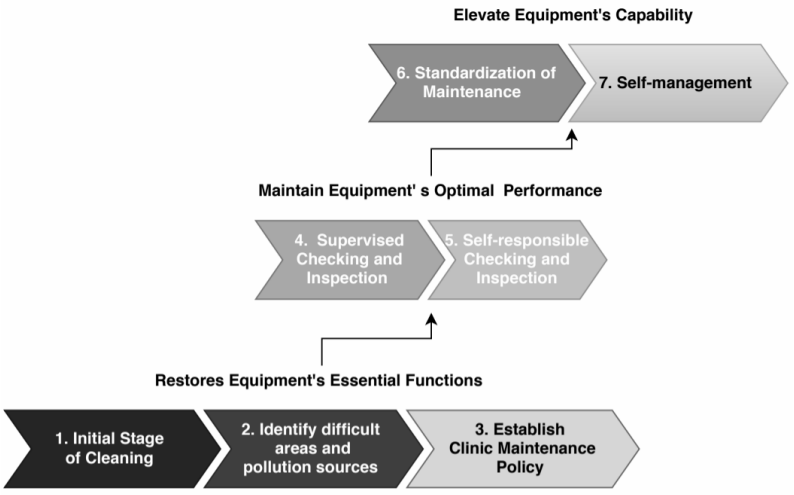

Figure 2-7 TPM implementation procedure

The following were the adoption steps for TPM at VTCL:

1) In the initial stage of cleaning, all of the onsite workers were required to clean the floor and all of machines in order to explore existing or potential problems with equipment.
2) After identifying the pollution sources and existing problems found in step 1, improvement solutions developed accordingly in order to reduce the initial cleaning time.
3) Temporary maintenance policy was created and documented. All the functional departments in the workshop needed to generate a temporary maintenance policy, and that would be printed out and hung up in an obvious location onsite.
4) Supervised checking and inspection was carried out. Frontline workers needed to receive training and understand comprehensively the principle, function, and structure of the machines. They needed to master the skill of inspection of all the components in a machine, identify the potential problems and develop improvement solutions to resolve the problems accordingly. All of this periodical inspection and preventive maintenance needed to be conducted under supervision from workshop managers.

5) Self-responsible checking and inspection was instituted. Steering organizations, aligned with the workshop managers and quality managers, needed to improve and perfect the clinic maintenance policy and improve the efficiency and accuracy of self-responsible checking and inspection.
6) Standardization of maintenance was implemented. The first 5 steps were reviewed, with all the checking and inspection activities standardized and documented.
7) Self-Management became commonplace. This is the optimal status and goal of TPM. Instead of top-down management, frontline workers gradually formed the routine of daily inspection and checking and had the motivation of constant improvement and assessment. Zero-defect production is the ultimate goal that VTCL is seeking to achieve in the future.

2.5.5 Control

The control phase is the sustainability stage that refers to continuing the follow-up improvement work after the LSS implementation phase so that the main gains of Lean Six Sigma projects in the company will be further enhanced. Every employee in the company should be able to feel the LSS culture from the bottom of their heart so that staff can voluntarily participate in the LSS work. Achievements and indicators of the implementation phase were tracked and monitored in order to make progress continuously.

Improvement results

Customer satisfaction

The major benefit of Lean implementation was improved customer satisfaction. Table 2-7 shows the percentage the defect rate and customer complaints improved after adoption. The improvement results were obviously outstanding. Before LSS implementation, the monthly defect rate of finished products could be as high as 2.63%, and it reduced to 1.08% after LSS adoption. Additionally, monthly customer complaints received decreased from 1.41 to 0.53 and the percentage of improvement was as high as 62.4%.

Table 2-7 Customer satisfaction improvement results

Item	Before (Monthly)	After (Monthly)	Percentage Improved
Defect rate of FP %	2.63%	1.08%	-58.9%
Customer complaints #	1.41	0.53	-62.4%

Inventory level

After the manufacturing mode transferred from "push" to "pull," the average days' sales of inventory decreased 19.2% from 7.43 to 6 days, resulting in less cases and shelves needed to store the raw materials and less storage space occupied in the warehouse. Additionally, liquidity of cashflow also increased dramatically because of the increased inventory turnover rate.

Overall equipment performance

After establishing a database of equipment management, failure analysis of equipment, operation standardization, standardized daily maintenance, and preventative maintenance for critical equipment there was an outstanding decrease in the failure rate of equipment. Overall Equipment Effectiveness (OEE) increased from 65% to 77.5%.

On-site working environment

After initiating 5S and visual management, the overall working environment has improved greatly. Equipment and floors were cleaned regularly. Tools at work stations were placed in order and in specific areas. Motion waste reduced dramatically. Operation safety was also improved accordingly.

Constant improvement

After the first Lean program was implemented in 2014, the owner of the company continually hired LSS experts and developed one Lean program and one LSS program in 2016 and 2018 to further enhance the development of LSS at VTCL. When the author visited VTCL in 2018, the author felt that LSS gradually became rooted in the culture and in the employees' values at VTCL.

2.6 Critical Success Factors of Lean Implementation

2.6.1 Data collection

The author collected data through direct observation on site, interviews and surveys to explore the critical success factors of Lean implementation at SMEs in China. The primary sources were interviews and surveys. The author collected 27 pages observation notes and analytical memos, received 46 valid questionnaires and interviewed 6 employees, including top management, middle management and LSS supporting personnel. Table 2-8 displays the quantity of the three data sources and the code used in the summary table of critical evidence forming the conclusions in the discussion section.

Table 2-8 Data sources of interview, survey, and on-site observation

Data Source	Quantity	Code
On-site observation notes, analytical memos	27	F1
Survey	46	F2
Interview	6	F3

On-site observation

Observation is a systematic data collection approach used in qualitative research. Researchers can utilize their senses to observe people's behavior in natural settings or naturally occurring situations. Participant observation combines researchers' participation in the lives of the people who were studied while maintaining a professional distance and allowing for adequate observation and data recording (Fetterman, 1998).

The author visited the factory of VTCL twice and worked in the steering organization at VTCL for 2 weeks. The author's natural involvement allowed her to observe how the Lean program was really adopted in the selected SME in China. The on-site observation data includes the notes and analytical memos of LSS activities that the author participated in.

Survey

The survey is used as one of the methods of data collection in this study. The questions used in the survey are the same questions developed by a Taiwanese researcher. In Cheng's research, this questionnaire is used to test the cause and effect relationship between the critical

success factors of Six Sigma implementation and quality performance in 160 Taiwanese companies (Cheng, 2013). Since the validity of the questionnaire has been tested in Cheng's paper, the validity of the questions will not be demonstrated again in this study. The detailed questionnaire can be found in Appendix B. Multiple linear regression is used to test which CSFs among the 7 variables (Xs) will significantly impact the Lean implementation results (Y).

Cohen (1988) defined the following conventional values for the effect size: small as 0.02, medium as 0.15 and large as 0.35. In this study, the author used the medium effect size of 0.15. Considering 7 independent variables need to be tested, when α is set as 0.1, effect size is set as medium 0.15, and the minimum sample size needed for each company should be at least 43 in order to get an actual power of 0.8 (see Figure 2-8). In this study, the survey data was collected from 46 employees participating in the Lean program, including frontline employees, frontline managers, middle managers, and senior managers.

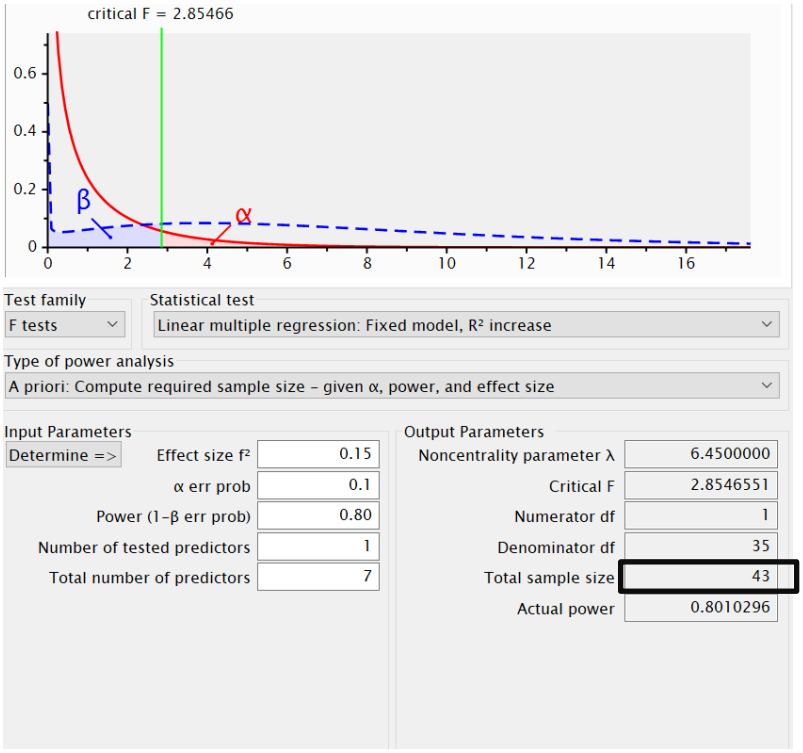

Figure 2-8 Sample size test results by G*Power software

In order to identify the critical success factors of LSS implementation in manufacturing organizations, participants were randomly selected by the HR director, representing the voice of

the whole company. Figures 2-9, 2-10, 2-11, 2-12 and 2-13 displayed the distribution of employees by department, position level, working time and age of the questionnaire participant.

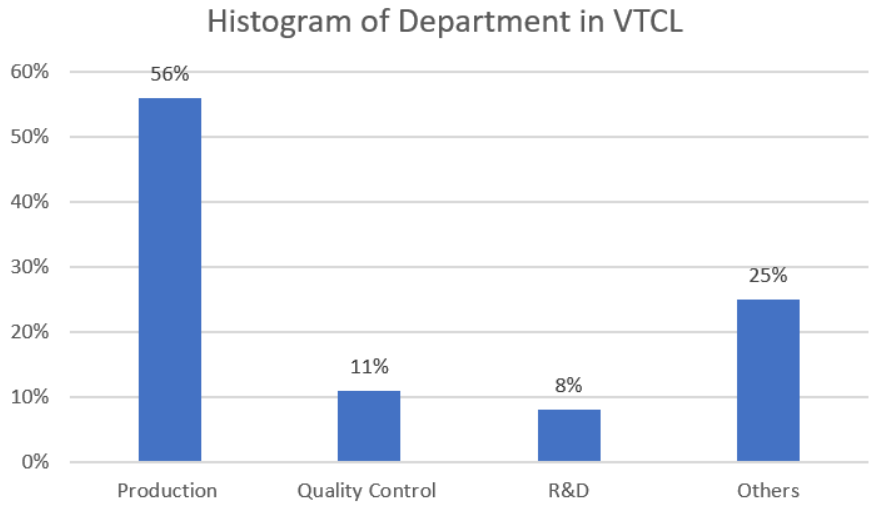

Figure 2-9 Histogram of departments in VTCL

Figure 2-9 displays the department these participants came from. 26 out of 46 (56%) participants came from the production department, 5 out of 46 (11%) came from the quality control department, 4 out of 36 (8%) came from R&D and 11 out of 36 (25%) came from other departments, like the financial department, HR and etc.

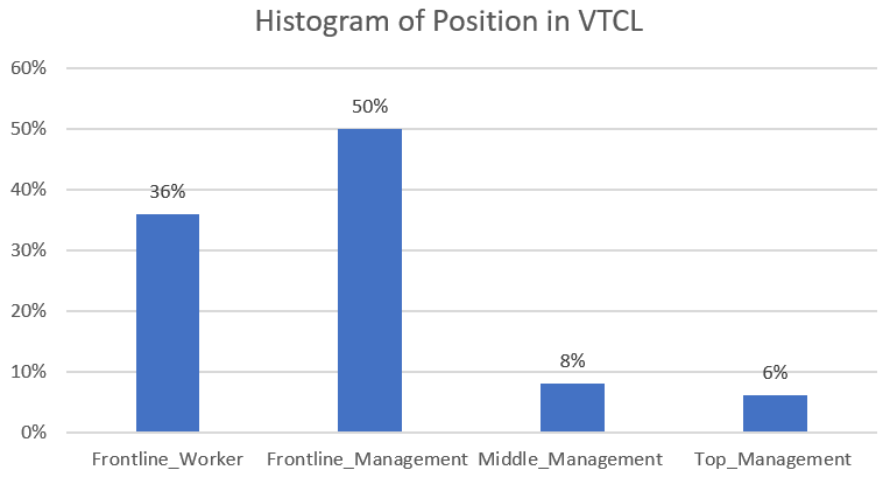

Figure 2-10 Histogram of positions in VTCL

Based on Figure 2-10, it is clear that the participants of the questionnaire include top management, middle management, frontline management, and frontline workers. Most of the participants are frontline staff. 17 out of 46 (36%) of participants are frontline workers, 23 out of 46 (50%) of the participants are frontline management, 4 out of 46 (around 8%) participants are middle management and 3 out of 46 (around 6%) participants are top management.

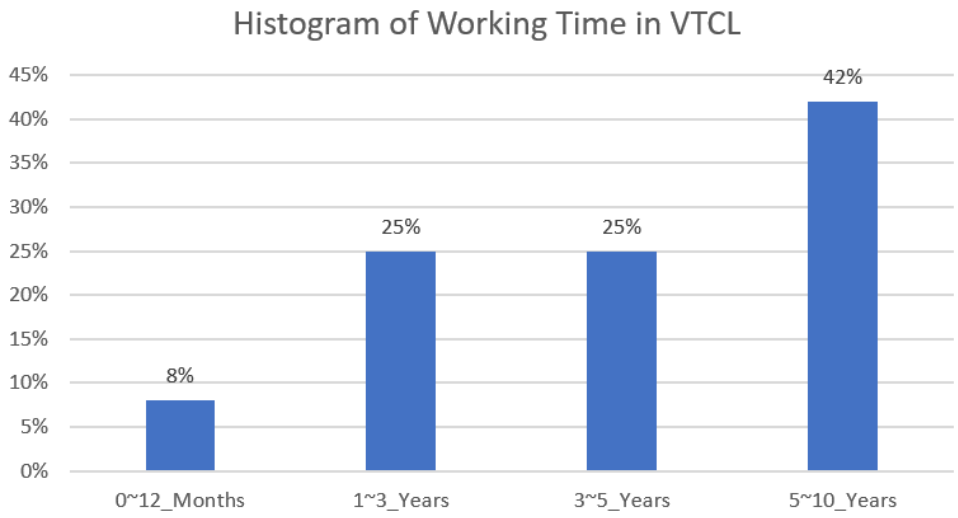

Figure 2-11 Histogram of working time in VTCL

At VTCL, the distribution of participants' working years was left-skewed and most of them (42%) had worked at VTCL for 5–10 years, since VTCL had been established for only 9 years, with no participants working there for more than 10 years. Only 4 out of 36 (8%) were new employees and had worked at VTCL for less than one year. 11 out of 46 (25%) participants had worked at VTCL for 1 to 3 years and 3 to 5 years.

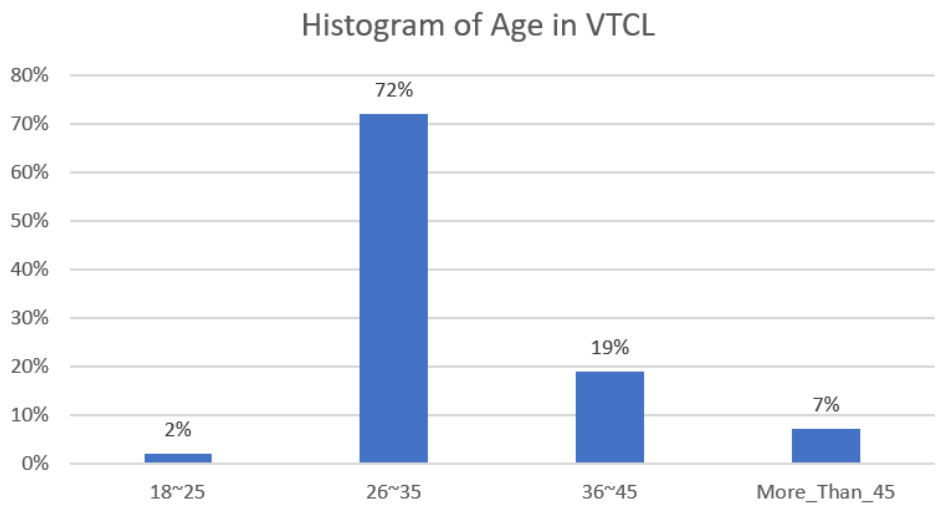

Figure 2-12 Histogram of age in VTCL

Figure 2-12 showed the age distribution of participants in this study, almost all of the participants at VTCL were at least more than 26 years old and most of the them were aged around 26–35. Only one participant is less than 25 years old. 9 out of 46 participants (19%) are 35–45 years old and only 3 participants are older than 45. Basically, most of the participants at VTCL are young people.

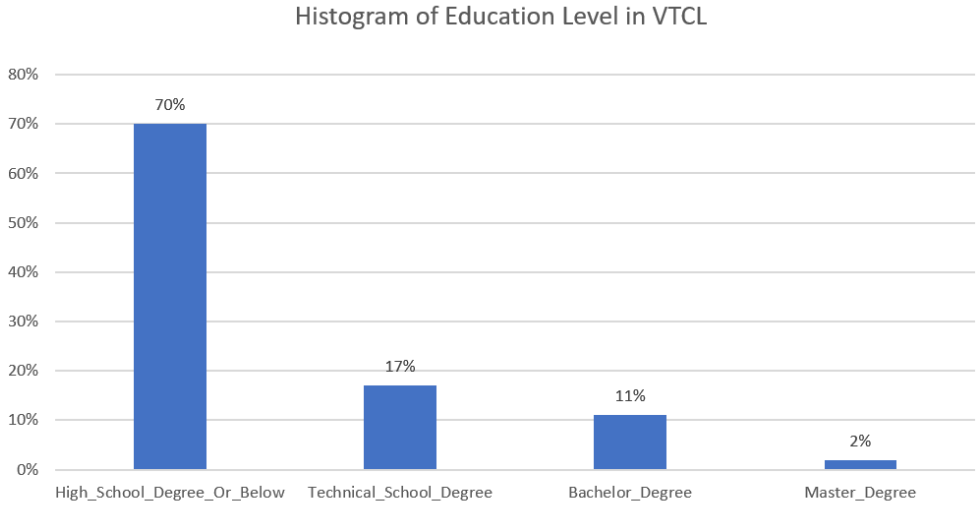

Figure 2-13 Histogram of education level in VTCL

Figure 2-13 displayed the distribution of the education level of the three companies. For VTCL, 70% of the participants' education is only high school or below. 17% of the participants

have graduated from technical school and only 5 participants (11%) have a bachelor's degree. In this plant, only the operation director has a master's degree.

Interview

The interview questions used in this study are based on the research by Peter Hines. The objective of the interview is to explore the critical success factors of the Lean program's implementation at VTCL. The interview question design basically followed the Lean iceberg model (Hines et al., 2008) and was developed from 5 perspectives, which were strategy and alignment, leadership, behavior and engagement, processes and technology, and tools and techniques. The detailed interview questions can be found in Appendix A.

Qualitative studies typically require a much smaller sample size than quantitative studies. The rationale here is that the researcher seeks rich, in-depth, meaningful data. In this study, the author interviewed 6 employees, including top management, middle management and LSS supporting personnel inside the organization. Table 2-9 shows the demographics of interview participants. T1, T2, M1, M2, S1, and S2 are the anonymous codes of interviewees' names and were used in data analysis and findings. "T" stands for top management, which means that the interviewees' position belongs to the top management level. "M" stands for middle management and "S" stands for LSS supporting personnel.

Table 2-9 Demographics of interview participants

Anonymous code	Position	Interview content	Frequency of interviews	Length of the interview
T1	Operational director	Lean implementation motivation, Lean implementation results evaluation, obstacles encountered during Lean journey	1	69 minutes
T2	Human Resource (HR) director	Lean implementation motivation, LSS implementation results evaluation, obstacles encountered during LSS journey	2	139 minutes
M1	Quality manager	LSS implementation results evaluation, obstacles encountered during LSS journey	1	47 minutes
M2	Production manager	LSS implementation results evaluation, obstacles encountered during Lean journey	1	35 minutes
S1	External LSS consultant/ LSS supporting personnel	LSS implementation results evaluation, obstacles encountered during Lean journey	2	95 minutes
S2	External LSS consultant/LSS supporting personnel	Lean implementation results evaluation, obstacles encountered during Lean journey	4	145 minutes

2.6.2 Data analysis

The primary data used in this study comes from surveys and interviews. In this section, the author describes the survey, interview data, and observation notes. Table 2-10 is the summary table and lists the typical evidence from interviews and on-site observation that contribute to the findings, as well as regression results from the survey.

Questionnaire

In the questionnaire, the participants were asked to score their LSS implementation results and their performance in each of the following criteria: leadership, customer-oriented mechanism, integration in business strategy, employee involvement, LSS skills and organizational culture based on 5 Likert scale. On the 5 Likert scale, 1 means very bad, 2 means bad, 3 means neutral, 4 means good and 5 means very good.

The following are the regression results (α=0.1):

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	5.05992	0.722845	7.14	0.000
X1-Leadership	1	0.44372	0.443721	4.38	0.046
X2-Customer-oriented mechanism	1	0.00029	0.000290	0.00	0.958
X3- Integration in business str	1	0.00276	0.002763	0.03	0.870
X4- LSS Steering organization	1	0.31401	0.314007	3.10	0.090
X5- Employee involvement	1	0.34380	0.343796	3.40	0.076
X6- Lean Six Sigma Skills	1	0.15327	0.153266	1.51	0.229
X7- Organizational culture	1	0.31933	0.319333	3.15	0.087
Error	27	2.73294	0.101220		
Lack-of-Fit	21	2.18294	0.103950	1.13	0.475
Pure Error	6	0.55000	0.091667		
Total	34	7.79286			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.318151	64.93%	55.84%	40.90%

The following is the regression equation of the model:

Y-LSS improvement results = 2.015 + 0.309 X1-Leadership
- 0.010 X2-Customer-oriented mechanism
+ 0.030 X3- Integration in business str
+ 0.393 X4- LSS Steering organization
+ 0.387 X5- Employee involvement
- 0.231 X6- Lean Six Sigma Skills
+ 0.352 X7- Organizational culture

Based on the regression results, the author found that X1-leadership, X4-LSS steering organization, X5-employee involvement, and X7-organizational culture are 4 significant CSFs

for LSS implementation at VTCL and these factors statistically impacted the success of LSS implementation when α is set as 0.1.

Interviews and onsite observation notes

The author collected and organized all the field notes and recorded interviews. After that, the author transcribed and typed all the notes in Word files. Then, the author printed all the interview transcripts and field notes on paper and developed two cycles of coding. During first cycle coding, the author employed In Vivo Coding and Initial Coding. During second cycle coding, the author adopted Focused Coding. In order to ensure the accuracy of the study, the author used data triangulation of the multiple data sources. Interviews and on-site observations were compared with survey results to determine consistencies and inconsistencies. The code column in Table 2-10 identifies the data sources in Table 2-11. F1 indicates that tabulated evidence contributes to key success factors, including observational data. F2 represents survey data, while F3 represents interview data.

Table 2-10 Data sources of interview, survey, and on-site observation

Data Source	Quantity	Code
On-site observation notes, analytical memos	27	F1
Survey	46	F2
Interview	6	F3

The following Table 2-11 is the summary of all the evidence included that contributes to the critical success factors in Lean adoption in SMEs, and propositions of how to implement Lean successfully are discussed in the next section.

Table 2-11 Summary table of on-site observation, survey and interview data

		Typical evidence examples	Number of entries	Data sources
CSF (Xs)	X1-Leadership	Leadership will **SIGNIFICANTLY** impact the LSS implementation results based on the regression results. "My boss deeply trusts the management team. He has a very good virtue which is that he is willing to afford the failure cost because he understands that failure is inevitable during the LSS discovery journey. As long as you can explain why the failure happens, he is willing to pay. If we are only focusing on not making mistakes, innovation and change won't happen." "Four years ago, both the operation director and I knew nothing about LSS. But now, we turned ourselves into LSS experts by constantly learning and practicing. We also persuaded our president to learn with us. I think the president and the top management team are like a couple. If the president always stays at home and does nothing while the top management team is stepping forward, this couple will be broken up finally. The development of the company needs the president and top management team to work together. Besides, if the president knows what LSS is, they will be able to support us in the long term and won't interrupt us during the LSS discovery journey." "Based on my 15 years in quality improvement, leadership is very important for LSS transformation." "When I came to the factory, I was surprised that the HR director has such a deep understanding of Lean management. She leared the new quality improvement philosophy by herself at first and led the LSS activities with the LSS consultant."	4	F1, F2, F3

Table 2-11 continued

	X2-Integration of LSS in business strategy	Integration of LSS in business strategy will **NOT SIGNIFICANTLY** impact the LSS implementation results based on the regression results. "We definitely implement LSS based on the management objectives. Otherwise, the more you did, the more mistakes you might make…We will always remind everyone to look back at the management objectives during the LSS adoption process." "I think for SMEs, business strategy is not that important because we will produce the vehicle handles based my customer's business strategy."	3	F2, F3
	X3-LSS steering organization performance	The steering organization performance will **SIGNIFICANTLY** impact the LSS implementation based on the regression results. "In the steering office, I think soft skills are more important than hard skills. (Soft skills are communication skills and hard skills are LSS technology and tools.) If your employees can't buy into LSS from the bottom of their heart, it's impossible to implement LSS successfully no matter how experienced and professional you are in LSS." "The LSS consultant is a very responsible and nice person. He will take the initiative to ask the frontline workers and check whether they have problems. If people tell him they don't know how to do it, he will teach them patiently. He stayed in the workshop from 8:30 AM to 11:00 PM. We are all moved by his spirit. He and I tend to be very good friends." "We used a top-down adoption method in the beginning, but it failed. Then, we tried different ways to get all the employees engaged in the LSS promotion activities. For example, we found that if we design the workstation for the workers, they will feel it is inconvenient. We encouraged them to design the workstation by themselves. They might propose a variety of improvement plans. Our steering office will be responsible for evaluation and choose the final improvement plan, but still, these plans are proposed by the workers, not the management team."	6	F1, F2, F3

Table 2-11 continued

		"In the beginning, when the LSS steering team and our middle management can't reach a unified opinion, we will organize weekly meetings and use brainstorming to display everyone's opinion. Now, our middle management and frontline workers will meet spontaneously to express their feedback and opinion by themselves even without the LSS steering office's supervision." "The HR director is the leader in the steering office. She did a good job because her communication skills and leadership are extraordinary which helps the employees buy into the improvement philosophy more easily."		
	X4-Employee's involvement	Employee's involvement will **SIGNIFICANTLY** impact LSS implementation based on the regression results. "People are lazy, and we don't want to change the environment because it's very painful. If people choose to change the environment, they must be forced to do that." "Compared to top management and frontline workers, middle management is the hardest level to change. They are the core members in LSS practices; however, their study base is very weak. They can't understand LSS content and are not capable of making PPT because they need to use PPT to display the improvement results every week." "We used a top-down promotion method in the beginning, but it failed. Then, we tried different ways to get all the employees engaged in the LSS promotion activities. For example, we found that if we design the workstation for the workers, they will feel it is inconvenient. We encouraged them to design the workstation by themselves. They might propose a variety of improvement plans. Our steering office will be responsible for evaluation and choose the final improvement plan, but still, these plans are proposed by the workers, not the management team"	8	F1, F2, F3

Table 2-11 continued

		"Employees' engagement changed during the promotion process. Most of the workers are only high school graduates and can't understand LSS, so the engagement was very low in the beginning. But we organized many different interesting activities and games about LSS. We tried to make our employees think LSS is an interesting thing instead of a task. They gradually started to buy into LSS these years" "In the beginning, the LSS implementation brought more work to the employees but we worked together and stuck with LSS. Gradually, the employees found their work actually reduced after LSS adoption." "The LSS consultant is a very responsible and nice person. He will take the initiative to ask the frontline workers and check whether they have problems…He is a critical person that helps the frontline workers to buy into the Lean philosophy." Since the appraisal system developed very well in this company, the employees are very excited to attend different LSS activities.		
	X5-Lean technology and tools	Employees' involvement will **NOT SIGNIFICANTLY** impact the LSS implementation based on the regression results. "The LSS consultant designed the project for our company. Since the education level of our employees is limited, the LSS consultant taught the training very slowly." "We just used the basic Lean tools, but it works in our company." The organization used QCC, 5S training, the 7 QC tools, Kaizen event, value Stream Mapping, and SOP.	4	F1, F2, F3

Table 2-11 continued

	X6-Organizational culture	Organizational culture will **SIGNIFICANTLY** impact the LSS implementation based on the regression results. "Human relationship" culture can be found in our company. The atmosphere in our company is homely. We are like family. The cohesiveness among the employees is very strong. The employee turnover rate is very low." "Our employees' belonging to the company is very high and it has also helped us overcome the problems together." "VTCL is very different from the other companies, the HR team humanized the working environment very well." "There are very few workers that will leave every year." LSS supporting personnel will do the Gemba Walk along the assembly lines. The HR director will warmly greet the frontline workers she met and give them advice and suggestions for LSS improvement. There is a farm inside the plant and the workers can grow and harvest vegetables. They also own a dog together.	5	F1, F2, F3
	X7-Customer-oriented mechanism	Customer-oriented mechanism will **NOT SIGNIFICANTLY** impact the LSS implementation based on the regression results. "As a SME, we highly depend on our customers. The production and planning control system were improved in this Lean project because we want to better predict our customers' demand variability and create a more flexible production system." "The initiative of Lean adoption is because of the customer complaints. Customer orientation is the primary purpose of our company"	3	F1, F2, F3

Table 2-11 continued

Results (Ys)	Lean implementation results	The average score of Lean implementations at VTCL is 3.94 out of 5 based on the questionnaire data. "LSS implementation was successful but the benefits gained from LSS are decreasing year by year. We are still exploring. We already tried to adopt LSS to see whether it can help improve the performance further." "The project implemented at VTCL was very successful and they became our loyal customer. The LSS consultants in our company will initiate the Lean implementation project very year." "Our customer complaints decreased 62.4% and the defect rate of finished products decreased 58.9% after Lean adoption."	3	F2, F3

2.6.3 Findings

In this section, the author discusses the CSFs of Lean implementation in SMEs based on survey, interview, and on-site observation data. The author makes four propositions and discusses the evidence from three data sources that contribute to the conclusions.

Proposition 1: Leadership is the most significant factor in Lean adoption in SMEs.

Based on the regression results of survey data, Leadership significantly impacts the Lean implementation results. The P-value of Leadership is also the smallest, which means that it is the most significant critical success factor of Lean adoption in SMEs. This conclusion is also consistent with previous literature and survey data. Achanga et al. (2006) concluded that leadership and management, financial capabilities, skills and expertise, and organizational culture are the four key fundamental critical factors for Lean implementation in SMEs in the UK. Among these four critical success factors, leadership and commitment management support are the most important cornerstones for successful Lean implementation within an organization.

Based on the interview with the top management at VTCL, the company owner of VTCL usually will not be involved in daily operations. The management team will be fully responsible for the day-to-day operations of the company. When Lean production was first introduced into VTCL, the management team did not rely too much on LSS consultants, but actively learned the

concept of Lean manufacturing. The LSS consultant also admitted that Leadership and consistent commitment to Lean transformation is very critical and the management team at VTCL did a good job of leading Lean implementation activities.

During the author's visit of VTCL, she was very impressed by the HR and operation directors' professionalism and comprehension level of Lean management. They believed that if they hope their employees will embrace a new approach to problem solving, then as leaders, they should first embrace it fully. Otherwise, the employees will just comply in public but oppose in private, especially the middle management.

Proposition 2: LSS technology and tools will not significantly impact the Lean implementation results in SME.

Based on the regression results, the coefficient of LSS technology and tools is negative in the regression equation. Meanwhile, LSS technology and tools is not a significant CSF for Lean adoption, which is inconsistent with previous researchers' conclusions. Cheng (2013) states that the use of LSS technology and tools is a CSF for LSS adoption based on the study of 160 Taiwanese companies. Laureani and Antony (2012) also pointed out in a literature review and based on survey results of enterprises that LSS technology and tools are one of the CSFs to effectively implement LSS.

Based on the interviews, the top management and LSS consultant all mentioned that the importance of Lean techniques is usually overestimated in some of Chinese enterprises. A common mistake that many Chinese enterprises make is that the LSS consultant or top management team believe Lean techniques are the core of Lean management while they start to implement Lean in an organization. However, the critical success factor for Lean management should also be focused on shifting employees' way of thinking instead of only learning Lean techniques. Principles like 5S, value stream mapping, visual management and the like are only tools that a company can utilize. In the interview, both senior and middle managers admitted that they used only basic Lean tools, but that it worked for their companies. Meanwhile, they also pointed out that the education level of employees is a major barrier to their understanding of Lean knowledge at the beginning of the project

Proposition 3：Employees' involvement significantly impacts the LSS implementation results.

Based on the regression results of survey data, employees' involvement significantly impacts the Lean implementation results.

The survey conclusion is also consistent with the interview results. The top management, middle management, and LSS consultant all admit the importance of employees' involvement in LSS activities, but the problem is convincing employees to buy into Lean ideas and adopt them over the long term.

The top management and LSS consultant pointed out that middle management is the hardest level to change among all the employees. They are the core members in LSS practices; however, their study base is very weak. For example, the middle management team at VTCL can't understand Lean content and is not capable of making PPT because they need to use PPT to display the improvement results every week. At the same time, the education level of frontline employees is relatively low, and even the management team cannot grasp the concept of Lean management well at the beginning. If the management teams expect to elevate workers' professional skills using Lean methods and change the workers' routine in a short time, this behavior will damage the employees' passion and patience. In order to resolve this problem, training for employees is necessary based on the interview with an LSS consultant and was discussed in many studies before (Laureani & Antony, 2012; Achanga et al., 2006; Cheng, 2013). The employees should also understand that Lean is a useful methodology and toolset for them to improve working efficiency instead of a burden. This can be achieved through the HR director's interview and the establishment of a good communication and feedback system. Additionally, the HR director also emphasized that an appraisal mechanism is very important to stimulate the employees' involvement. At VTCL, the company will share the benefits gained from the improvement activities with the employees who actively participated in the implementation.

Proposition 4: Integration of LSS in the strategy and alignment of all Lean practices to company strategy are not the critical factor in Lean adoption in SME.

Integration of LSS in strategy and alignment of all Lean practices to company strategy are not critical factors identified in the regression model, as VTCL only manufactures vehicles

handles for automakers. The operational director also stated that strategy will be much more important for group corporation in the interview.

Proposition 5: Organizational culture will significantly impact Lean adoption in SME.

Based on the regression results of survey data, organizational culture significantly impacts the Lean implementation results. Emiliani (2011) pointed out that it is a very narrow and outdated view that Lean management is only continuous improvement. Real Lean management should consists of two key principles, which are "continuous improvement" and "respect for people." "Respect for people" can be obviously found in the organization's culture at VTCL based on the author's observation. When visiting VTCL in 2018, the author noticed that there was even a mini-farm inside the plant. The farm grows variety of vegetables. Worker can plant seeds and harvest as they wish. The HR director mentioned that their company is like a home for everyone and the employee turnover rate is very low in their company, at only 6%. Shah and Ward (2003) stated that the influence of unionization on LSS implementation was huge. They also stated that unionized facilities would resist adopting Lean practices because most manufacturing practices need to negotiate changes within the organizations (Shah & Ward, 2003). At VTCL, the high loyalty level of the employees as well as the unionization level highly impacted their involvement in improvement activities.

Proposition 6: The performance of the steering office will significantly impact Lean adoption in SMEs.

Based on the regression results of survey data, the performance of the steering office significantly impacts the Lean implementation results. It is also consistent with conclusion formed from the interviews.

In the interview, the HR director and LSS consultant both emphasized that soft skills are more important than hard skills for LSS supporting personnel in the steering office. Soft skills are communication skills, and hard skills are knowledge of LSS technology and tools. If your employees can't buy into LSS from the bottom of their heart, they won't be able to implement it successfully, no matter how experienced and professional they are in the tools of LSS. In this case, communication skills tend to be very important to persuading the employees to buy in. They also pointed out that they used a top-down adoption method in the beginning, but it failed.

Then, they tried different ways to get all the employees engaged in the LSS promotion activities. For example, they found that if the LSS consultants design the workstation for the workers, the frontline workers will feel that it is inconvenient. So, they encouraged the frontline workers to design the workstation by themselves. Frontline employees can also come up with improvement plans, directing the office to be responsible for evaluating and selecting the final plans, but these are proposed by the employees, not the management team. It means that the steering office's adoption method of LSS is also critical.

Proposition 7: A customer-oriented mechanism will not significantly impact Lean adoption in SMEs.

Based on the regression results of survey data, a customer-oriented mechanism will not significantly impact the Lean implementation results in SMEs. This is inconsistent with previous literature. Laureani and Antony (2012) and Achanga et al. (2006) mentioned that customer orientation was one of the critical success factors for LSS implementation. However, this research was only focused on the companies in western countries, not SMEs in China.

Meanwhile, in the interview, the top management acknowledged the importance of a customer-oriented mechanism. The operation director mentioned that they highly depend on their customers. The improvement of production and the planning control system is one of the critical objectives that they want to achieve, because the management team at VTCL hopes to predict their customers' demand variability accurately and build a more flexible production system. As well, adopting Lean initiatives was motivated by customer complaints.

In conclusion, the author discussed the critical success factors of Lean adoption in the selected SME in China and compared the survey conclusions and interview conclusions to check for consistency. Based on the collected data, the author found that the key success factors identified for successful Lean project implementation in SMEs were leadership and LSS mentoring of the organization, employee involvement, and organizational culture.

2.7 Conclusion

In conclusion, this paper provided a framework for Lean implementation using DMAIC methodology for SMEs in China, which was derived from the experience of successful Lean implementation in a SME in China. Therefore, it will be more suitable for SMEs in that context.

In addition, the authors sent questionnaires to employees at different management levels and identified key success factors in different Lean implementation processes based on regression models. The critical success factors identified in this successful Lean program in SEM are leadership and an effective LSS steering organization, employee involvement, and organizational culture.

CHAPTER 3. DESIGNING FOR SIX SIGMA IN A PRIVATE ORGANIZATION IN CHINA UNDER TQM IMPLEMENTATION: A CASE STUDY

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3.1 Introduction

An increasing number of Chinese enterprises started to implement Six Sigma methodology to improve product quality after China entered the WTO in 2001. This case study was conducted in a large Chinese manufacturing enterprise, called Everlasting Battery Holdings Limited (EBHL) in this study, which is principally engaged in the manufacturing and sales of lead-acid motor batteries and other related products widely used in electric bikes, electric vehicles and special-purpose electric vehicles. The purpose of this study is to understand the application of Six Sigma methodology (DMADV) design for training employees in quality tool use under Total Quality Management (TQM) adoption in a private organization in China. DMADV (Define-Measure-Analyze-Improve-Control) refers to a problem-solving methodology in Six Sigma which is primarily utilized for the development of a new service, product or process as opposed to improving a previously existing one.

The author presented a Six Sigma DMADV project which was utilized to design the Six Sigma training program at EBHL. Problems and barriers with regard to quality culture inside the organization were encountered, identified, and reconciled during this project while building a quality management system. These problems were also discussed at the end of the chapter. Additionally, the benefits of DMADV application and the financial returns from the project were discussed.

3.2 Case Study

The background of this project was that EBHL was facing persistent high rates of product returns, resulting in lost sales and fierce competition from other companies. TQM was utilized to establish a systematic Quality Management System (QMS) at the headquarters and 27 branches.

In Figure 3-1, we can find that “Implementation of LSS” is an important pillar under quality improvement. In this situation, a DMADV project was utilized to design the Six Sigma training program in order to elevate employees’ understating and application of advanced quality tools, as well as nurture a great number of Green Belts (GBs) and Black Belts (BBs) to deploy Six Sigma (SS) improvement projects in the future.

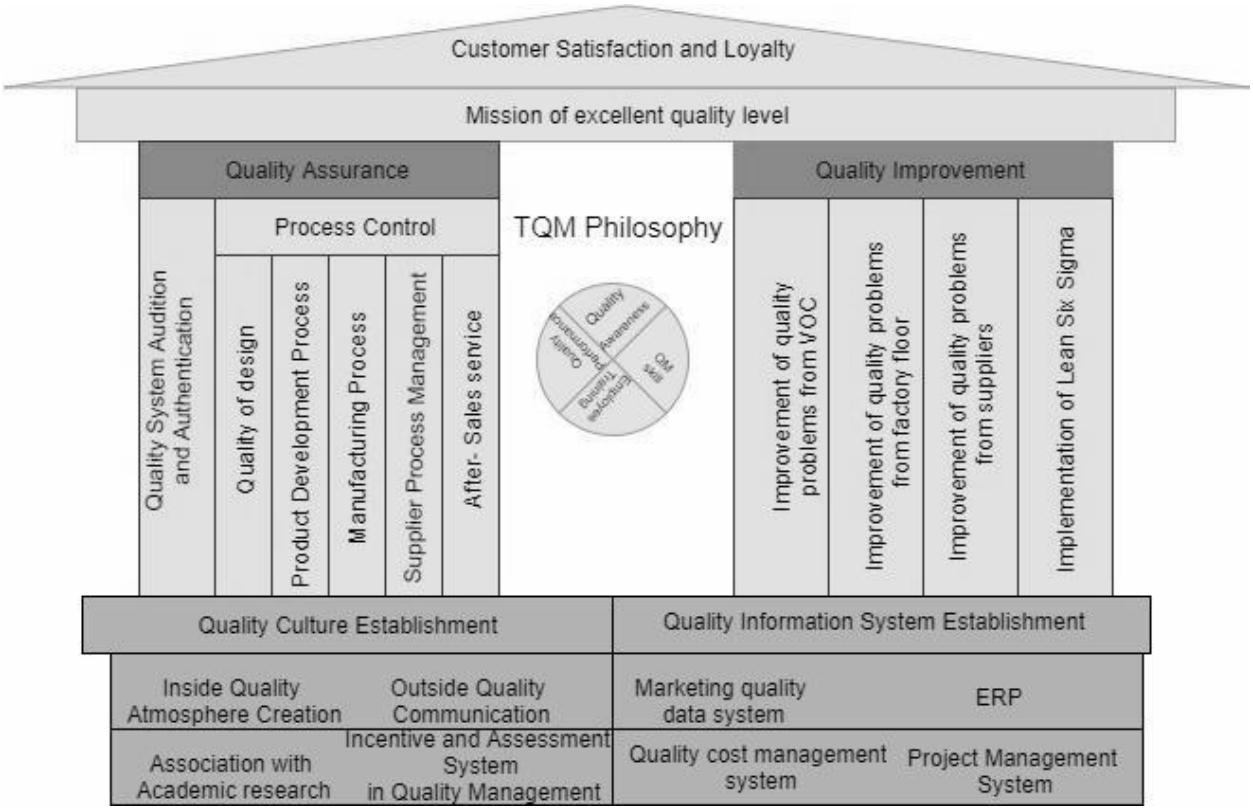

Figure 3-1 QMS framework in EBHL (Li, Laux, & Antony, 2018)

The case study followed a DMADV framework. The project benefits include the following:

(1) Three training camps (GB training camp and YB boot camp) were developed based on internally assigned resources where all tutors (MBBs) were inside the organization.

(2) Internal training greatly reduced costs, with the consulting fee being approximately 1800,000 RMB.

(3) The 28 GB projects that were conducted resulted in gains of 5600,000 RMB of financial benefits in the branches.

3.3 Discussions

This DMADV project was launched successfully and achieved desired results. However, problems and obstacles were also faced at EBHL in the effort to implement LSS under TQM adoption. The biggest problem was organizational culture change. Womack and Jones (2005) stated that a big challenge often encountered during Lean implementation is culture change because the stakeholders' way of thinking needs to be shifted fundamentally. Even the LSS transformation that received the top management's commitment and support still encountered soft resistance from the middle management, which became a big problem for the transformation. QC personnel struggled to move to a prevention-based system from a detection-based system because their routine and way of thinking had been formed for decades, which was very difficult to change in short time. In addition, the number of experts in LSS was way too small for a large company with 27 branches and a lack of professionals was another problem. Frontline personnel's time was also fully occupied by the production and other tasks. They could barely assign time for LSS improvement activities. The whole transformation was deployed in a rushed manner because the CEO of this company was eager to see transformation results, which actually diminished the implementation results and negatively impacted the LSS improvement results.

CHAPTER 4. CRITICAL SUCCESS FACTORS FOR LSS IMPLEMENTATION IN CHINESE MANUFACTURING ORGANIZATIONS

A paper to be submitted to Journal of *Quality Technology.*

4.1 Introduction

Steadily rising Chinese labor costs have dampened China's industrial output. Chinese manufacturers need to focus on developing and increasing levels of global operational excellence in order to deliver increasingly customized innovative products with high quality at a low cost. If Chinese companies continue to deploy manufacturing strategies that are solely based on low staff wages and domestic growth, they will eventually suffer the consequences of these actions (Eloot, Huang & Lehnich, 2013).

Lean Six Sigma (LSS), which can increase the operational efficiency of the process by removing all types of waste from different areas in the supply chain, reduce the variation of the product, and bring quality of product under control, is an effective business strategy to resolve this problem that Chinese companies face currently. Eloot et al. (2013) noted that achieving manufacturing excellence by using LSS was an opportunity for many companies. That's why more Chinese companies have started to utilize LSS to constantly improve services, the manufacturing process and product quality. However, many companies have struggled to use LSS to achieve the expected results. This problem is not only happening in Chinese enterprises. Liker and Rother (2011) pointed out that only 2 percent of companies that implemented Lean management achieved the anticipated results based on the results of a survey conducted by Industry Week in 2007, even though LSS had been implemented worldwide for many years and proved to be successful in many organizations. Liker and Rother (2011) also stated that the Shingo Prize committee, which assesses Lean implementation and gives awards for excellence in Lean manufacturing, found that many of the past winners had not sustained their progress on the Lean journey after winning the award. Sustaining the pursuit of excellence through Lean methodology tends to be a common problem for companies that start to conduct Lean practices (Liker & Rother, 2011). Compared to Lean, Six Sigma is an even more challenging methodology to implement because it combines different quality tools, including complicated statistical tools.

The educational background required to implement Lean is also relatively high. While most Chinese frontline managers are high school graduates, most middle management in manufacturing organizations in China are below the college level. One LSS expert at a LSS conference in Suzhou mentioned that the average success rate of LSS implementation in China was less than 10%.

In this study, the author used multiple case studies as a research approach and answered the research question of why LSS is hard to successfully implement in Chinese manufacturing companies. Stake (1995) stated that the multi-case study method makes a special effort to examine something that has lots of cases, parts or members. In this study, the author follows Stake's approach and uses multiple case studies to investigate a particular phenomenon (LSS implementation) at a number of different sites. The purpose of this study is to identify the critical success factors (CSF) that impact LSS improvement in Chinese manufacturing companies with different infrastructure, such as size and LSS promotion progress. More specifically, this study also discussed the propositions of successful LSS implementations based on findings. To corroborate findings, the author utilized data triangulation of multiple data sources, including interviews of top management and LSS support personnel who led LSS implementation inside the organizations, on-site observation notes and archive documents. The author analyzed interview results from six participants, representing LSS support personnel, plant managers, and quality managers from these companies. On-site observations were recorded by the author to corroborate findings. Archive documents including LSS implementation plans and LSS project or activity reports were provided by the company. The Lean Iceberg Model was used to help analyze study results and posit how to assist LSS practitioners in implementing LSS in Chinese manufacturing firms.

4.2 Literature Review

In previous literature, scholars use multiple theoretical models to assess or explain the LSS transformation processes within an organization from different perspectives. In this section, the author listed four major models, including Total Quality Management (TQM), the Baldrige Business Excellence Model, the Lean Iceberg Model, and the Six Sigma Maturity Model. Among these, TQM, the Baldrige Excellence Model, and the Six Sigma Maturity Model have been adopted and studied with respect to implementing LSS in China. These models are based

upon an amalgamation of TQM constructs. In China, TQM is usually utilized as the fundamental framework for LSS transformation. The Baldrige Excellence Model is applied to assess the LSS implementation results, and the Six Sigma Maturity Model is used to assess company infrastructure and verify whether current organization status is mature or ready for Six Sigma implementation. Few companies in China have utilized the Lean Iceberg Culture Model to analyze LSS adoption, even though from a cultural perspective, the success rate of LSS implementation in China is less than 10 percent. Additionally, organizational culture is often noted as a critical success factor for LSS implementation. In this study, the author adopted the Iceberg Culture Model as the theoretical framework for conducting interviews and analyzing the data collected.

4.2.1 Total Quality Management (TQM) Model

Total Quality Management (TQM) is a continuous improvement philosophy focusing on quality improvement of goods and services by participation of all the employees of different levels and functions in the whole organization (Pfau, 1989).

TQM originated in Japan in the early of 1970s. It has been implemented in many developed countries, especially in United States and Western Europe. TQM is a systematic methodology that is used to remove waste and non-productive activities from the organization and aims at maximizing customer satisfaction, productivity and quality of goods and services (Yusuf, Gunasekaran, & Dan, 2007). TQM has been studied widely in the literature which analyzes the essence of TQM and how it should be implemented in organizations (Ahire & Dreyfus, 2000; Crosby, 1979; Porter & Parker, 1993). Many companies in developing countries, such as China, have begun to adopt TQM and to use it to improve performance and competitive position since the 1980s. In addition, the adoption of LSS has showed an upward trend in industry (Desai, 2006). As a result, many Chinese companies decide to deploy LSS practices under the TQM framework. Based on ISO 9001:2000, the eight principles of the TQM implementation process are outlined in the Figure 4-1:

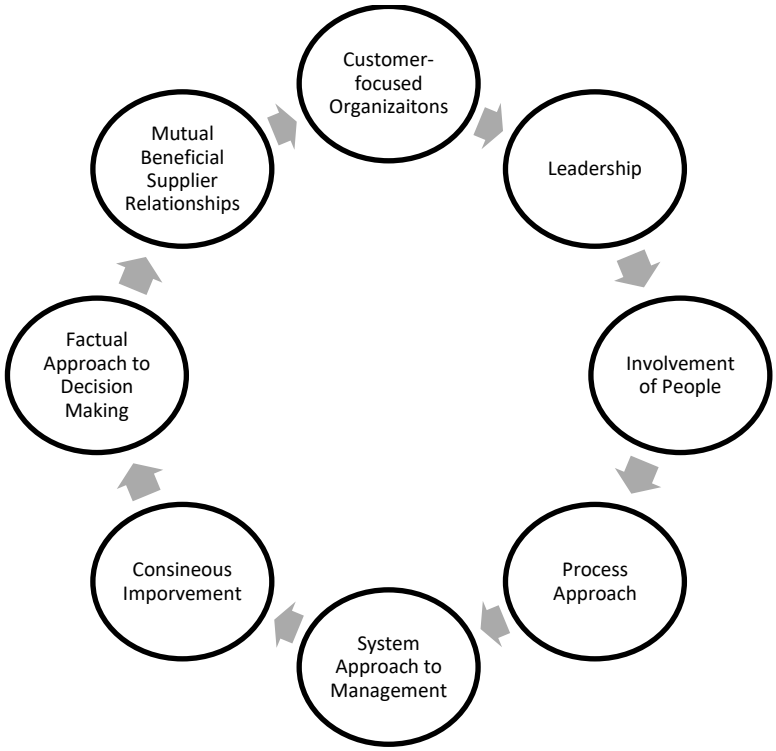

Figure 4-1 Eight principles of TQM implementation (ISO9001:2000)

4.2.2 Baldrige Excellence Model

The Baldrige Excellence Model is applied by the Malcolm Baldrige National Quality Award (MBNQA) to judge performance excellence of companies. In 1987, the United States Congress established an award, which is the highest presidential honor for performance excellence, to recognize the companies that implemented quality management systems successfully, aiming to raise awareness of quality management in the USA (ASQ, 2019). The Baldrige Excellence Model is an integrated performance management model that has evolved in both experiences of winning companies in quality management and high-performance management practices. The Baldrige Excellence Models, was also called the Performance Excellence Model, originates from customer demand and aims towards performance excellence management, including integration of leadership, strategy, customers, workforce, operations, and results (Figure 4-2).

Figure 4-2 Baldrige Excellence Framework for Business/Business Nonprofit (NIST, 2019)

4.2.3 Six Sigma Maturity Model

The Six Sigma Maturity Model is used to assess Six Sigma deployment inside organizations and was developed by multiple scholars. Raje (2009) developed a Six Sigma model identifying five maturity levels of Six Sigma implementation, including the project launch, early success, scale replication, institutionalization and culture transformation. The "launch" is the initial stage of LSS training and projects. "Early success" represents the initial projects that achieved success early on in the implementation process. "Scale replication" is where the successful elements are introduced to other parts of the whole organization leading to a broader launch of LSS projects. "Institutionalization" is the stage where projects yield broad-based financial impact throughout the whole organization. "Culture transformation" is the final stage of LSS deployment where LSS has become deeply rooted inside the organization and financial impact is sustainable in the long term (Raje, 2009).

He (2009) developed a Six Sigma Maturity Model based on the Baldrige Excellence Model. This Six Sigma model was based on survey results from 106 companies that implemented Six Sigma in China. This model can provide an analysis of an enterprise's cultural transformation over the course of the Six Sigma process (He, 2009). It consisted of seven categories, 26 items and 47 areas for assessment (He, 2009). The following figure displays the seven major categories of the model: Six Sigma leadership, customer focus, Six Sigma strategy, Six Sigma project management, evaluation and motivation, Six Sigma infrastructure and business results (He, 2009).

Figure 4-3 Six Sigma Maturity Model (He, Z.,2009)

4.2.4 Lean Iceberg Model

The iceberg theory, which was also known as the "the theory of omission" is a term used to describe a technique of writing coined by American writer Ernest Hemingway in 1923. Hemingway believed that evident on the surface can not display the deeper meaning of a story. The true evidence must be shine through implicitly. Edward T. Mall developed the Iceberg Model of Culture in 1976. The common knowledge of the tragedy of the Titanic is that people omit that the majority of an iceberg is under the surface of the ocean, with just the tip visible. Hall (1976) believed that the Iceberg theory may also be applied in cultural aspects. The visible aspects of culture are only the "the tip of the iceberg", where what drives most of cultural transformation is below the surface, unseen and subconscious (Hall, 1976). Hanley (1999) also stated that culture may be compared to an iceberg where the influence of culture on the elements of communications should be explicitly explored. In the Iceberg model of culture, culture renewal, observable behaviors in workplace, discourses and practices are visible above the waterline, while beliefs, values, philosophies, and attitudes, which are below the waterline, are often invisible and taken for granted (Abbasi, 2011).

Braithwaite (2011) pointed out that culture change can not only influence and shape human behaviors and practices but also change attitudes and values. Cultural change can be conceptualized as an iceberg. On one hand, organizational and clinical activities are above the waterline and are the visible portion, one the other hand mental constructs are the invisible portion (Braithwaite 2011).

Hines et al. (2008) developed the present Lean Iceberg Model to differentiate between the factors that are below the waterline and the visible factors that are above the waterline. This Iceberg Model is based on the theory that the visible portion of the "iceberg" is supported by a firm organizational foundation that enables the company to develop, whereas the visible portion represents only 30% of the whole. This model is aligned with Krüger's (2004) Change Management Iceberg. Hines et al. (2011) believed that the foundation of successful Lean implementation was in the enabling elements of strategy, alignment and leadership, and the human aspects of behavior and engagement. However, the enablers noted above are usually hidden from view. Processes like order creation, product lifecycle management and others aligned with Lean technology, tools, and techniques are visible factors that can be observed and used to improve the business process performance in Lean deployment (Hines et al., 2007). The model is represented in Figure 4-4 as below.

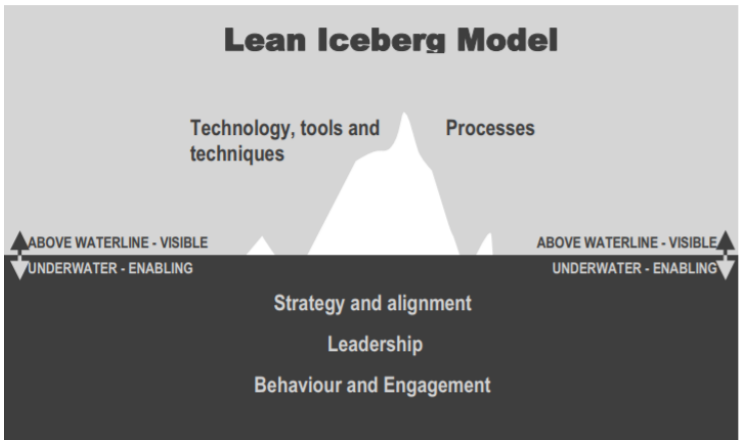

Figure 4-4 Lean Iceberg Model (Hines et al., 2008)

In this study, the Lean Iceberg Model is the theoretical framework used in the interviews and provides a basis for interpreting and understanding the relevance of the findings.

4.3 Theoretical Framework

Organizational culture transformation is a major critical success factor (CSF) of LSS implementation (Laureani & Antony, 2012). There are often five levels of successful LSS deployment and culture transformation noted that organizations should target (Raje, 2009) but these two factors are missing in organizations now (Naslund, 2008). Sigler and Pearson (2000) as well as Schein (1985; 1992) stated that organizational culture was representative of the pattern of values, beliefs, and assumptions that was shared by all the members throughout the organization. Organizational culture can be seen as an explanatory factor that can distinguish one organization from another (Schein, 1985), and it also plays a critical role in driving the actions done in the organization (Nahm et al., 2004).

The Lean Iceberg Model (shown in Figure 4-4) is built upon two layers to reflect the variables of Lean implementation above and below the waterline. Hines et al. (2008) concluded that Lean transformation inside the organization was primarily driven by five major variables. Two visible variables are "technology, tools, and techniques" and "process management." These variables are above the waterline; easy to identify and learn about. "Strategy and alignment," "leadership," and "behavior and engagement" are the three variables below the waterline, which are out-of-awareness. The following are the definitions of the five factors (Hines et al., 2008):

Strategy and Alignment: Strategy can be defined as setting the future direction for the organization in order to achieve the improvement goal. Alignment works to make sure that all the employees in the organization understand the company strategy, and everything they do is necessary to achieve the organizational goals successfully.

Leadership: Leadership establishes the future direction of the organization, develops a future vision, and sets strategies to achieve the future vision by making the changes needed.

Behavior and Engagement: This factor is about employees at all levels of the organization and how motivated they are to adopt Lean behaviors and become engaged in the Lean transformation process.

Process： Process is about how to design and optimize key processes in order to deliver value to the customer, business or value stream.

Technology, tools, and techniques (TTT)： These are the Lean tools and technologies using Toyota's system and should be driven by the needs of the customer, the business, and the people within the business.

In order to empirically study the LSS implementation experience from the lens of organizational culture, the author adopted the Lean Iceberg Model developed by Hines and associates as the theoretical framework of the study to analyze three Chinese manufacturing organizations (Hines et al., 2008).

4.4 Research Methodology

The primary methods of research may be categorized as quantitative, qualitative, and mixed methods approaches (Yin, 1994). Research strategies include experiments, surveys, archival analysis, history, and case studies. The choice of research strategy depends upon the type of research questions that are being asked, the control an investigator has over actual behavioral events, and the study's focus on contemporary as opposed to historical phenomena. Yin (1994) pointed out that "How" and "Why" questions were likely to favor the use of a case study, experiment, or history method. As well, if the study was focused on contemporary events with no researcher control over behavioral events, a case study should be selected (Yin, 1994). Below is a summary of these ideas.

The qualitative method chosen for this research is suitable based on the author's philosophy, perspective, the nature of the research questions, the data collection methods, and the researcher's role in this study. The author sought to represent the reality of the event of LSS implementation in each organization by taking the perspective that meaning and knowledge are socially constructed.

This paper aims to investigate the differences in CSF during the critical implementation process of LSS in this case study based upon previous literature. Additionally, the reasons LSS is difficult to implement in Chinese manufacturing organizations is also investigated and discussed from the cultural perspective. To fulfill this aim, a well-documented case study can provide a very effective approach (Eisenhardt, 1989; Yin, 1994).

Creswell (2013) defined the case study method as a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) studied over time by using detailed and in-depth data collection from multiple sources of information. Gustafsson (2017) pointed out that when a study included more than one single case, a multiple case study was needed. The major differences between a single case study and a multiple case study is that the researchers are seeking to understand the differences and similarities between cases by studying the latter

(Baxter & Jack, 2008; Stake, 1995). In this study, the author decided to investigate three manufacturing companies as three separate cases, so a multiple case study was used to explore the different LSS implementation processes in these three organizations.

A case study design is a useful research methodology to explore a phenomenon, and it involves data gathering from multiple sources. Usually, the interview will be used as the primarily data collection method, and data can also be gathered partly by on-site observation (Stake, 1995; Yin, 1994;). In this case study, interviews, on-site observation, and questionnaires were used as the main methods of data collection.

Figure 4-5 displays the research design of this study. As shown below, the study started with a review of a collection of existing literature of the CSFs of LSS implementation in different countries. A current research gap arose from a review of the literature identifying a real need to summarize the CSFs and explore the challenges of the strategy of LSS implementation for Chinese manufacturing, in order to increase success rate of LSS transformation. The author contacted three manufacturing organizations of different sizes, industry sectors and implementation results, both successful and unsuccessful. After gaining access and approval from the management of these three firms, the author visited each company in turn, and subsequently administered online questionnaires and long-distance interviews (Six individuals) by WeChat, which is a popular chatting app software. The case studies conducted in these three companies are referred to as EBHL, VTCL, and BAG for reasons of confidentiality.

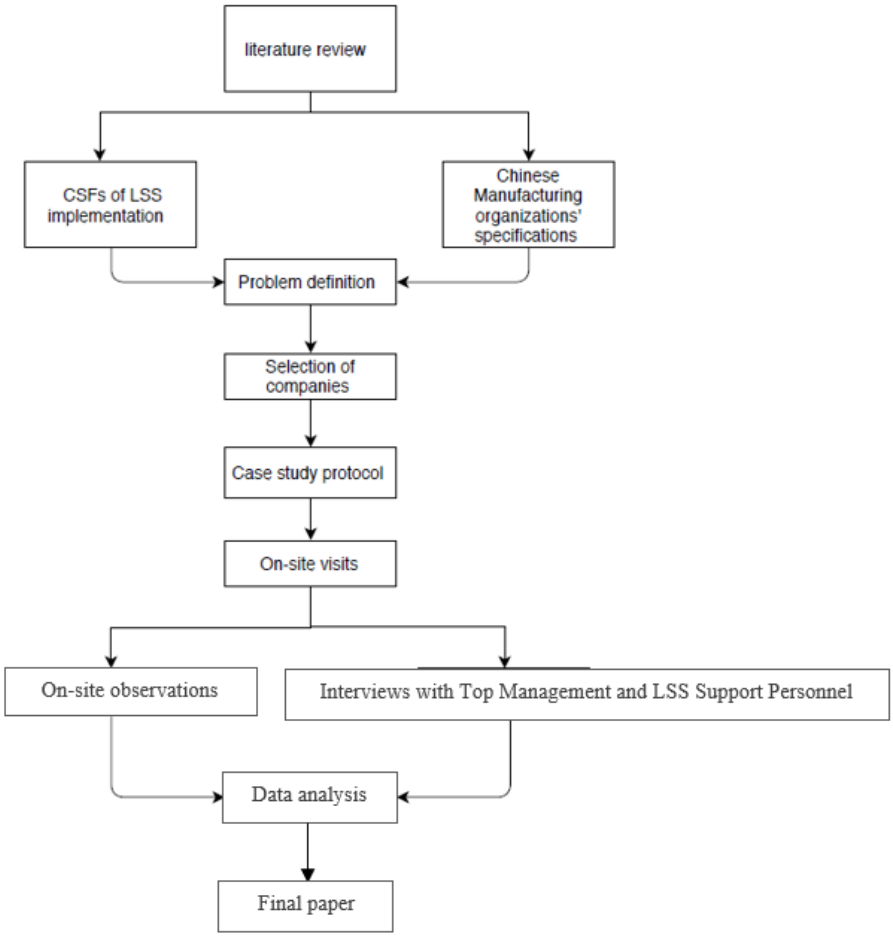

Figure 4-5 Research design

It is important to situate the author's identity and role in this research. The author worked as a LSS consultant in the Quality Control department in each of the three companies. The author supported each company's establishment of TQM and conducted Six Sigma and Lean training with company employees. However, the author's participant activities in each company were situated secondary to the primary role as researcher.

The author's main activities in this qualitative study were data collection and analysis. The author was situated as an insider in this study since she fully participated in the LSS improvement activities in each company. Since the author's participation affected the whole implementation process extensively, and the author's interactions with participants were close, the author was conscious to be as objective as possible to minimize bias.

4.5 Research Sites

The three research sites selected for this study are Everlasting Battery Holdings Limited (EBHL), Victory Technology Company Limited (VTCL) and Brother Electronics Group Company Limited (BAG). The research sites were chosen due to available access to the context of the environment by the researcher and different LSS implementation performance levels.

4.5.1 Everlasting Battery Holdings Limited (EBHL)

Everlasting Battery Holdings Limited (EBHL)is located in South China and was established in 2007. The total number of employees is approximately 1600, including 1475 frontline workers. The annual productivity is around 23 million units with annual sales around $1.89 billion. Since the staff turn-over rate is relatively high, only 17% of the employees' average working time is above 5 years. The environment of lead-acid battery manufacturing is defined as having minor toxicity because of the lead dust and sulfuric acid mist present on the shop floor. This results in minor threats to human health in the manufacturing environment. Additionally, the workload is very heavy for frontline workers and the chemical manufacturing process is relatively complicated to control. These are all the unalterable obstacles for LSS implementation in EBHL.

4.5.2 Victory Technology Company Limited (VTCL)

Victory Technology Company Limited (VTCL) mainly produces a variety of automobile interior decorations, including the assembly of vehicle air outlets, vehicle assistance handles, vehicle auxiliary clothing, and cap hooks. About 90% of customer orders are vehicle roof auxiliary handles. VTCL has 27 injection molding machines and 12 assembly lines. The core technology of VTCL is gas-assisted injection molding, and there are 4 sets of gas-assisted machines. A Lean program was started at VTCL in 2014. The first Lean program adoption achieved great success and even exceeded the top management's initial expectations, with VTCL being recognized as the Lean model company locally. However, after 4 years of adoption, the marginal return from Lean adoption is diminishing. Thus, the sustainability of Lean management is a problem for VTCL during the continuous improvement journey.

4.5.3 Brother Electronics Group Company Limited (BAG)

Brother Electronics Group Company Limited was established in 1984 and is listed as a Fortune 500 company. BAG is a global customer electronics and home appliances manufacturer in China. The total number of employees is approximately 73,000 with annual sales of 29 billion RMB in 2016. BAG major product lines cover almost the whole home appliance market, including refrigerators, washing machines, TVs, air conditioners, water heaters, and microwave ovens. BAG started to implement LSS in 2005 and is one of the first companies to implement LSS in China. However, they are in an idle period in the LSS journey.

4.6 Participants

Overall, interviews were conducted with six participants. The purposeful sample of participants was comprised of top management and LSS promoters. It included top managers and LSS supporting personnel who led the LSS implementations in the organizations. LSS supporting personnel's opinions are important because their voices help understand the challenges that occur during LSS implementation in these companies. Since the researcher worked in these companies, her involvement gave her access to the interview participants. T1, T2, T3, P1, P2, and P3 are all anonymous codes used for participants who attended the interview. T stands for top management. P stands for LSS support personnel. Table 4-2 displays the demographics of the participants interviewed.

Table 4-1 Demographics of interview participants

Anonymous code	Company	Position	Age	Gender	Responsibility in LSS implementation
T1	EBHL	General Branch Manager of Yongda plant	37	Male	Leader
T2	BAG	General Branch Manager of Shangyong plant	42	Male	Leader
T3	VTCL	Operational Director of VTCL	37	Male	Leader
P1	EBHL	MBB in the Quality Control department of EBHL	37	Male	LSS supporting personnel
P2	VTCL	HR director of VTCL	45	Female	LSS supporting personnel /Leader
P3	BAG	BB in LSS steering organization of Shangyong	27	Male	LSS supporting personnel

T1 (General Branch Manager of EBHL) is a 37-year-old male. He has worked in EBHL for 15 years and started as a frontline worker, working up to General Manager of the Yongda plant. His branch was selected as the EBHL unit to adopt LSS. He is also the one who was under the most pressure because the success of LSS implementation in this location was perceived to determine his future career path. He had great passion for LSS transformation but was worried about whether LSS would be successful at his location.

T2 (Branch Manager of BAG) is a 42-year-old male. He has worked at BAG for over 20 years and started as a Quality Engineer, working up to General Branch Manager at the Shangyong plant. He has been certified as a LSS Master Black Belt (MBB) for over 10 years and supported LSS implementation in his plant.

T3 (Operational Director of VTCL) is a 37-year-old male. He has worked at VTCL for 7 years. He is perceived to be a faithful follower of LSS after the Lean program was initiated in 2014 and achieved success. The owner of the company usually does not get involved in the daily operations; T3 is perceived as the person who manages the whole company.

P1 (MBB in the Quality Control department of EBHL) is a 37-year-old male and was assigned from the headquarters to assist EBHL to adopt LSS. He worked at EBHL for just 2 years. He is an experienced MBB and has worked in LSS consulting for more than 10 years.

P2 (HR director of VTCL) is a 45-year-old female. She is also the HR director of VTCL. She had worked at VTCL for 7 years. Before she worked at VTCL, she was a salesperson. She is perceived to have excellent communication skills, and she contributed to LSS promotion at VTCL.

P3 (BB in the LSS steering organization at BAG) is a 27-year-old male. He has worked at BAG for 5 years. He is a BB and has primary responsibilities in Six Sigma, Lean, and TQM implementation and training in Shangyong with BAG.

4.7 Data Collection

In qualitative studies, researchers generally use triangulation to ensure the study is rich, robust and comprehensive. Denzin (1978) and Patton (1999) identified four types of triangulation: methods triangulation, triangulation of sources, analysis triangulation and theory/perspective triangulation. Methods triangulation, which means checking the consistency of findings generated by different data collection methods, is used in this study. The author collected data through direct observations, interviews and document review. The primary source was interviews with individual respondents.

4.7.1 Interviews

The interview questions used in this research originated from Hines et al. (2008). The objective of the interview was to discuss the challenges met during the LSS implementation from the top management and LSS promoters' perspectives.

Since the interview is a qualitative phenomenological method, qualitative studies typically require a much smaller sample size than quantitative studies. The rationale here is that the researcher seeks rich, in-depth meaningful data. This occurs when the recruited participants are well-versed in the phenomenon being studied, rather than sourcing a large number of participants with surface knowledge of the phenomenon. In this study, six participants were

selected from each site: those responsible for general management (General Managers) and those responsible for LSS promotion in the organizations (LSS supporting personnel).

The interviews were conducted during several site visits and online through WeChat. The six interviews were taped and transcribed. Each interview lasted 60 to 90 minutes. The author asked open-ended questions of respondents and let them relate personally to LSS: challenges, goals, and the like, in their respective organizations. The interview had two sections, beginning with the personal background of the respondent. In the second part, through the perspective of the company, the questions focused on five points of view of LSS implementation, including strategy and alignment, leadership, employee behavior and engagement, processes, and LSS tools and techniques. The five points of view followed the Lean Iceberg Model (Hines et al., 2008) described previously. At the end of the second section, one question was asked to let the respondents evaluate their LSS performance based on their subjective judgment. Detailed interview questions can be found in Appendix A. Table 4-3 below provides interview sources and an interview description. Table 4-4 displays the interview data.

4.7.2 On-site observation

The author visited the locations of all the three companies and worked in the LSS steering organization at BAG and VTCL for two weeks and in the quality control department of EBHL for six months. The author's involvement in each organization provided access to nearly all LSS establishment activities of the three companies, especially EBHL.

4.7.3 Document review

Document review is used as an additional source of data in this study. Documents included company websites, minutes from LSS promotion meetings, LSS implementation reports, and financial documents. Observations and document review were used to triangulate the data gathered through the interview by observing what LSS elements were actually implemented in the organizations.

Table 4-2 Data source quantity

Data Source Type	Data Source	Quantity
First-hand source	Interview with top management	4
	Interview with LSS supporting personnel	7
	On-site observation notes, analytical memos	27
Second-hand source	Company website, minutes from LSS promotion meetings, LSS implementation reports and financial documents	18

Table 4-3 Information from interview data

Anonymous code	Position	Interview content	Frequency of interviews	Length of the interview
T1	General Branch Manager of Yongda, EBHL	LSS implementation motivation, LSS implementation results evaluation, obstacles encountered during LSS journey	1	67 minutes
T2	Branch Manager of Shangyong, BAG	LSS implementation motivation, LSS implementation results evaluation, obstacles encountered during LSS journey	1	93 minutes
T3	Operational Director of VTCL	LSS implementation motivation, LSS implementation results evaluation, obstacles encountered during LSS journey	2	129 minutes
P1	MBB in Quality Control department of Yongda, EBHL	LSS transition process, LSS practices adopted, obstacles encountered during LSS promotion	3	177 minutes
P2	HR director of VTCL	LSS transition process, LSS practices adopted, obstacles encountered during LSS promotion	2	146 minutes
P3	BB in LSS steering organization of Shangyong, BAG	LSS transition process, LSS practices adopted, obstacles encountered during LSS promotion	1	54 minutes

4.8 Data Analysis and Data Validation

Data collected through multiple data sources was organized based on the categories in Lean Iceberg Model in order to search for patterns (Denzin, 1978). Yin's (1994) case study

analysis approach was utilized for the data analysis. This method focuses on describing the case, theoretical propositions and contending explanations.

The author first collected and organized all the field notes and recorded interviews. Then, the author transcribed and typed all the notes in Word files. To prepare text-based qualitative data for manual (paper-and-pencil) coding and analyzing, the author printed all the interview transcripts, filed notes. At the initial stage, the author read all the transcripts and fields notes and wrote several analytical memos. Saldana (2015) defined analytical memos as researcher journal entries or blogs, where the researcher can "dump the brain" about the participants, phenomenon, or process under investigation. The author then developed two cycles of coding. During first-cycle coding, the author used In Vivo Coding and Initial Coding. Initial Coding may employ In Vivo coding or any other qualitative coding methods and technology (Saldana, 2015). In Vivo Coding uses a word or short phrase from the actual language found in the qualitative data record (Strauss, 1987). Initial Coding implies that the coding is an initiating procedure step in congruence with the first-cycle coding process (Charmaz, 2014). Strauss and Corbin (1998) stated that Initial Coding broke down qualitative data into discrete parts and compared the similarities and differences between these parts. During second-cycle coding, the author used Focused Coding. Focused Coding usually follows In Vivo, Process and/or Initial Coding (Saldana, 2015). Charmaz (2014) pointed out that Focused Coding searched for the most frequent or significant terms to develop the most salient categories in the data body.

Since the author coded alone, she had discussed the coding and analysis with several LSS supporting personnel at the three research sites. As well, the author consulted the participants during the analysis process in order to support validation of the findings. As part of data triangulation, onsite observation notes and analytical memos were compared against interview transcripts for any inconsistencies. Documents including the company website, minutes from LSS promotion meetings, and LSS implementation reports were used as additional data sources to understand the company background and the whole LSS implementation history of the organizations.

The data was categorized by author definition, including the organization infrastructure that was related to successful LSS implementation (i.e. leadership type, business type, company size, LSS implementation length). The transcribed interview copies were sent to the respondents to check the accuracy of results.

4.9 Findings

The research findings are presented in the following section. A description of each individual case study of LSS implementation developed from interviews, document review and on-site observation notes is displayed along with a cross-case comparison of company infrastructure in section 4.9.2. Meanwhile, themes developed in the interviews, documents and observation data are presented and summarized in section 4.9.3.

4.9.1 Organizing LSS implementation in manufacturing companies

Based on the analysis of LSS implementation reports, company websites and financial documents, as well as on-site observations, the author first investigated the infrastructure of the research sites. Such infrastructure included products, organization type, number of employees, annual sales, years in business and LSS implementation length at EBHL, VTCL, and BAG sites.

4.9.2 Profiles of EBHL, VTCL, and BAG

A company profile is a professional summary of the business and its activities. The following sections describe the profiles of EBHL, VTCL, and BAG. Since the LSS implementation is studied at one location of each EBHL and BAG, the author will focus on the company basics of EBHL's Yongda plant and BAG's Shangyong plant. The third research site is the VTCL plant – the company's only location. These findings are summarized in Table 4-5.

Everlasting Battery Holdings Limited (EBHL)

As stated above, EBHL produced a variety of lead-acid storage batteries and lithium batteries. Currently, it is one of the largest batteries manufacturers in China and has 27 plants located in strategic areas. The total number of employees is around 20,000. EBHL was established in 1998 and started to greatly expand by the acquisition of other companies since 2004. Some of the owners of these companies joined EBHL as partners. Figure 4-6 showed the rapid growth of sales at EBHL from 2012 to 2017. The data was collected from a review of financial statements that were provided by the financial department of EBHL. Based on the interview with T1(the General Branch Manager of Yongda), increased customer demand and

acquisition brought opportunity to the development of the company. However, it also brought risk and hidden problems for corporation management and product quality.

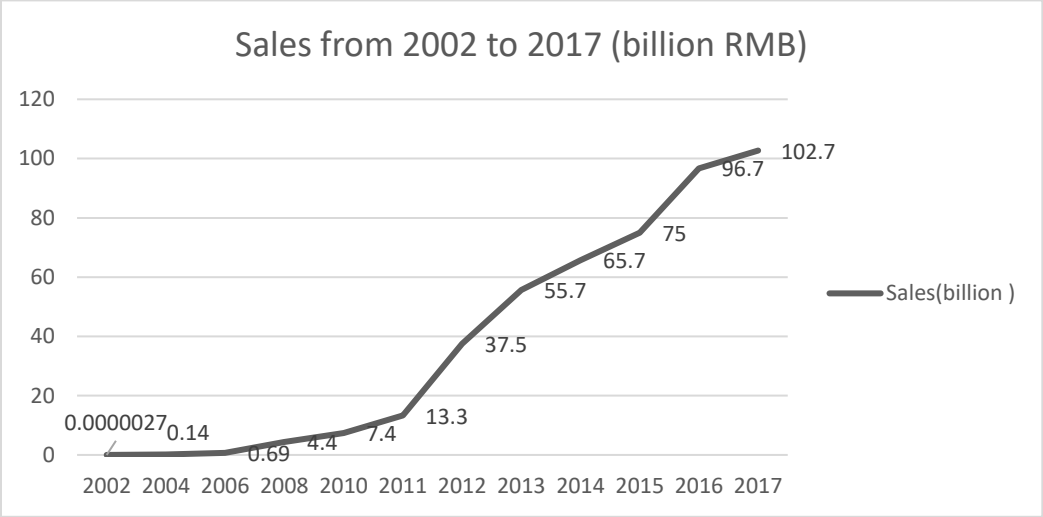

Figure 4-6 The annual sales of EBHL (2002–2017)

The author worked as an LSS consultant and stayed in this company from January 2018 to July 2018. There, she had the chance to directly observe the LSS adoption on-site, the organizational culture change. The author also investigated the obstacles and problems that occurred. Based on on-site observation, the author found the source of the administrative power was concentrated entirely among the founders' family members at EBHL. The strategic level decisions could be made in a very short timeframe and primarily depended on the "family meeting" which only included the two company founders and their parents. At the time, the biggest problems of LSS implementation came from the organizational culture change. A "survival anxiety" from the company's owner was observed during a LSS implementation meeting by the author. This anxiety was the result of threats from competitors and a sense of crisis, and it was the primary motivation for the Chairman to make changes and establish LSS to improve product quality. The occurrence of several severe quality accidents reported in 2016 poorly impacted the reputation of the company, resulting in lost market share and lower sales. Additionally, return rates of products has remained stubbornly high and were higher than those of major competitors. The 15-month return rate of the poorest performing plant was as high as 63.6%, according to data gathered in February 2017. Because of this "survival anxiety," the company owners decided to adopt LSS. However, if LSS adoption failed, the organization would

take the risk of going bankrupt, according to the LSS meeting minutes. That's why the LSS steering organization was under great pressure and everybody was rushed to see significant financial benefits right after the LSS adoption, which inversely impacted the LSS results.

The Yongda plant was first established in 2002. It is a branch of EBHL, which is a major player in the manufacturing of lead-acid batteries for electric vehicles. Since 2016, the Yongda location started to face stubbornly high return rates of defective products, slower sales, and fierce competition. Since the management team at the Yongda plant is relatively young (the average age of the managers is around 35 years old) and more willing to embrace a new management philosophy compared to the other branch plants, the Yongda plant was selected as the first location to implement LSS.

Victory Technology Company Limited (VTCL)

Victory Technology Company Limited (VTCL) is a small private enterprise with two plants, an employee population of approximately 170 people, and a managerial and technical staff of 30 people. . The plant being studied primarily produces a variety of automobile interior decorations. Based on the definition of small and medium-sized enterprises (SMEs), VTCL is a typical representative of SMEs in the manufacturing industry in China. The overall organizational structure of VTCL is relatively flat, and the administrative operations are comparatively simple.

Brother Appliances Group (BAG)

The Shangyong plant

The Shangyong plant is a location of Brother Electronics Group Company Limited which was established in 1999, located in the North of China. The Shangyong plant is primarily responsible for central air conditioner manufacturing. The annual sales of the Shangyong plant are around 4 billion RMB, with a total number of employees around 1400. BAG started to adopt LSS in 2005, while the Shangyong plant began to implement LSS in 2009. At the time of the study, the LSS implementation at BAG has stalled based on the interviews with LSS support personnel in the steering office of the Shangyong plant. A perceived problem for BAG is that all the Black Belts (BBs) and Master Black Belts (MBBs) are part-time employees. These Six

Sigma professionals who are supposed to initiate and lead the Six Sigma projects are busy with their functional work and can barely assign time to develop and successfully conclude Black Belt projects. The author observed that new employees at the Shangyong plant are eager to participate in Six Sigma Black Belt training, but after certification, these newly educated Black Belts are reluctant to conduct improvement projects practically in the future.

Table 4-4 Company profiles of three research sites

Company Name	Industry Sector	Organization Type	Number of employees	Number of employees in the whole company	Annual Sales (Million RMB)	Year of establishment	Year of first LSS implementation
Yongda, EBHL	Electric vehicle batteries	Private/ Branch of large company	1600	20,000	1800	1998	2017
VTCL	Automobile roof handles	Private/ SME	150	150	70	2014	2014
Shangyong, BAG	Air conditioners	Public/ Branch of large company	1400	73,000	4000	1984	2009

4.9.3 Critical success factors of LSS implementation in China

In this section, the author gathered qualitative assessments from three locations and multiple information sources: direct on-site observations, interviews of company personnel (top management and LSS support personnel) and document review. This data is meant to address the following research questions: what are the critical success factors (CSF) that impact LSS improvement performance in Chinese manufacturing companies, and how can LSS principles be successfully adopted by these companies? What emerged from the data were insights from the top management and LSS promoters on what problems occurred during organizational change. Table 4-7 is a summary that describes initial coding, secondary coding, critical evidence from the interviews, field notes and document review that focused on the CSFs of LSS implementation. The primary data sources were interviews with top management and LSS supporting personnel. The interview questions were designed based on the five principles of the Lean Iceberg Model described previously. Appendix A contains the detailed research questions. The followings is the

critical evidence from interviews and on-site observations that formed the themes. The evidence was categorized based on primary coding that included themes of leadership, integration of LSS in business strategy, LSS steering organization performance, employee engagement, LSS technology and tools, and company culture.

Leadership

Leadership is one of the most important perspectives of the Lean Iceberg Model (Hines et al., 2008). It is also one of the primary coding categories and critical success factors identified from interviews and on-site observation. Hines et al. (2008) utilized the Toyota leadership model to categorize Leadership types in Lean implementation. In this study, the author also used the Toyota leadership model to categorize the top management leadership at all three research sites, because the author wants to explore whether different leadership types might impact LSS performance. Table 4-5 describes the Toyota leadership model.

Table 4-5 Toyota Leadership model (Hines, 2008)

Bottom-up empowerment	Group facilitator	Builder of learning organizations
	You're empowered. Do it **your** way	Here is our purpose and direction. I will guide and coach. Follow me and let's figure this out **together**.
Top-down directives	Bureaucratic manager	Task manager
	Follow the rules. Do it **my** way.	Here is what to do and how to do it! Now do it **my** way.

The General Manager (T1) of the Yongda plant of EBHL had a mixed leadership role as both "Group Facilitator" and "Task Manager." He was perceived to be a very responsible person and always stated he worried about whether subordinates can work hard enough. He mentioned to the author that:

> I tried to give my subordinates authority to work independently, however, I figured out that they won't work hard without my control. I have to keep my eyes on so many things. I always feel so tired of doing that, but I have to, otherwise, things will get out of control.

Under his support, LSS improvement activities were implemented throughout the whole plant very quickly. It seems everyone joined in this LSS "battle." However, once his attention moved to other work, the progress of LSS slowed. The LSS improvement promotion activities only went on for a couple of months and then everyone's passion drained away.

The president of VTCL was assessed as a "Bureaucratic Manager." However, at the time of the study, he was barely in charge of the daily management of VTCL based on the interview with P2 (HR Director of VTCL). All management decisions were made by P2 (HR Director) and T3 (Operational Director of VTCL). Both the HR Director and General Manager were assessed as "builders of learning organizations." Unlike other top management who required the subordinates to learn Lean concepts, P2 and T3 were both loyal followers of the LSS philosophy. After the first Lean program initiated in September 2014, P2 and T3 started to learn Lean principles and tools and eventually started learning Six Sigma. P2 and T3 also tried to practice the principles and tools they learned in their plant. P2 and T3 eventually turned to Lean experts and practitioners.

The leaders of BAG were assessed as "Group Facilitators" based on the Toyota leadership model. Group facilitator is the type of leader who always has strong facilitation and communication skills. They can motivate employees to work together to achieve the common goals while the leader himself might not really understand the work (Hines et al., 2008). The General Manager of the Shangyong plant of BAG would authorize subordinates to complete work independently, and he cared primarily about the outcomes.

The three interviewed LSS supporting personnel at each location mentioned the importance of leadership in LSS implementation. If the top management cannot support LSS implementation, it's almost impossible to adopt LSS successfully. This was the case at EBHL. Most of the general managers of the branches held negative attitudes towards the change. The initial disagreement among the top management set up huge obstacles for the following LSS adoption. P1 was the newly hired quality director of EBHL, who was also an MBB and experienced LSS consultant. As the person who led their LSS promotion, he pointed out that "branches of EBHL cannot understand why we are doing LSS now. It's a long-term task to persuade everybody to buy into the new management philosophy. It's a very tough thing!"

Aside from the inconsistent results from top management, the president of EBHL just provided oral authority and couldn't provide long-term support for LSS implementation based on

the interview with P1 (MBB in the Quality Control department of EBHL) who led the LSS implementation activities. Once it became clear that the LSS adoption didn't achieve the expected results at EBHL, he would question the LSS steering office and put pressure on the implementation team. On the contrary, the president of VTCL is highly trusted among the management team who is also responsible for LSS adoption with help from external LSS consultants. The VTCL president has a higher tolerance for failure during the LSS adoption and is also willing to absorb the failure costs. P2, who is the LSS promoter and HR director of VTCL, shared that:

> My boss deeply trusts the management team. He has a very good virtue which is that he is willing to absorb the failure cost because he understands that failure is inevitable during the LSS discovery journey. As long as you can explain why the failure happens, he is willing to pay. If we are only focusing on not making mistakes, innovation and change won't happen.

The author also found that top management from the three companies had very different views on learning LSS themselves. The General Manager from EBHL mentioned that he was busy managing the whole plant and didn't have energy and time to deeply learn LSS. He shared that "the reason I spent a lot of money on hiring these LSS experts is because I need them to help me resolve my problems. If I had time to learn these things by myself, why would I hire them?"

However, the Operation manager and HR manager at VTCL believed that the upper management's understanding and learning LSS is very critical for LSS promotion. The HR director of VTCL, P2, shared that:

> Four years ago, both T3 and I knew nothing about LSS. But now, we turned ourselves into LSS experts by constantly learning and practicing. We also persuaded our president to learn with us. I think the president and the top management team are like a couple. If the president always stays at home and does nothing while the top management team is stepping forward, this couple will be broken up finally. The development of the company needs the president and top management team to work together. Besides, if the president knows what LSS is, they will be able to support us in the long term and won't interrupt us during the LSS discovery journey.

Since BAG is one of the first groups of companies to implement LSS in China, the interviewed top manager, T2, was a very experienced MBB and LSS expert, according to an informal conversation the author had with employees during a field visit to BAG. T2 started to implement LSS practices in the plant in 2011, but the support for his initiatives stayed superficial and not operational. A member of the LSS support personnel at BAG, P3, shared that:

> T2, as the general manager in our plant, supports LSS promotion work, but he only cares about the results and won't concern himself with the process. Because he is missing from the promotion process, I suffered great resistance from the other employees during my promotion work.

Integration of LSS in business strategy and performance

Several interview participants, including top management and LSS supporting personnel, mentioned that it's very important to integrate LSS in business strategy and performance based on management objectives. However, the LSS promoters from EBHL and BAG complained that their companies didn't perform very well in this area. The General Branch Manager of the Yongda plant of EBHL, T1, shared that:

> The implementation strategy of LSS didn't mix very well with the management objective. For example, we believed that quality improvement can be achieved by improving battery production technology but the new coming LSS promoters always mentioned the process control…

The LSS supporting personnel member P3, from BAG also shared that:

> We didn't implement LSS based on the management objective. Actually, we don't even have an LSS implementation strategy. Our plant will just promote the related quality improvement activities based on the order from the headquarters. The priority of different quality improvement activities is based on the deadline provided by the headquarters.

The LSS supporting personnel and HR director in VTCL, P2 emphasized that:

> We definitely implemented LSS based on the management objective. Otherwise, the more you did, the more mistakes you might make…We will always remind everyone to look back at the management objective during the LSS adoption process.

All three companies constantly trained employees in quality skills, and conduct quality improvement activities and LSS projects to integrate LSS into the business strategy in order to make sure LSS can be implemented in the long term. The MBB in the Quality Control department of EBHL, P1 pointed out that:

> Our ultimate goal is to establish a new quality culture and change the way of thinking in this company. In order to achieve this goal, we need to integrate LSS into our business strategy via continuous education of employees on LSS and launching LSS improvement projects.

Tracking financial benefits generated from LSS projects is useful to integrate into a business strategy. Indeed, gaining financial benefits is one of the most important reasons that the companies studied decided to implement LSS in their organizations. However, if upper management cannot maintain LSS development and handle the relationships between immediate interests and long-term interests, this factor will become an obstacle to LSS implementation. The LSS supporting personnel in EBHL, P1 (MBB in the Quality Control department of EBHL) shared that:

> The upper manager at EBHL is only concerned with the immediate interests. He can only wait for one or two years to see the financial benefits gained from the LSS promotion and there is no way for him to wait more than two years. He doesn't care about the establishment of a quality system or quality improvement. He is only interested in the problems that you can resolve, the financial benefits that he can gain from the LSS implementation.

The president of VTCL is also concerned with LSS financial benefits, but VCTL's strategy is not focusing on the amount of money saved and instead on careful calculation of financial benefits gained based on the observations. The LSS supporting personnel and HR director of VTCL, P2, shared that:

> We will calculate the financial benefits before the project. However, the financial benefits gained after the project cannot be admitted by the financial department. They will question financial gains generated from the quality improvement. Since the financial department is administrated by the headquarters, the LSS promoter in the plant can't get the support from the financial department.

The LSS promoter at BAG also agrees that measurement of financial benefits is useful, however, this strategy is restricted by their company structure. He stated that "the financial benefits gained from each project will be calculated carefully. For example, the frontline workers improved the way of cutting shims and this improvement project can help us to save 2000 RMB per year."

LSS steering organization performance

All three companies have LSS steering organizations, even though the format of the organizations is different. The LSS steering organization at EBHL was a newly hired LSS consultant team in the quality control department. The HR director, operation director, and external LSS consultant formed the LSS steering office at VTCL. BAG also had LSS steering

offices at each location. Most of the participants admitted that the performance of the LSS steering organization will directly impact the LSS implementation results. Both the general manager at EBHL and the LSS promoter at VTCL mentioned that the promoters' communication skills had potential influence on LSS buy-in among the employees. The general manager at EBHL, T1, commented that "the LSS steering organization's communication skills in our company is too bad. Their bureaucratic promotion method cannot build trust bonds with the employees. They need to communicate with frontline workers on site more."

The LSS supporting personnel and HR director of VTCL, P2, emphasized that:

> In the promotion office, I think soft skills are more important than hard skills. (Soft skills are communication skills and hard skills are LSS technology and tools.) If your employees can't buy into LSS from the bottom of their heart, it's impossible to implement LSS successfully no matter how experienced and professional you are in LSS.

The implementation methods of LSS are either top-down or bottom-up. Two of the companies, EBHL and BAG, admitted that their LSS promotion was top-down, but all companies met soft resistance from the middle management and frontline workers. The LSS supporting personnel from VTCL shared that:

> "We used a top-down promotion method in the beginning, but it failed. Then, we tried different ways to get all the employees engaged in the LSS promotion activities. For example, we found that if we design the workstation for the workers, they will feel it is inconvenient. We encouraged them to design the workstation by themselves. They might propose avariety of improvement plans. Our steering office will be responsible for evaluation and choosing the final improvement plan, but still, these plans are proposed by the workers, not the management team."

Establishment of appraisal mechanisms is critical to getting employees involved in the quality improvement activities. All three companies implemented appraisal management. EBHL had a very good start: employees who proposed good improvement ideas got financial rewards and were praised in public. However, it didn't last long. After one year, the appraisal mechanism gradually disappeared. On the other hand, the appraisal mechanism at BAG was a problem. Since the financial department in the plant was administrated directly by the headquarters, BAG did not admit the financial benefits gained from the quality improvement activities and didn't give its employees any financial support. The LSS steering office in the plant could only work

with the trade union in the plant and provide prizes, such as quilts, mugs, and so on. The LSS supporting personnel at BAG shared that:

> It's very difficult to implement appraisal management in my company. We can't provide financial rewards like other companies because the financial department in the plant is administrated directly by headquarters. We can't get financial support for the good quality improvement projects…

Additionally, the LSS supporting personnel at VTCL stated that the communication and feedback system establishment was also very important in the beginning of the LSS adoption. She said that:

> In the beginning, when the LSS implementation team and middle management couldn't reach a unified opinion, we would organize weekly meetings and use brainstorming to display everyone's opinion. Now, the middle management and frontline workers will meet spontaneously to express their feedback and opinion by themselves even without the LSS steering office's supervision.

All three companies either have internal MBBs and BBs, or have hired MBBs or LSS consultants to adopt the LSS approach in their organizations. These MBBs and LSS consultants from all three companies are all very experienced, especially at BAG. All the middle managers at BAG accepted the BB training, resulting in the company having a great number of MBBs and BBs.

Evaluation methods for the performance of quality improvement activities is also an important task for LSS steering activities. There are primary differences in evaluation methods between the three companies. Based on field visits, the author observed that EBHL was using a patrol mechanism. The LSS steering office assigned staff to patrol the frontline workers regularly and check the LSS improvement results. The LSS promoter at VTCL shared that "LSS evaluation has been added to the employees' KPI (Key Performance Indicators) and is part of the daily work for the employees."

The LSS promoter at BAG shared that:

> After the employees finish the improvement projects, our LSS steering office will give an evaluation comment for the project. If the comment is negative, the employees' salary will be reduced. We worried that this might generate resistance to doing projects. I will just give them positive comments regardless of the performance of the project.

Employee engagement

Employee engagement is critical to LSS implementation success. All the participants emphasized the importance of employees' involvement in the quality improvement activities. All the LSS promotors confronted resistance during LSS promotion, but only VTCL seemed to successfully resolve this problem based on the interview with T3, (Operational Director of VTCL).

In EBHL, there are too many different education and training resources in the pilot factory. It turns out the employees' attention was unfocused and they could not make time or did not have energy to attend LSS education workshops. The General Branch Manager at EBHL, T1, said that:

> No resources are a problem, but my problem is that the headquarters gave too many different resources to my plant. We are implementing TQM, LSS, quality systems and so on. Employees only have limited spare time because they also have functional tasks they need to complete every day.

The problem at VTCL is that the education level of the middle management is comparatively low, and most of managers only have a high school education. It's very hard for VTCL's management to digest the necessary LSS concepts, but the LSS steering organization organized interesting activities and games to arouse employee interest. The LSS promoter at VTCL shared that "in the beginning, we organized many different interesting LSS activities and games. We tried to make our employees think that LSS is an interesting thing instead of a task. It very important to let them buy into LSS gradually."

The phenomenon of employee involvement in LSS education at BAG is interesting. The employees show a lot of excitement, especially the new employees involved in Lean and BB training. BAG currently has a sophisticated LSS training program and BB training will be organized every year. However, the employees are only interested in receiving training to get the BB certification, and are reluctant to launch LSS improvement projects afterward. The general manager at BAG mentioned that "we have a sophisticated LSS training system and customized teaching materials. The BB instructors hired every year for the training program are experts with a solid reputation in the quality control area in China, but our employees don't have time."

Since at the beginning, the LSS change requires extra work on the part of the employees, participants described a common problem during the LSS implementation. They indicated that employees tended to give very low priority to LSS work compared to their daily functional work.

The LSS promoter at EBHL said that:

> The middle management has their functional duties. Since the LSS consultant is a freshman to the company, the middle management will tend to finish their daily work first…We need to fight for resources and attention in order to finish our promotion work.

The LSS supporting personnel at BAG said that:

> The employees treat LSS as perfunctory work assigned by the LSS steering office. Once the LSS office launches some activities, the middle management will just receive the task and assign the work to their subordinates…Since LSS doesn't add to the KPI, the employees will give very low priority to LSS work…Resistance from the employees is huge because they think they are already tired with the daily work and can't make more time or energy to deal the LSS anymore.

LSS technology and tools

Both EBHL and VTCL launched systematic LSS training and implementation. The LSS technology and tools that EBHL and BAG used include QCC (Quality Control Circle), 5S, QC 7 tools, SPC, C_{pk}, Visual Management, FMEA, DOE (Design of Experiment), Kaizen event, TPM, Value Stream Mapping and SOP. VTCL implemented selected LSS technology and tools, including QCC, 5S, QC 7 tools, Visual Management, Kaizen event, and Value Stream Mapping. Among the LSS tools and technology noted above, QCC is different from the other LSS tools. It originated from Japan and the format is similar to Quality Improvement Circles. QCC is organized by the frontline workers themselves and the number of members is typically 4 to 7 individuals. Usually, the team members in one team come from the same functional area. The QCC teams meet regularly and carry out quality improvement activities, such as 5S, Visual Management, TPM and so on.

The LSS supporting personnel from VTCL emphasized that communication skills are more important than knowledge of LSS technology or tools.

The general manager of BAG stated that:

> My plant was selected as a pilot plant in 2017 and implemented many Six Sigma tools, such as SPC, Cpk, FMEA, DOE and so on. However, these implementations didn't achieve expected results. For example, we spent a lot of money on DOE to explore the optimal parameters for the battery formatting process, but we failed. I think implementation Six Sigma is not the right strategy for BAG right now. Our product is lead-acid batteries and it is a chemical reaction. As far as I know, Six Sigma is more suitable for the automotive industry.

> Lean might be useful, such as 5S and Visual Management, but the current achievement is minor.

Organizational culture

Organizational culture is a set of shared assumptions that guide the employees to behave appropriately in various situations and settings (Ravasi & Schultz, 2006). Both EBHL and VTCL are private organizations. Based on the on-site observation, the author found "Renqing" culture existed in the management of these two companies. "Renqing" means "human relationships" in Chinese. The LSS supporting personnel in EBHL shared that:

> I think our company has "Renqing" culture and it is also a typical characteristic in private organizations. For example, the company founder will assign his relatives and friends to the critical functional department inside the organization, such as the financial department.

He also shared that:

> The "Renqing" culture in China will also form "Quanzi" culture. ("Quanzi" means "Circle" in Chinese). Once a circle is formed in a company, the good side is that the cohesiveness ofthe circle is very strong and then work can be done efficiently inside the circle. However, the bad side is that the external consultants are a new force, and employees inside the circle will act naturally against the new force. Employees in the same circle have similar patterns of behavior. If the new consultants ask them to follow the new scientific management philosophy and change their behavior and habits, they will resist.

He admitted that "Quanzi" culture is the biggest barrier at EBHL currently. The LSS supporting personnel at VTCL also pointed out "Renqing" culture is obvious inside the plant. She said that "the atmosphere in our company is homely. We are like family. The cohesiveness among the employees is very strong. The employee turnover rate is very low."

During a field visit to VTCL, the author found that the LSS promoter will do Gemba Walks along the assembly lines. She will warmly greet the frontline workers she met and give them advice and suggestions for LSS improvement. There is a farm inside the plant and the workers can grow and harvest vegetables. All the employees in the plant also own a dog together. The atmosphere of the plant is very harmonious and relationships between frontline workers and the management team is very relaxed.

During the field visits to EBHL and BAG, the author found that their LSS work is somewhat superficial. The employees in these two companies also complained that LSS work

doesn't add real value to their daily tasks. In the interview, the LSS supporting personnel of BAG complained that:

> Our work is very superficial. We just talk about slogans such as "zero defect" every day. Even I, as an LSS promoter, don't know the strategy this year and there is no strategy to tell us what kind of promotion topics we should follow.

However, the operation director of VTCL stated a different scenario:

> Everybody knows what we should do this year and why we need to do it. Strategy shouldn't only exist in the top management's mind and all the employees need to know it. We will not only let them know what the goal is this year but also tell them what benefits they can get.

Employees willingness to change is a common problem in LSS change based on the replies from almost all the participants interviewed. They all mentioned that the middle management is the most important in LSS implementation compared to top management and frontline workers.

The LSS promoter at EBHL said that "we need to get the agreement and commitment from the top management to start LSS change but the middle management is the most important in the practical implementation."

The LSS promotor at VTCL shared:

> Compared to top management and frontline workers, middle management is the hardest level to change. They are the core members in LSS practices; however, their study base is very weak. They can't understand LSS content and are not capable of making PPT because they need to use PPT to display the improvement results every week.

The LSS promoter at BAG shared:

> We can use training and management mechanisms to force and drive the middle management to change. However, the frontline workers will think my talent is limited and I am not capable of doing the job. They will just leave the company.

But at BAG, even though middle management is the most important level of LSS practice implementation, the frontline workers are the hardest level to change. The yearly turnover rate at BAG is very high, at more than 100%. He also shared that "during implementation, I think middle management is more important because they need to be responsible for the specific projects or activities. If they are willing to do this, their subordinates will also be willing to do it."

Process management

Sustainability of LSS implementation is also a common problem mentioned by the participants interviewed. The general manager of EBHL mentioned that the implementation results are temporary. The LSS promoters of EBHL shared that "currently, there is no scientific process to support constant improvement and all the supporting process is temporary. As time goes by, it just disappears gradually."

The author checked the QCC activities at EBHL every 3 months. The author found that the frontline workers' passion is high in the beginning, but their activities are mainly cleaning and maintenance instead of LSS improvement, and all the QCC activities gradually disappeared after one year. The general manager of VTCL is very proud of their supporting process. He mentioned that they kept improving the supporting process. He also shared that:

> I think the first part of LSS implementation is establishing standardization. We need to standardize all the production processes in detail. After everyone has become familiar with everything, we don't need to follow the detailed regulations that exactly. The process goes from simple to complex and then finally to simple again.

As the LSS promoter at BAG mentioned before, the financial and HR departments do not belong to the plant and cannot provide support. Even the LSS implementation has been admitted by the general manager of the plant, they can't get support from HR and financial department. He also mentioned that the standardization of the manufacturing process at BAG is reasonably good, but the LSS implementation is the problem.

LSS implementation results

The three companies are still adopting LSS and there are primary differences between the LSS implementation results.

The general manager of EBHL commented that their LSS implementation has temporarily failed in its current phase. He also admitted that some changes happened in his plant. For example, the standardization of assembly lines increased from 10% to 15% of the production efficiency. He said that they need self-examination and are still on the LSS journey.

The operation director of VTCL commented that their LSS implementation was successful but he also admitted that the benefits gained from LSS are decreasing year by year. He said they are still exploring.

The general manager of BAG commented that their LSS implementation was successful. However, the LSS supporting personnel believed their LSS work is still in progress and they will keep implementing LSS.

The following Table 4-7 is the summary of the typical themes emerging from interview evidence, document analysis, and on-site observations. In the data source column, F1, F2, F3, S1 are the codes that represent the data sources (Table 4-6).

Table 4-6 Data source code

Data Source		Quantity	Code
First-hand source	Interview with top management	4	F1
	Interview with LSS supporting personnel	7	F2
	On-site observation notes, analytical memos	27	F3
Second-hand source	Company website, minutes from LSS promotion meetings, LSS implementation report and financial documents	18	S1

Table 4-7 Summary of evidence from interview data, field notes, and document review

	Primary Coding	Secondary Coding	Typical evidence examples			Number of entries	Data Source
			EBHL	VTCL	BAG		
CSF	Leadership	Upper management commits to LSS	"The voice of top management at the headquarters is mixed. Most of the top managers state negative attitudes towards LSS implementation." "Branches of EBHL cannot understand why we are doing LSS now. It's a long-term task to persuade everybody to buy into the new management philosophy. It's a very tough thing."	"When our company was going bankrupt, our president decided to adopt LSS to break through the bottleneck of management because he knows LSS can reduce production costs and decrease defects." "As the primary LSS promoter, I have very strict requirements for myself. I am willing to constantly improve and accept challenges. So, the LSS implementation process is also a form of self-transcendence for me."	"I was certified as MBB in 2005 and have considerable high recognition of LSS and will implement it constantly in my plant."	5	F1, F2, F3
		Upper management supports LSS	"The implementation is still at verbal authorization and encouragement. For example, the president will just say implement it successfully in the pilot factory first. There is no long-term sustainable support and once mistakes or problems occur, the president will question the talent of promoters and consultants and put pressure on them."	"My boss deeply trusts the management team. He has a very good virtue which is that he is willing to absorb the failure cost because he understands that failure is inevitable during the LSS discovery journey. As long as you can explain why the failure happens, he is willing to pay. If we are only focusing on not making mistakes, innovation and change won't happen."	"I will support you to do this implementation and give you authorization, but for the process, I can assign a MBB to tutor you. I am only concerned about the results." "Our general manager supports LSS promotion work, but he only cares about the results and won't concern himself with the process. Because he is missing from the promotion process, I suffered great resistance from the other employees during my promotion work."	6	F1, F2

Table 4-7 continued

		Upper management's understanding and learning of LSS	"The reason I spent a lot of money hiring these LSS experts is because I need them to help me resolve my problems. If I had time to learn these things by myself, why would I hire them?"	"Four years ago, both the operation director and I knew nothing about LSS. But now, we turned ourselves into LSS experts by constantly learning and practicing. We also persuaded our president to learn with us. I think the president and the top management team are like a couple. If the president always stayed at home and did nothing while the top management team stepped forward, this couple would be broken up finally. The development of the company needs the president and top management team to work together. Besides, if the president knows what LSS is, they will be able to support us in the long term and won't interrupt us during the LSS discovery journey."	"Our general manager has a deep understanding of LSS and he is also an experienced MBB by himself. "	5	F1, F2

Table 4-7 continued

	Integration of LSS in business strategy	Based on management by objective	"The implementation strategy of LSS didn't mix very well with the management objective. For example, we believed that quality improvement could be achieved by improving battery production technology but the new coming LSS promoters always mentioned the process control…"	"We definitely implement LSS based on the management objective. Otherwise, the more you did, the more mistakes you might make…We will always remind everyone to look back at the management objective during the LSS adoption process."	"We didn't implement LSS based on the management objective. Actually, we don't even have a LSS implementation strategy. Our plant will just promote the related quality improvement activities based on the order from the headquarters. The priority of different quality improvement activities is based on the deadline provided by the headquarters."	7	F1, F2
		Based on continuous education of quality skills	"Our ultimate goal is to establish a new quality culture and change the way of thinking in this company. In order to achieve this goal, we need to integrate LSS into the business strategy through continuous LSS education and by launching LSS improvement projects."	"Our company will hire external LSS consultants and initiate a training program based on the current status every year. "	"We will launch a blackbelt training program every year and invite well-regarded experts and scholars. "	4	F1,F2
		Based on project management in organization	"The format of LSS implementation is based on frontline improvement and process control projects."	"We will develop related quality improvement projects based on the current status and advice from the LSS consultant. "	"We mainly promote LSS by doing projects."	4	F1, F2, S1

Table 4-7 continued

		Based on the execution of different quality improvement activities	N/A	"We developed different quality improvement activities, such as a quiz about 5S and VM and spot the differences game for Lean. These quality improvement activities are simple and interesting which can interest the employees right away. "	N/A	3	F2, F3
		Based on the measurement of financial benefits from quality improvement	"The upper manager at EBHL is only concerned with the immediate interests. He can only wait for one or two years to see the financial benefits gained from the LSS promotion and there is no way for him to wait more than two years. He doesn't care about the establishment of quality systems or quality improvement. He is only interested in the problems that you can resolve, the financial benefits that he can gain from the LSS implementation."	"The financial benefits gained from each project will be calculated carefully. For example, the frontline workers improved the way of cutting shims and this improvement project can help us to save 2000 RMB per year."	"We will calculate the financial benefits before the project. However, the financial benefits gained after the project cannot be admitted by the financial department. They will question financial gains generated from the quality improvement. Since the financial department is administrated by the headquarters, the LSS promoter in the plant can't get the support from the financial department."	8	F2,F3, S1

Table 4-7 continued

	LSS steering organization performance	Communication skills with employees	"The LSS steering organization's communication skills in our company are too bad. Their bureaucratic promotion method cannot build trust bonds with the employees. They just utilize authorization to implement LSS from top to bottom. They need to communicate with frontline workers onsite more."	"In the promotion office, I think soft skills are more important than hard skills. (Soft skills are communication skills and hard skills are LSS technology and tools.) If your employees can't buy into LSS from the bottom of their heart, it's impossible to implement LSS successfully no matter how experienced and professional you are in LSS." "The LSS consultant is a very responsible and nice person. He will take the initiative to ask the frontline workers and check whether they have problems. If people tell him they don't know how to do it, he will teach them patiently. He stayed in the workshop from 8:30 am to 11:00 PM. We are all moved by his spirit. He and I tend to be very good friends."	"He is a very responsible person, but his communication skills might still need to be improved because he needs to drive the interests of employees."	11	F1, F2, F3

Table 4-7 continued

		Promotion methods (top-down or bottom-up)	"Our promotion strategy is built around the 1122 model and promoted from top to bottom." "We will tell the employee what to do and the steering office will inspect regularly. If the employee didn't perform very well, we will build a related punishment system."	"We used a top-down promotion method in the beginning, but it failed. Then, we tried different ways to get all the employees engaged in the LSS promotion activities. For example, we found that if we design the workstation for the workers, they will feel it is inconvenient. We encouraged them to design the workstation by themselves. They might propose variety improvement plans. Our steering office will be responsible for evaluation and choosing the final improvement plan, but still, these plans are proposed by the workers, not the management team."	"Every time, once we get the instructions from the headquarters, I will build a project bank based on the problems in the production process associated with the advice of the quality director. Then, employees can choose the improvement topic from the bank." "Basically, we use a top-down mechanism to promote LSS."	13	F1, F2

Table 4-7 continued

		Appraisal management implementation	The Yongda family (QCC) has an appraisal system and the company will reward employees accordingly based on the quality improvement performance.	"In order to motivate employees to conduct quality improvement, we will buy a variety of prizes before the activities and place them in prominent locations where the employees can easily see them when they go to the cafeteria." "I think if we want to implement LSS in the long term, we need to utilize both appraisal management and a constraint mechanism. The two mechanisms need to work together. If we just reward without constraints, LSS won't last long. If we only have constraints without reward and motivation, the employees will be under pressure and gradually generate negative a attitude."	"It's very difficult to implement appraisal management in my company. We can't provide financial rewards like other companies because the financial department in the plant is administrated directly by the headquarters. We can't get financial support for the good quality improvement projects…"	16	F1, F2, F3, S1

Table 4-7 continued

		Communication, feedback and cognition system construction	"No feedback system. They only have an inspection system. "	"In the beginning, when the LSS promotion team and middle management couldn't reach a unified opinion, we would organize weekly meetings and use brainstorming to display everyone's opinion. Now, the middle management and frontline workers will meet spontaneously to express their feedback and opinion by themselves even without the LSS steering office's supervision."	"No feedback system, but we will ask them to fill out a feedback questionnaire sometimes."	4	F2, F3
		Sufficient self-fulfillment of MBBs, BBs, and GBs	"In the beginning, our company had four MBBs and seven BBs. After two years of training, we have 16 BBs and 50 GBs in the organization. "	"We have a connection with a consulting company over the long term and this company will send 1–2 consultants to our company every year. "	"As one of the first companies that started to implement LSS in China, our company has a great number of MBBs, BBs, and GBs."	5	F1, F2, F3
		Competence of MBBs' and BBs' capability of instruction	"The MBBs and BBs are very experienced experts and have experience in both the manufacturing industry and consulting companies."	"The external LSS consultant hired is a very experienced LSS expert."	"Our company has a great number of MBBs and BBs and they are very experienced in doing projects. Besides, our LSS projects have won in national SS competitions many times."	5	F1, F2, F3

Table 4-7 continued

		Clearly express the objective of improvement	"We will briefly tell them the objective of quality improvement projects and activities. "	"We will tell the employees what kind of improvement we will make and why we need to make them. "	"I can just briefly tell employees the major benefits that these quality improvement activities can bring us."	3	F2
		Clearly convey the urgency of changing	N/A	"In 2014, our company was going to go bankrupt. We had a meeting with all the employees and stated the urgency of changing and why we adopted LSS."	N/A	1	F2
		Evaluation method for the performance of quality improvement activities	"The evaluation method is the inspection system. The LSS steering office will send quality control engineers to do a Gemba Walk regularly. Additionally, the LSS steering office will display the promotion results by PPT in monthly meetings with the president and receive evaluations from the president."	"LSS evaluation has been added to the employees' KPI (Key Performance Indicators) and is part of the daily work for the employees."	"After the employees finished the improvement projects, our LSS steering office will give them an evaluation comment for the project. If the comment is negative, the employees' salary will be reduced. We worried that this might generate resistance to doing projects. I will just give them positive comments regardless of the performance of the project."	11	F2,F3

Table 4-7 continued

	Employee engagement	Supporting, involving in education of quality management	"No resources can be a problem, but my problem is that the headquarters gave too many different resources to my plant. We are implementing TQM, LSS, a quality system and so on. Employees only have limited spare time because they also have functional tasks they need to complete every day."	"Employee engagement changed during the promotion process. Most of the workers are only high school graduates and can't understand LSS, so the engagement was very low in the beginning. But we organized many different interesting activities and games of LSS. We tried to make our employees think that LSS is an interesting thing instead of a task. The gradually started to buy into LSS these years."	"New employees' engagement is very high and they are still eager to participate in LSS training programs and learn new knowledge." "We have a sophisticated LSS training system and customized teaching materials. The BB instructors hired every year for the training program are experts with a high reputation in the quality control area in China, but our employees don't have time."	7	F1, F2
		Priority in implementing quality activities of department	"The middle management has their functional duties. Since the LSS consultant a is freshman to the company, the middle management will tend to finish their daily work at first." "We need to strive for employees' resources and attention in order to finish our promotion work."	"The priority is high for sure. LSS work has been added to their KPI and that is also part of their daily work. "	"The employees treat LSS as perfunctory work assigned by the LSS steering office. Once the LSS office launches some activities, the middle management will just receive the task and assign the work to their subordinates." "Since LSS doesn't add to the KPI, the employees will give very low priority to LSS work…" "Resistance from the employees is huge because they think they are already tired from the daily work and can't make more time or energy to deal with the LSS anymore."	8	F2, F3

		Involving in implementing the quality improvement activities	Most of the employees didn't buy into the LSS philosophy. Even though they participated in the quality improvement activities, these changes are very superficial and can't last long."	"In the beginning, the LSS implementation brought more work to the employees but we worked together and stuck with LSS. Gradually, the employees found their work actually reduced after LSS adoption."	"After the employees completed training and started to do the LSS projects, they encountered problems and resistance and most of them just give up. Most of the employees were reluctant to do the projects."	4	F2, F3
	LSS Technology & Tools	QCC (Quality Control Circle)	Implemented in the organization	Implemented in the organization	Implemented in the organization	5	F2, F3, S1
		5S training and implementation	Implemented in the organization	Implemented in the organization	Implemented in the organization	7	F2, F3, S1
		QC (Quality Control) 7 tools training and implantation	Implemented in the organization	Implemented in the organization	Implemented in the organization	4	F2, F3, S1
		SPC skills training and implementation	Implemented in the organization	N/A	Implemented in the organization	3	F2, F3, S1
		Cpk skills training and implementation	Implemented in the organization	N/A	Implemented in the organization	3	F2, F3, S1
		Visual Management training and implementation	Implemented in the organization	Implemented in the organization	Implemented in the organization	8	F2, F3, S1
		FMEA training and implementation	Implemented in the organization	N/A	Implemented in the organization	3	F2, F3, S1
		DOE training and implementation	Implemented in the organization	N/A	Implemented in the organization	3	F2, F3, S1

Table 4-7 continued

		Kaizen event training and implementation	Implemented in the organization	Implemented in the organization	Implemented in the organization	3	F2, F3, S1
		TPM training and implementation	Implemented in the organization	N/A	Implemented in the organization	4	F2, F3, S1
		Value Stream Mapping training and implementation	Implemented in the organization	Implemented in the organization	Implemented in the organization	5	F2, F3, S1
		SOP (Standard Operation Procedure) training and implementation	Implemented in the organization	Implemented in the organization	Implemented in the organization	8	F2, F3, S1
	Organizational Culture	″Renqing″ – human relationship culture	"I think our company has "Renqing" culture and it is also a typical characteristic in private organizations. For example, the company founder will assign his relatives and friends to the critical functional departments in the organization, such as the financial department." "The "Renqing" culture in China will also form "Quanzi" culture. ("Quanzi" means "Circle" in Chinese). Once a circle is formed in a company, the good side is that the cohesiveness of the circle is very strong and then work can be done efficiently inside the circle. However, the bad side is that the external consultants are a new force and employees inside the circle will naturally be against the new force. Employees in the same circle have similar patterns of behavior. If the new consultants ask them to follow the new scientific management philosophy and change their behavior and habits, they will resist."	"Renqing culture can be found in our company. The atmosphere in our company is homely. We are like family. The cohesiveness among the employees is very strong. The employee turnover rate is very low."	"Our company culture is a mix of bureaucracy and military management. "	13	F2, F3

Table 4-7 continued

		Express the transition and action required to bridge from the current status to the future status	"Before implementation, we built a theoretical model called a 1122 model. It expresses the transition and action required to implement LSS in order to achieve the ultimate goal which is quality culture." "The LSS steering office is very good at making plans and always has very detailed plans and their PPT presentations of LSS results are also very good. However, the practical implementation is very superficial."	N/A	N/A	3	F1, F2, F3
		Confirming the short-term, and long-term quality strategy with all employees in the organization	N/A	"Everybody knows what we should do this year and why we need to do it. Strategy shouldn't exist in the top management's mind and all the employees need to know. We will not only let them know what the goal is this year but also tell them what benefits they can get."	"Our work is very superficial. We just talk about slogans such as "zero defect" every day. Even I, as an LSS promoter, don't know the strategy this year and there is no strategy to tell us what kind of promotion topic we should follow."		F2

Table 4-7 continued

		Employees' belonging to the company	"The turnover rate of middle management is comparatively low but the frontline workers' turnover rate is comparatively high."	"Our employees' belonging to the company is very high and it has also helped us overcome the problems together." "There are very few workers who will leave every year." "The LSS promoter will do the Gemba Walk along the assembly lines. She will warmly greet the frontline workers she met and give them advice and suggestions for LSS improvement. There is a farm inside the plant and the workers can grow and harvest vegetables. They also own a dog together."	"For frontline employees, belonging to company is very low. For middle management, belonging to the company is not very high and is much higher than the frontline workers. The turnover rate of middle management is comparatively low but the frontline workers' turnover rate is very high every year."	7	F2, F3

Table 4-7 continued

		Employees' willingness to change	"We need to categorize employees into top management, middle management, and frontline workers. Top management is the easiest to change, then middle management and then frontline workers are the hardest group to change." "We need to get the agreement and commitment from the top management to start LSS change but the middle management is the most important in the practical implementation."	"People are lazy and we don't want to change our environment because it's very painful. If people choose to change the environment, they must be forced to do that." "People have different reactions to change. Some of them are willing to embrace change. Some of them will hesitate in the beginning and change their attitude when they see the LSS results. There is still a very small group of people who are very stubborn and reluctant to change at all from the beginning to the end." "Compared to top management and frontline workers, middle management is the hardest level to change. They are the core members in LSS practices; however, their study base is very weak. They can't understand LSS content and are not capable of making PPT because they need to use PPT to display the improvement results every week."	"The LSS implementation in our company has moved to an idle period and employee commitment to LSS is far lower than before." "During implementation, I think middle management is more important because they need to be responsible for the specific projects or activities. If they are willing to do this, their subordinates will also be willing to do it." "We can use training and management mechanisms to force and drive the middle management to change. However, the frontline workers will think my talent is limited and I am not capable of doing the job. They will just leave the company." "Employees just made a perfunctory effort." "Almost 90% of employees scored 5 out of 5 when they were asked to evaluate the LSS implementation in their company. This is impossible."	19	F1, F2, F3

Table 4-7 continued

	Process Management	Supporting process for constant improvement	"Currently, there is no scientific process to support constant improvement and all the supporting process is temporarily. As time goes by, it just disappears gradually."	"We are constantly improving the supporting process." "LSS needs cross-department cooperation but it's very difficult. So, we establish a related supporting process. However, a supporting process can't resolve all the problems, implementation still has problems."	"We can't get the supporting process from financial and HR departments. They don't recognize the financial benefits gained from quality improvement."	7	F2
		Standardize processes	N/A	I think the first part of LSS implementation is establishing standardization. We need to standardize all the production processes in detail. After everyone has become familiar with everything, we don't need to follow the detailed regulations that exactly. The process goes from simple to complex and then finally to simple again.	"Standardization implementation went very well in our company but the following practical implementation has problems."	3	F2
Results	LSS implementation results		"LSS implementation has temporarily failed in the current phase. He also admitted that some changes happened in his plant. For example, the standardization of assembly lines increased from 10% to 15% of the production efficiency. He said that they need self-examination and are still on the LSS journey"	"The LSS implementation was successful but the benefits gained from LSS are decreasing year by year. He said they are still exploring."	"The LSS implementation was successful." "The LSS work is ongoing but they will keep implementing LSS. "	4	F1, F2, S1

4.9.4 Propositions for LSS implementation for Chinese manufacturing organizations

The original Lean Iceberg Model explains that there are five major factors that will impact the Lean implementation inside the organization, including tools and techniques, process, strategy, leadership and behavior, and engagement. However, tools and techniques as well as process are the two visible factors that can be noticed by the organization. However, the real enabling factors that will impact the Lean implementation results are strategy and alignment; leadership and behavior; and engagement.

The model in Figure 4-7 is the proposed LSS implementation model for Chinese manufacturing organizations based on the findings in the interviews. The left model is the traditional Lean Iceberg Model. LSS technology and tools and process management are the two visible factors of LSS implementation in the tractional Lean Iceberg Model. In the proposed LSS implementation model, the author believes that process management is also an enabling factor under the water line.

Additionally, organizational culture is added in the model as a background to the LSS implementation. Raje (2009) pointed out that cultural transformation was the ultimate stage that organizations should target, but it is currently missing in some organizations. In this study, the author found that organizational culture shouldn't be the ultimate stage or target of organizational change. Organizational culture itself is a very important factor that impacts LSS change inside the organizations. However, it also changes naturally during the process of LSS adoption. EBHL tried to manipulate the organizational culture in the beginning but failed. VTCL didn't mean to change the culture but their LSS culture gradually adjusted over the course of the successful LSS implementation in the organization.

Finally, the performance of the steering office is added as the agency factor that may constrain or elevate the performance of the visible and enabling factors. The author found that the performance of the LSS steering office was a critical factor in LSS implementation, but this factor was ignored in the previous literature. All the participants in the interview mentioned that the LSS promotion methods and communication skills of the LSS promoter were very important in persuading the employees to buy into the new philosophy gradually.

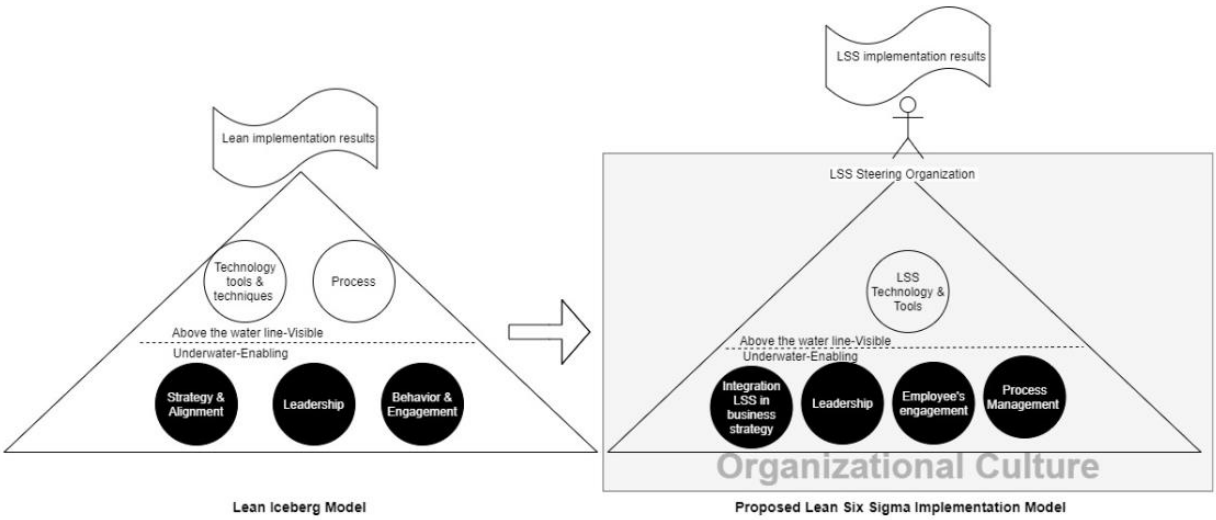

Figure 4-7 Proposed LSS implementation model

The three Chinese manufacturing organizations all spent most of the time developing a variety of LSS improvement projects and activities, especially EBHL and BAG. However, the employees in these two companies didn't genuinely buy into the LSS philosophy based on the author's observations. The result was that these changes were superficial, and the employees just made a perfunctory effort. The LSS supporting personnel in steering office at BAG believed that their work was very superficial, and they just talked about slogans such as "zero defect" every day. The MBB at VTCL stated that the steering office was good at making plans, but the practical implementation was very superficial.

During a visit of VTCL, the author found the HR director, who was also the leader of the LSS implementation team at VTCL, had extraordinary communication skills. She knew everyone in the plant and greeted them during the Gemba Walk. In the interview, the HR director of VTCL pointed out that LSS promoter's communication skills can play a critical role in the LSS buy-in among employees. It was even more important than the LSS knowledge they had, because if the employees can't buy in at first, they can't embrace the changes no matter how many times they are told that LSS tools are useful. Based on these findings from interviews and observations, the author proposes the following:

Proposition 1: LSS promoter's soft, or communication skills are more important than hard skills, or knowledge of LSS technology and tools during the LSS promotion.

Hines et al. (2008) defined Process Management as the supporting processes from Financial and HR departments and standardization processes, such as the production process, the cross-department system, the LSS feedback system, the appraisal system and so on. In this study, the author adopts Hines' definition. Sustainability of process management is a problem pointed out by the previous scholars. Liker and Rother (2011) stated that the Shingo Prize committee, which assesses Lean implementation and gives awards for excellence in Lean manufacturing, found that many of the past winners had not sustained their progress on the Lean journey after winning the award.

Based on the interview results, the author found that process management should also be the enabling factor under the water line that impacts the sustainability of LSS implementation but can't be seen by some companies. The LSS supporting personnel from EBHL and BAG all mentioned that the lack of a scientific process to support constant improvement was a primary reason that LSS implementation results didn't last long. In the interview, the HR director from VTCL emphasized that the supporting process had been built up in VTCL but it needed cross-department cooperation and this was very difficult to achieve. She also pointed out supporting process establishment was necessary but can't resolve all the problems because implementation of the supporting process itself was also a problem. Meanwhile, one Operational Director in VTCL believed that supporting processes should be modified constantly as well as the progress of LSS implementation. Based on these findings, the author proposes:

Proposition 2: Process management, including the supporting process establishment and process standardization, will effectively enhance the sustainability of LSS implementation. Process management should be constantly improved based on the progress of LSS implementation.

Based on the interviews and on-site observation, the author believes that organizational culture will impact the visible and enabling factors and will also be changed gradually as LSS implementation progresses. "Renqing," or human relationship culture was said to exists in all three companies. However, the expression of "Renqing" culture is different in the three investigated organizations based on the interview data and on-site observation. At EBHL, the

expression of "Renqing" is that the company founder assigns his relatives to work in critical functional departments, such as the financial department. At VTCL, "Renqing" culture constitutes a homely atmosphere and high cohesiveness among the employees. At BAG, "Renqing" culture is a form of bureaucracy mixed with military management.

Most of the interviewees from the three companies mentioned that LSS transformation involved teamwork, no one group was elevated above any other, and each management level played their own role. The Operational Director of VTCL pointed out that top management and LSS promoters should be responsible for making rules and establishing process support, the middle management was the most important group for promoting LSS and implementing the LSS tools on the shop floor in the plant, and frontline management and workers were the main participants of LSS improvement activities. All the employees together would form the culture in the organization. Both the MBB in the Quality Control department at EBHL and LSS support personnel from BAG believed that if the company wanted to implement LSS, all of the employees should work together, change their attitude and form a new "routine" or "LSS culture." It was very hard! However, once it was formed, this new problem-solving methodology would become part of employees' way of thinking. Based on the author's observations, LSS culture had gradually formed at VTCL already. The top management or LSS promoters didn't need to emphasize LSS anymore because that was their daily routine.

Based on the interviews and on-site observations, the author found that if the employees' loyalty and group cohesiveness was very high, it would greatly help the transformation, especially in the beginning of the adoption. This conclusion is also consistent with Shah and Ward's 2003 study. They stated that unionized facilities would resist adopting Lean practices because most manufacturing practices need to negotiate changes within the organizations (Shah & Ward, 2003). The author found that this HR director and the Operational Director of VTCL mentioned many times that their employees' loyalty was very high, and this company was like a family to them in the interview and in the LSS meeting minutes. The author also checked the annual staff turnover rate of VTCL from the documents provided by the HR department and it was only 6%, which was a very low number for manufacturing companies in China. The annual staff turnover rates for EBHL and BAG were 36% and 80% based on the information provided by their HR department. Based on these findings, the author proposes:

Proposition 3: Employees' loyalty and union is helpful in LSS implementation.

EBHL and BAG are big companies and have thousands of employees based on the documents provided by the HR department. During the on-site visits of EBHL, the author heard words similar to "fake LSS" from the middle management and LSS promotors. In the LSS meeting minutes, the author found that the middle management of the Yongda plant of EBHL mentioned several times that the LSS implementation didn't work however the LSS steering office still persistent to implement LSS in their way without taking feedback from the employees. The author observed that they just did perfunctory work to complete the tasks based on their performance in the LSS improvement projects. At BAG, the scenario was similar, and the employees were reluctant to initiate the LSS projects. Even though they did LSS tasks, their work was subpar. This phenomenon was both observed by the author and mentioned by the interviewees.

Unlike EBHL and BAG, VTCL is a very small company and only has 150 employees based on the documents provided by the HR department. However, because of its small size, the administration work is quite simple based on the interview with the HR director of VTCL. The author found communication from the top management to frontline workers was much more efficient than at big companies like EBHL and BAG based on the observation notes during research visits. Small companies usually are more flexible in dealing with changes. For the big companies, hierarchy dampens efficient and effective communication throughout the organization, which was mentioned by the LSS supporting personnel in the steering office at BAG. The voice and feedback from the employees cannot be conveyed to the management level and LSS supporting personnel efficiently and accurately. Based these findings, the author proposes:

Proposition 4: It is easier for small companies than large ones to implement true LSS. In large enterprises, the LSS implementation tends to become superficial or "fake".

Based on the interview, the LSS implementation methods of the three companies were all top-down and only VTCL changed from top-down to bottom-up when they found the former doesn't work. In the interview, all of the LSS supporting personnel mentioned that frontline management were the group of people who didn't want to change the most. The MBB from

BAG pointed out that most of the frontline management had worked on the shop floor for more than 20 years and they believed their rich experience could help them resolve any problem that occurred on the shop floor. This phenomenon was also observed by the author when she helped the steering office conduct LSS activities at EBHL. The frontline management believed that the reason that the LSS consultants introduced these improvement principles was because they didn't trust their ability of work. However, under huge pressure from the top management (General Manager and Deputy Quality Manager), they pretended to comply with the transformation, which was observed by the author and mentioned by the LSS supporting personnel. The MBB at BAG admitted that this "fake" continuous improvement implementation was even worse than if they had just said "No" directly. The LSS supporting staff from BAG explained that the frontline workers would just obey the orders from supervisors, however, their time was fully occupied by daily operation. Based on the documents provided by the HR department of the three companies, the author found that the frontline workers had to work 12 hours per day and would only take one to two days off per month. Their productivity was closely related to their wages, as mentioned by the HR director. During the Gemba Walk at EBHL, the author found that for most of the time, the frontline workers would not pick the poor-quality products out on purpose because it would decrease their productivity and affect their wages. They heard about this transformation from the shop floor managers, however, they didn't care because it would not increase their wages and their daily schedule was too tight for them to think about it. Based on the interview with the MBB at EBHL, the LSS supporting personnel taught the frontline workers how to use control charts to monitor the quality of the product and these operators were supposed to report to shop managers once the quality level of the products was out of the control lines. However, 3 months later, when the LSS consultant revisited the shop floor, he found most of them just knew to draw these lines but had no idea why they were doing this and how these charts would help their daily operational performance. The top management and LSS supporting personnel at EBHL, BAG, and VTCL all believed that since the frontline management and workers were the group of people who didn't want to change the most, they were also the main participants in the LSS improvement transition. It was very important to let them buy into the philosophy. The HR director of VTCL pointed out that if the LSS can be implemented bottom-up, the implementation might be easier. The methods used to interest the employees were varied, including encouragement and reward, simple and interesting LSS improvement activities, strong

communication skills of the LSS personnel and more spare time allowed for the workers. Based on these findings, the author proposes:

Proposition 5: LSS implementation will be more successful if it is implemented from the bottom up.

4.10 Conclusion

In summary, this article investigated three selected manufacturing companies which adopted LSS implementation. VTCL successfully implemented LSS inside the organization. At EBHL, LSS implementation had temporarily failed in its current phase but they were still on the LSS journey. The LSS work at BAG was superficial but they still continued implementation. Based on the interviews with top management and LSS promoters, associated with the field notes recorded by the author during site visits, the author proposed a LSS implementation model. This model is based on the Lean Iceberg Model. The primary differences are that "process management" goes from being a visible factor to being an enabling factor; "the performance of LSS the steering organization" is added as an agency factor that evaluates or constrains the performance of the other five factors; and "organizational culture" is added as the background to LSS implementation that will impact the other five factors and will also change gradually as the LSS implementation goes on. Based on the findings, the author also makes five propositions as follows:

1) LSS promoters' soft skills, like communication, are more important than hard skills, such as knowledge of LSS technology and tools during LSS promotion.
2) Process management, including supporting process establishment and process standardization, will effectively enhance the sustainability of LSS implementation. Process management should be constantly improved based on the progress of LSS implementation.
3) Employees' loyalty and union is helpful in LSS implementation.
4) It is easier for small companies than large ones to implement true LSS. In large enterprises, the LSS implementation tends to become superficial or "fake".
5) LSS implementation will be more successful if it is implemented from the bottom up.

CHAPTER 5. CONCLUSION

The objective of this study was to understand how LSS is implemented in China, reveal the primary barriers and obstacles encountered by manufacturing enterprises, and explore the CSFs of LSS implementation in China.

In Chapter Two, a case research approach was employed to explore the CSFs of Lean implementation in a SME using DMAIC in China (Yin, 1994). In this chapter, the author first conducted a literature review on the subject of CSFs of LSS, including CSFs of Lean, Six Sigma and LSS in the USA, the UK, and other western countries. Then the study described how a Lean program was deployed successfully by using the DMAIC methodology of Six Sigma at VTCL. The CSFs of Lean implementation were analyzed and summarized based on the survey data collected from 36 participants, who were randomly selected from different managerial levels, including senior managers, middle managers, frontline managers, and frontline employees. The results indicate that key success factors for the adoption of Lean production in SMEs include leadership, an LSS steering office, employee participation, and organizational culture.

Chapter Three is a summary of a published journal article of a case study on how to design LSS training programs using the DMADV method under TQM in Chinese manufacturing enterprises. This DMADV project was launched successfully and achieved desired results, however, problems and obstacles were also faced at EBHL in an effort to implement LSS under TQM adoption. The biggest problem was organizational culture change. Womack and Jones (2005) stated that a big challenge during Lean implementation was culture change, because stakeholders' way of thinking needed to be shifted fundamentally. Even though the LSS transformation received the top management's commitment and support, soft resistance from the middle management occurred and became a big problem for the transformation. QC personnel struggled in moving to a prevention-based system from a detection-based system, because their routine and ways of thinking had been formed over decades, which was very difficult to change in short time. In addition, the number of experts in LSS was way too low for a large company with 27 branches and a lack of professionals was another problem. Frontline personnel's time was also fully occupied by the production and other tasks. They could barely allocate time for LSS improvement activities. The whole transformation was deployed in a rushed manner

because the CEO of this company was eager to see transformation results, which actually diminished the implementation results and negatively impacted the LSS improvement.

Chapter Four is based on Chapter Two and Three and adopts a multiple case study method. The research questions of this study are how to implement LSS in manufacturing companies in China and what are the CSFs of LSS implementation in China. The author collected questionnaire data from top management and LSS promoters and used survey and on-site observation data. Based on qualitative data and the Lean Iceberg Model, a new LSS implementation model is proposed. Based on the results, the author also made six propositions:

1) LSS promoter's soft skills, such as communication, are more important in LSS implementation than hard skills, such as knowledge of LSS tools and technology.
2) Process management, including supporting process establishment and process standardization, will enhance the sustainability of LSS systems. Process management should be constantly improved based on the progress of LSS implementation.
3) Employees' loyalty and union are helpful in LSS implementation.
4) It is easier for small companies than large ones to implement true LSS. In large enterprises, the LSS implementation tends to become superficial or "fake."
5) LSS implementation will more successful if it is implemented from the bottom up.

The major limitation of this study is that the research settings are three non-randomly selected manufacturing companies, so the sample is not representative of the manufacturing industry in China as a whole. In order to increase the validity of the study, the author plans to verify the CSFs identified and propositions made in more manufacturing organizations. As well, the suggested model can also be tested in different countries and can help the researcher verify whether CSFs of LSS implementation are different in different cultures.

APPENDIX A. INTERVIEW

General Questions about LSS implementation:

1. Currently, LSS implementation is adopted in {name of the company} and you are in the management position. Correct?
2. I am interested in hearing the story of how LSS was implemented in {name of the company}, as well as any challenges faced while on this LSS journey.
3. How many phases do you think LSS will go through?
4. What is the current phase of LSS implementation in your company?
5. What is your future plan of LSS adoption?

Questions about the challenges met during LSS implementation:

1. Which leadership type do you think the top management in your company uses based on the Toyota leadership model? (If you are the top management, please score yourself) Choose between group facilitator, builder of learning organizations, bureaucratic manager, and task manager.

Bottom-up empowerment	Group facilitator	Builder of learning organizations
	You're empowered. Do it **your** way.	Here is our purpose and direction. I will guide and coach. Follow me and let's figure this out **together**.
Top-down directives	Bureaucratic manager	Task manager
	Follow the rules. Do it **my** way.	Here is what to do and how to do it! Now do it **my** way.

Figure 1: Toyota leadership model (Hines, 2008)

2. Please assess the middle management leadership in your company.

Leadership at {name of the company}	
What is done well?	What is not done well?
What could be done to improve?	What is missing?

Figure 2 - Leadership assessment

3. What is the strategy and alignment in your company? Have any challenges come up? Strategy means the improvement and direction for the organization. Alignment means that everyone understands the strategy and does everything that contributes to the success of achieving the organization's goal.

4. Among frontline workers, middle management, and top management, which management level do you think is most important to change while implementing LSS?
5. Which management level do you think is most difficult to change while implementing LSS?
6. What resistance did you get from the employees during LSS adoption?
7. What is the initial involvement motivation for the employees?
8. What kind of activities has your company organized in order to empower the employees?
9. What kind of training and implementation challenges were met with respect to LSS techniques and tools?
10. Can you assess the process management in your company?
11. What kind of challenges came up because of the current status of process management in your company? What action has your company taken to resolve the problem?
12. Can you prioritize the importance of the following critical factors that will contribute to the success of LSS implementation? Strategy and alignment, leadership, employee behavior and engagement, process management and LSS technology and tools.
13. Is there anything else you would like to add before I close?

APPENDIX B. QUESTIONNAIRE

LSS Application Assessment Questionnaire

Section 1: Background Information

1. Which of the following is your company?

A. EBHL C. VTCL D. BAG

2. What is your position?

A. Frontline worker B. Middle management C. Top management

3. What is your age?

A. Less than 20 years B. 20–25 C. 26–30 D. More than 30years

5. What is your gender?

A. Male B. Female

4. How long have you worked in your company?

A. Less than 1 year B. 1–3 years C. 3–5 years D. 5-10 years E. More than 10 years

Section 2: Quality Performance Improvement Results

Please score _____increased level after quality program (TQM, Lean, Six Sigma, LSS) initiated in your company?

1-Inferior 2-Somewhat inferior 3-Same 4-Somewhat superior 5-Superior

Employee motivation in quality improvement program

1 2 3 4 5

Customer satisfaction in product quality

1 2 3 4 5

Increases in profit

1 2 3 4 5

4. Standardization, optimization and redesign of process management

1 2 3 4 5

Section 3: Critical Factors of Quality Program Initiation

1. Please score the performance of _____which is used to evaluate the leadership in your company.1-Highly Dissatisfied 2-Dissatisfied 3-Neutral 4-Satisfied 5 Highly Satisfied

Upper management's commitment to quality programs (TQM, Lean, Six Sigma, LSS)

1 2 3 4 5

Upper management support of quality program

1 2 3 4 5

Upper management's understanding and learning of LSS philosophy

1 2 3 4 5

2. Please score the performance of _____which is used to evaluate the customer orientation mechanism in your company.

1-Highly Dissatisfied 2-Dissatisfied 3-Neutral 4-Satisfied 5 Highly Satisfied

Constructing the consensus of customer satisfactory

1 2 3 4 5

The establishment of a customer orientation indicator system

1 2 3 4 5

3. Please score the performance of _____which are used to assess the integration of quality improvement strategy with business strategy and performance in your company.

1-Highly Dissatisfied 2-Dissatisfied 3-Neutral 4-Satisfied 5 Highly Satisfied

Strategy based on management by objective (MBO)

1 2 3 4 5

Continuous education in quality skills

1 2 3 4 5

The project management of your company

1 2 3 4 5

The value of quality education

1 2 3 4 5

The topic and attainability of quality improvement activities

1 2 3 4 5

The measurement of financial benefits from quality improvement

1 2 3 4 5

4. Please score the performance of _____which is used to assess the LSS steering organization in your company.

1-Highly Dissatisfied 2-Dissatisfied 3-Neutral 4-Satisfied 5 Highly Satisfied

TQM/Lean/Six Sigma steering organization

1 2 3 4 5

Self-fulfillment of MBBs, BBs, and GBs

1 2 3 4 5

Quality of MBBs' and BBs' instruction

1 2 3 4 5

Clearly expressed executive vision

1 2 3 4 5

Communication strategy

1 2 3 4 5

Communicated sense of urgency for change

1 2 3 4 5

Measured and evaluated performance of quality improvement activities

1 2 3 4 5

5. Please score the performance of _____which is used to assess employees' involvement in LSS programs in your company.

1-Highly Dissatisfied 2-Dissatisfied 3-Neutral 4-Satisfied 5 Highly Satisfied

Supporting, involving in education and project management

1 2 3 4 5

Implementing quality management education

1 2 3 4 5

Confirming the short, medium, and long-term quality strategy with all employees in the organization

1 2 3 4 5

Implementing appraisal management to motivate employees to perform quality improvement

1 2 3 4 5

Constructing the system of communication, feedback, and cognition

1 2 3 4 5

6. Please score the performance of _____which is used to assess your LSS skill set in terms of quality performance in your company.

1-Highly Dissatisfied 2-Dissatisfied 3-Neutral 4-Satisfied 5 Highly Satisfied

QCC (Quality Control Circle) activities training and implementation

1 2 3 4 5

5S training and implementation

1 2 3 4 5

QC7 tools training and implementation

1 2 3 4 5

SPC skills training and implementation

1 2 3 4 5

Cpk skills training and implementation

1 2 3 4 5

Visual Management training and implementation

1 2 3 4 5

FMEA training and implementation

1 2 3 4 5

DOE training and implementation

1 2 3 4 5

Kaizen event training and implementation

1 2 3 4 5

TPM training and implementation

1 2 3 4 5

Value Stream Mapping training and implementation

1 2 3 4 5

7. Please score the performance of _____which is used to assess organizational culture in your company.

1-Highly Dissatisfied 2-Dissatisfied 3-Neutral 4-Satisfied 5 Highly Satisfied

Identification of vision-sharing

1 2 3 4 5

Express the transition and action required to bridge from current status to future status

1 2 3 4 5

Define priority of implementing quality activities of department

1 2 3 4 5

Willingness to change (Staying Lean book)

1 2 3 4 5

How about your sense of belonging to your company?

1 2 3 4 5

APPENDIX C. PUBLISHED ARTICLE

Designing for Six Sigma in a Private Organization in China under TQM implementation: A Case Study

1. Introduction

Industrial Quality Management (QM) was originally derived from the United States and Japan and has spread globally, including to China. After joined the WTO, Chinese industries undertook further structural adjustments to global value chains (Bhattasali, D., Li, S., & Martin, W. J. Eds., 2004). As Chinese economic growth slows, with wages and other factor costs rising, the global value chain becomes more and more complex, and customers grow more sophisticated and demand changes rapidly (Eloot, K., Huang, A., & Lehnich, M.,2013). As Chinese labor costs rise and slowing growth dampens the ability of China's steadily rising industrial output to deliver regular productivity gains, Chinese manufacturers will need to strive for increased levels of global operational excellence. Achieving manufacturing excellence by using Lean and Six Sigma (LSS) provides an opportunity for many companies (Eloot, K., Huang, A., & Lehnich, M., 2013). Moreover, previous work has studied the essence of Lean, Six Sigma and how Six Sigma may be adopted in organizations. Recently, companies in developing countries, such as China, have begun to adopt Six Sigma and how deployment has improved organizational performance and competitive position. However, since the 1980s, there has been little empirical work in such countries. Therefore, it is essential to investigate how Six Sigma has been implemented in developing country companies and what benefits Six Sigma has brought to these industries, with the perspective for comparative understanding in Western and Japanese companies.

According to an investigation by the China Association for Quality (CAQ), in 2007, 2009 and 2013, most Chinese enterprises have been certified by ISO 9000, but the effect is not obvious. The major reasons have been that quality awareness among top management still needs improvement, that the implementation of modern quality management methods and tools are still comparably low, and enterprises lack a high number of quality professional personnel needed to manage quality.

A strategic, planned change at Company A, which is principally engaged in the manufacturing and sales of lead-acid motor batteries and other related products, widely used in electric bikes, electric vehicles and special-purpose electric vehicles, was undertaken for the establishment of an integrated Quality Management System (QMS). This case study, as a Black Belt project, was launched to enhance quality tools employee applications inside the organization to support building a quality culture. This project was a small part of the quality journey of organizational transformation. However, the persistent personal resistance and struggles among different levels of employees to systematically change during the QMS establishment was reflected in this Black Belt project.

2. Background and Methods

In this paper, the authors note that this Six Sigma case study was conducted under the guise of TQM implementation in VTCL. As TQM is considered as a quality philosophy in China, Six Sigma is seen as one of the methods to support quality improvement and culture change in China. TQM implementation status is discussed for context and field study of this project. Still, Six Sigma may be defined as an operational philosophy of management which can be shared beneficially among customers, shareholders, employees and suppliers (Chakrabarty and Tan, 2007). Tacitly, the purpose of Six Sigma is to reduce cost by reducing the variability in the processes, leading to decreased defects. Two problem-solving methodologies employed in Six Sigma initiatives are DMAIC (Define-Measure-Analysis-Improve-Control), which is primarily used to the improvement of existing products, service or processes, and DMADV (Define-Measure-Analysis-Design-Verify), focused primarily on designing new products, services or processes. The Black Belt (BB) project introduced in this paper is focused on DMADV utilization. Since training and education is one of the most important aspects for businesses in quality management adoption, this Black Belt DMADV project was conducted to support the establishment of a TQM culture in VTCL.

A QMS framework of this case study is shown in figure 1. VTCL has been integrating a quality management system, based upon this framework since February 2017.

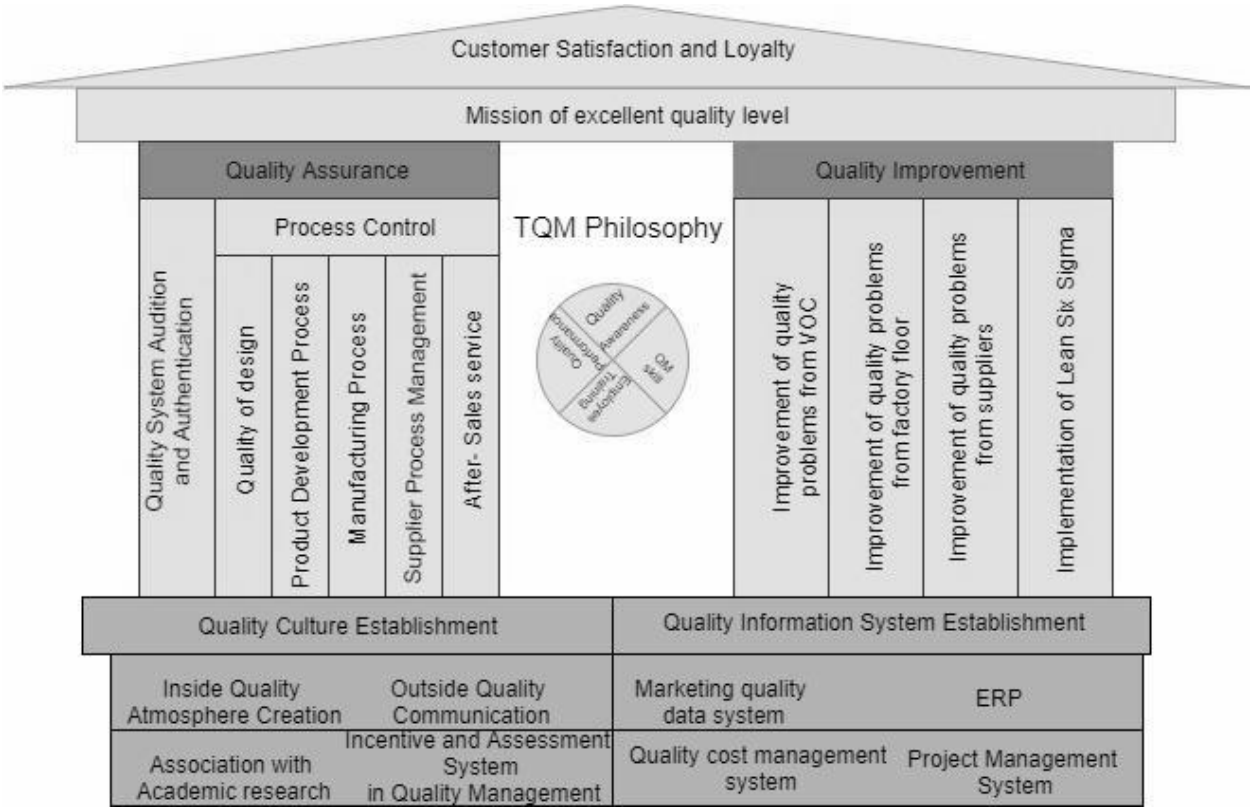

Figure 6-1 QMS framework in Company A

This integrated framework is adapted from “Zero defect” mindset, the Baldrige Excellence Framework, TQM, Six Sigma and ISO 9001. The timeline that Company A follows is defined by Evans (1992) and in table 1 below. The company’s establishment of QMS is in the awareness phase (since February 2017), but work has jumped into subsequent phases as well, as demonstrated in this study.

Table 1 TQM implementation timeline

Stage	Time frame of Implementation	Tasks
Awareness	< 1 year	Training focus on developing basic tents of TQM philosophy.
Process Analysis	2-3 years	Training focus on SPC training and mapping of process.
Process Ownership	3-6 years	SPC well established, and effort focus on continuous improvement of processes and greater cross-functional involvement
Total Quality Culture	>10 years	Quality is completely integrated into all aspects of the organization's daily and long-term functions. Employees are aware of the impact of all their actions.

3. Case study

3.1 Define Phase

Problem statement. Since 2016, Company A started to face persistent high rates of return of products, resulting in lost sales and fierce competition from competitors: 1) The occurrence of several severe quality-related accidents reported in 2016 badly impacted the reputation of the company, resulting in lost market share and sales. 2) The rates of return of products has remained stubbornly high and was significantly higher than major competitor(s). The 15-month-return rate of the worst-rated plant climbed as high as 63.6% according to data gathered in February 2017.

Under this situation, the risks of QMS transformation increased the pressure on top management for results. The "survival anxiety", composed of the threat from competitors and a sense of crisis, was the primary motivation for the Chairman of the company to make changes and establishment of Quality Management to ultimately improve product quality. However, if the strategic attempt to change fails, the organization takes the risk of bankruptcy. Under all these negatives, based upon inside and outside factors, how to implement Quality Management in this organization is an urgent problem that needs to be solved. This BB project is dedicated to contributing to this QMS establishment.

Team composition. The team was comprised primarily of 7 members, including one Champion (CEO), one advisor (Quality Director in the Quality Control department), three Master Blackbelts and two process owners (Division Managers).

Project Plan. A project plan was developed with five components, including project objectives, project scope, GANTT chart, Risk & Benefits, and a Micro SIPOC, to define the project.

Project Objectives. The DMADV project was conducted in the context of the background described above with the aim to build a quality culture and enhance the implementation of quality tools among employees, to increase the utilization of critical thinking in daily operations and work among personnel.

Project Scope. A main consideration with regard to the project scope were resource constraints and competing commitments. There were only two Division Managers interested in joining this particular project because of a shop floor boot camp strategy that was being deployed at the same time and involvement in this effort would have impacted normal production schedules of these divisions' work. These division heads were needed to provide support for all training actives conducted within their respective divisions. Another scoping issue considered was the short time frame involved. Quality culture establishment is a much longer effort than the 4 months this project allowed to realize financial benefits. Financial gains were expected through the reduction of quality defects, through the enhancement of quality tool adoption and elevation quality awareness among personnel, in their daily work, a soft benefit taking much longer to realize.

Gantt Chart. A Gantt Chart was used to layout the time frame of the project. From this timeline, the following table showed the distribution of days expended in each phase.

Table 2 Project timeline

Project Phases	Time Period (days)	Proportion in the whole project (%)
Define	15 days	12.5%
Measure	30 days	25%
Analysis	30 days	25%
Design	15 days	12.5%
Verify	30 days	25%

Project risk analysis. An analysis of costs, benefits, and risks was conducted among stakeholders to proactively identify and mitigate if needed risks to the project as perceived by levels of personnel as shown in table 3 below.

Table 3 Project risks estimated in the project

Related Personnel	**Weak**	**Medium**	**Strong**	**Support**
Top Management-Provide resources and authority support			OX	O=Current level X=Needed level
Middle Management (Process owners)-financial support		O	X	
Experts in different functional departments – Expertise in related areas	O	X		
First-line mangers-support and involvement in the training activities	O	X		
Directors (senior)in different functional departments in headquarter which are related to the improvement work -support and involvement in the training activities	O	X		
Critical and creative thinkers	OX			
Resources in TQM training (Leader, coach, tutor)			OX	
IT resources and training	O	X		

After an assessment of current and needed support by employee level, noted risks identified. Financial support from middle management, who are the branch financial managers, exhibited medium support where strong support was needed. The reason noted was attributed to the early

stages of TQM adoption, due to minimal organizational performance improvement and explicit financial rewards to point to.

Technical support from different functional levels in select divisions was weak where a modicum level of support was needed. The major reason attributed to weak technical support was that as supporting operations, technical teams had their own functional, daily work from direct supervision, with limited capacity to support the BB project.

Involvement and time dedication from first-line managers were very weak where moderate support was needed. Front line managers were a group of people who historically were the most resistant to daily work transformation because functional managers are faced with learning new techniques while meeting current production schedules. Additionally, the functional managers here were already overwhelmed by quality problems and related issues occurring on the shop floor and with little time to attend to perceived 'superficial' training activities.

Support and involvement from directors (senior) in different functional departments from headquarters were very weak where medium risk was nominally needed. The awareness among these employees was that the quality issues were owned by the Quality Control department, who should be fully responsible for quality issues, not specific company divisions.

IT resources were limited and the previous training of TQM philosophy, Six Sigma and Lean Manufacturing, Statistical Analysis or any Problem-Solving methodologies (DMAIC, PDCA, 8D, Kaizen) had never previously occurred. Subsequently, the required level was moderate risk.

Project benefits and costs. The project would be beneficial to quality improvement and quality culture establishment in a QMS framework. The successful project would elevate the employee's awareness, which is using scientific methods to resolve problems occurring in the company with data to support solutions in daily work, instead of rules of thumb from norms drawn from experiences and practice. This project would enhance the employee's ability to resolve the problems systematically, for example following DMAIC, PDCA, 8D problem-solving methodologies instead of only experience and subjective judgment. Project goals met would help

to disseminate a TQM philosophy and guide employees from different functional departments to participate in the quality improvement journey. The realization by company personnel that improving quality needs the involvement from all departments instead of only the Quality Control department. At the same time, this project can establish the framework of advanced quality tools application in Private Organization in China. The costs incurred in this project was around 950,000 RMB (~$143,390), including travel expenses and teaching fees for coaches and tutors, training instruments and bonus and reward for trainees.

Micro SIPOC. The Micro SIPOC (Figure 2 below) listed all the stakeholders in this project and defined, in brief, the training process. The Micro SIPOC would guide the development of the DMADV phases.

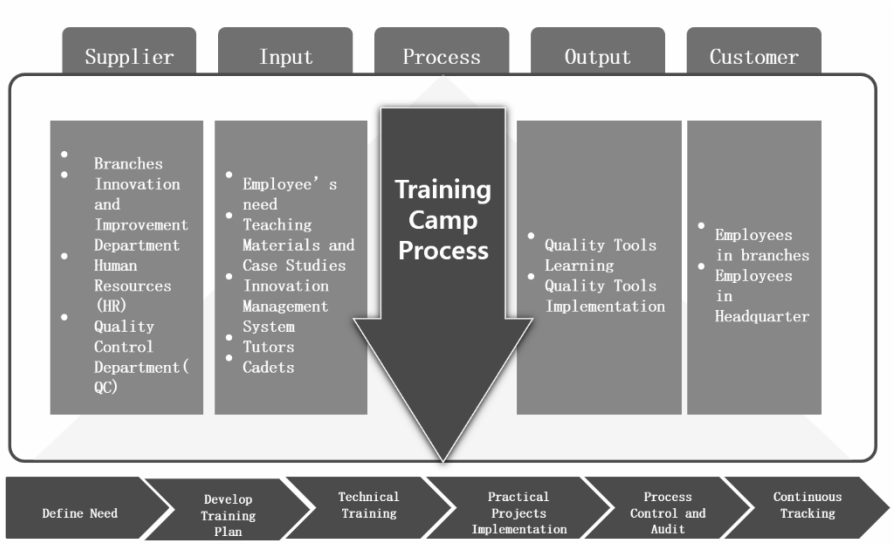

Figure 2 Micro SIPCO

Quality Tools selection. Noted in Table 4 below, the BB team selected 17 quality tools from a potential list of 43 techniques and methods listed by China Association for Quality (CAQ).

3.2 Measure Phase

Table 4 Quality tools and methodologies (China Quality Association, 2017)

Order	QM tools	Order	QM tools
1.	Histogram	23.	Brainstorm
2.	Pareto Chart	24.	Tree Diagram
3.	Cause-and-Effect diagram	25.	QFD
4.	Check Sheet	26.	POKA-YOKE
5.	Stratification	27.	Gantt Chart
6.	Scatter Diagram	28.	Network Planning
7.	SPC	29.	Statistical Significance
8.	Affinity Diagram	30.	ANOVA
9.	Inter-relationship diagraph	31.	Regression Analysis
10.	Tree diagrams	32.	CPK/PPK
11.	Matrix Diagram	33.	Survey
12.	PDPC	34.	Graphic method
13.	Arrow Diagram	35.	Flow Chart
14.	Matrix Data Analysis	36.	Benchmarking
15.	FMEA	37.	Wave Patten
16.	DOE	38.	Hypothesis Testing
17.	Survey	39.	Taguchi Methods
18.	Statistical sampling	40.	TIPS
19.	Descriptive Statistics	41.	MSA
20.	Importance & Performance Analysis	42.	Time Series Plot
21.	Performance Index	43.	Six Sigma
22	Run Chart		

A questionnaire was sent out to employees in both headquarters and company branches in order to assess the degree of mastery of the 17 selected quality tools among personnel, before the project initiation. Participants positions were varied and covered all functional departments in the enterprise, including Procurement, Production, Supply Chain, R&D, HR, Finance, Administration, Improvement, and Innovation Department (a department was established to steer the current QMS transformation), Sales & Marketing, Customer Service and others. The BB project team collected 90 valid responses in total. The followings are the investigation results of employees' perception of understanding (cognition) of quality tools.

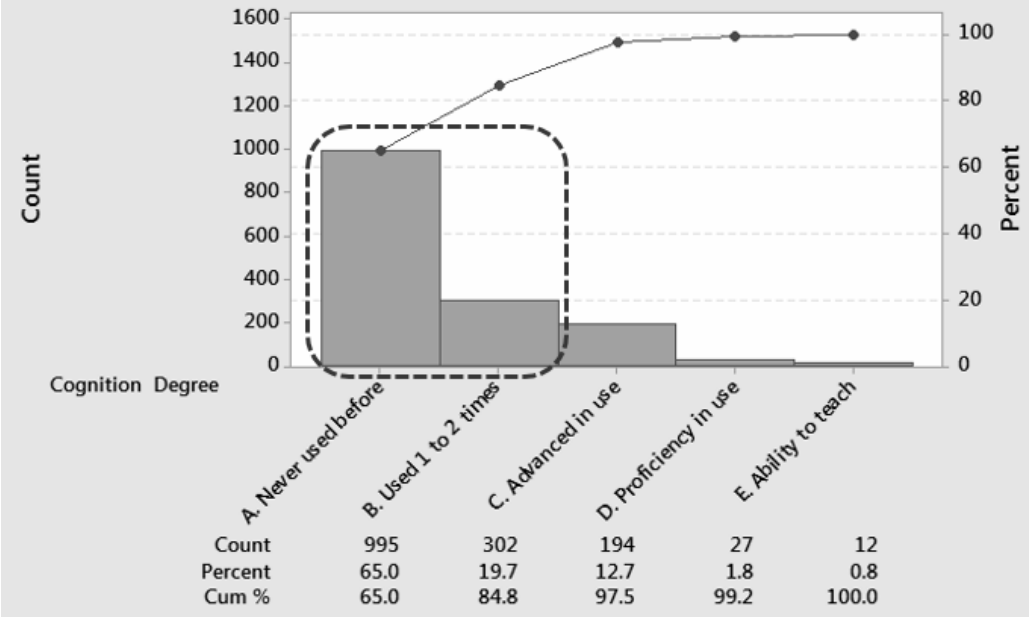

Figure 3 Pareto Chart of cogitation degree of quality tools by employees

Based upon results, the overall understanding among employees, assessed by degree of application-level of the 17 quality tools was very low. Around 85% of the participants had not applied the quality tools. A majority of employees self-reported as being in the stage of "never used before" or "used only 1 to 2 times".

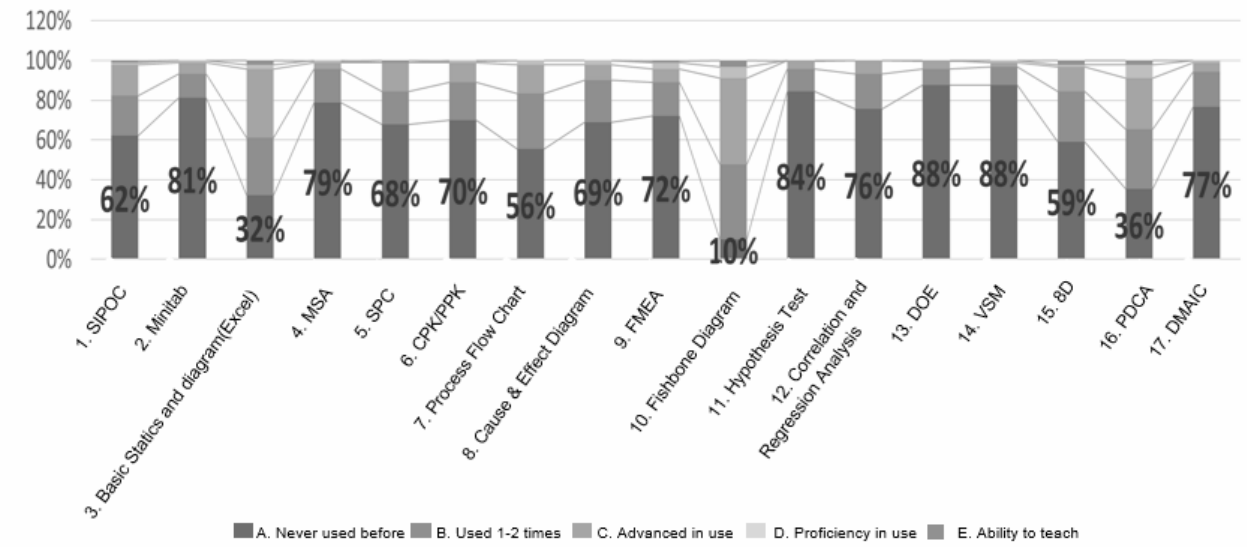

Figure 4 Degree of understanding of specific CAC quality tools and techniques

The majority of advanced quality tools (SIPOC, Minitab, MSA, SPC, CPK/PPK, C&E matrix, FMEA, Hypothesis Test, Correlation and Regression Analysis, DOE and DMAIC), had never been applied by 60% of employees in their daily work. Basics statics and diagraming in Excel, Fishbone diagram, and PDCA were quality tools that had been applied.

Project Indicators. After the preliminary assessment, project objectives were refined where the key objective (Y) was to enhance the quality tools awareness and applications among personnel. To reach the key goal, three sub-objectives (y) were developed as subsequent goals (Table 5):

y_1=number of certified Yellow/Green Belts. Trainees need to attend training program and pass an exam.

y_2=number of Green Belt (GB) projects. GB projects should be conducted by trainees under the tutoring and guidance from coaches

y_3=number of prototype plants for quality tools application. this is defined by the practical application of MSA/SPC/CPK etc., in the shop floor with the prototype plant establishing a complete application system for quality tools

Table 5 Project objectives decomposition

Key Objective(Y)	**Sub objectives (y)**	**Score (Points)**	**Small y**	**Definition**	**Score (Points)**	**Indicator Definition**
Quality tools learning and application (Total: 100 points)	y_1: Number of certified Yellow/Green Belts	40 points	y_{1-1}	Number of certified Green Belts	30	30* completion rate
			y_{1-2}	Number of certified Yellow Belts	10	10* completion rate
	y_2-: Number of Green Belt projects	40 points	y_{2-1}	Number of Green Belts projects	40	40x completion rate
	y_3 ：Number of prototype plants for quality tools application	20 points	y_{3-1}	Number of prototype plants for quality tools learning and application	20	20x completion rate

3.3 Analysis Phase

Quality function deployment (QFD). The first step in the Analysis phase was to use a QFD to identify the one-to-one relationships among three sub-objectives and key step(s) in the process flow. Table 6 below represents a QFD portion. The BB team used project sub-objectives, which acted as a sample role of needs identified from a Voice of the Customer (VOC) identification in the QFD. The rating of the importance for each step varied, with regard to the different project objectives, and were listed in the same line as related sub-objectives.

Table 6 QFD of sub-objectives

Project objectives (y)	Severity	Key Process steps (X)												
		Project and Personnel selected	Expectation defined	Curriculum Scheduling	Resources Allocation	Venue and time reservation	Class Preparation and Teaching	Self study and tutoring	GB/YB project launch	GB/YB project tutoring	Replication & dissemination	Curriculum results tracking	Issuing of YB/GB Certification	Systematic quality application
# of GB	6	6	9	6	6	3	6	3	6	6	3	3	6	
# of GB projects	9	6		6	6	3	6	3	9	6	3	3	3	6
# of prototype plants in quality Tools application	9				6	3	6	3	3	6	6	3		9
Total Score		**90**	54	**90**	**108**	54	**108**	54	**126**	**108**	63	54	63	**135**

Based on the cross rating of three sub-objectives and process steps, the team concluded that the key process steps (X) were project and personnel selected, curriculum scheduling, resources allocation, class preparation, and teaching. GB/YB projects launch, GB/YB tutoring, and systematic quality tools application in the prototype plants, noted in bold above. A detailed description of each step follows below.

X_1=Project and personnel selected. The Improvement and Innovation department sifted through 75 potential topics related to quality improvement and innovation based on a comprehensive assessment of the current state, with the help from an outside consultant team. The BB project team selected Yellow/Green Belt projects from these 75 topics based upon the decision tree noted below (see Figure 5). Trainees were selected for the particular type of

training, and subsequent projects to apply training to, such as Yellow Belt, etc., based on their position, previous project experience, education background, and work experiences.

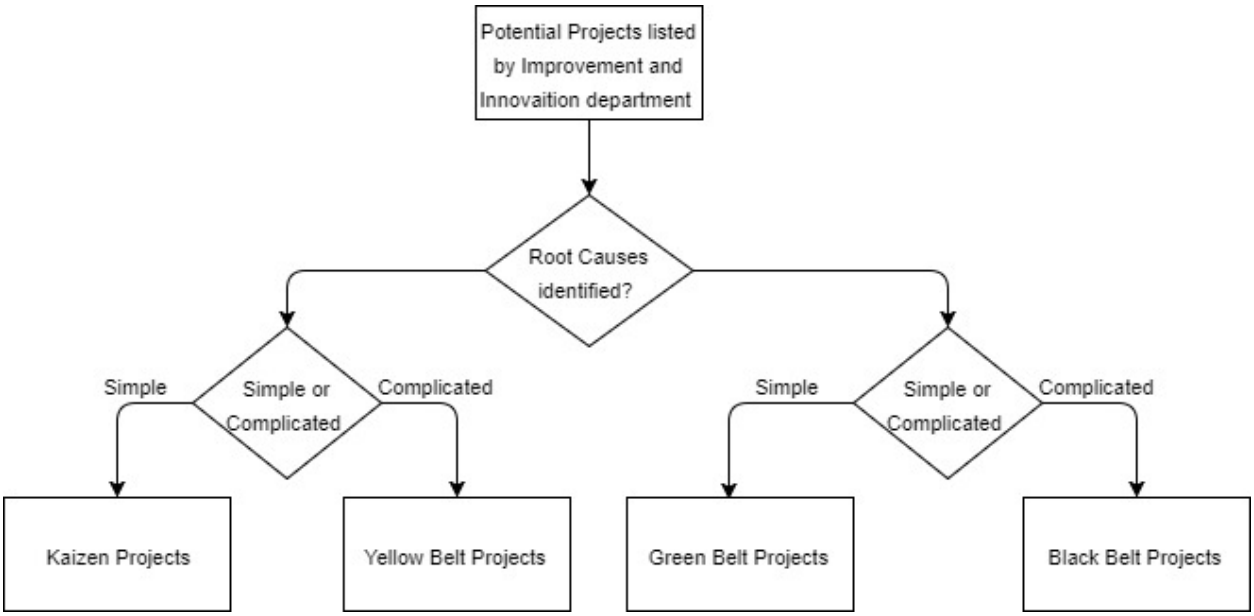

Figure 5 Decision tree of project types

X_2=Curriculum scheduling. The BB project team designed the varying curriculum according to employee position and requirements (Table 7). In the table below, Six Sigma level represents the expected level employees should be able to achieve after the designed program. Curriculum included the QC seven basic/modern tools, seven classic Lean wastes, Yellow Belt (YB) basics, TQM philosophy, a First-Line improvement training camp, GB/BB theoretical and practical training, and training for GB tutors in company branches/divisions. In this project, the scope of a particular project with regard to training activities was aimed at employee levels of Foremen, Technical Engineers, Shop Managers, Quality Inspection Managers, and Chiefs; Production Chiefs in selected branches, and Senior Quality Engineers and Process Engineers at headquarters, based upon the project objectives.

Table 7 Curriculum scheduling for employees with DMADV project scope noted

Six Sigma Level	Position	Training Plan									
		QC Seven Tools	Seven Wastes in Lean	YB Training	TQM	First-line Improvement Training Camp	GB Theoretical Training	GB Practical Training	BB Theoretical Training	BB Practical Training	GB Tutor Training
YB	Branch-Foreman	★	★	★	★	★					
YB	Branch-Technical Engineer	★	★	★	★	★					
YB	Branch-Shop Manager	★	★	★	★	★					
YB	Branch-Quality Inspection Manager	★	★	★	★	★					
GB	Branch-Production Chief	★	★		★		★	★			
GB	Branch-Quality Inspection Chief	★	★		★		★	★			
GB	HQ-Quality Engineer (Senior)	★	★		★		★	★			
GB	HQ-Process Engineer (Senior)	★	★		★		★	★			
BB	Branch-Quality Director				★				★	★	
BB	Branch-Technical Director				★				★	★	
BB	Brach-Production Director				★				★	★	
BB	HQ-R&D Manager				★				★	★	
BB	HQ-Quality Manager				★				★	★	
BB	HQ-Process Manager				★				★	★	
BB	HQ-R&D Manager				★				★	★	
MBB	HQ-Quality Director				★				★	★	★
MBB	HR-Technical Director				★				★	★	★
MBB	HQ-R&D Director				★				★	★	★

X_3=Resources allocation. A final assessment of GB candidates was represented by 20% of training attendance, 30% of certification exam score, 10% of tutor evaluation, 30% of GB project presentations of results (auditions), and 10% of evaluations in process. For the candidates whose final grades were above 70 out of 100, the candidates were awarded with a GB certificate, with an employee bonus of 2000 RMB (~$300) per person. Financial, tutor, venue resources, top management support, and commitment at both headquarters and branches, and reward mechanism were also included in resource allocation.

X_4=Class preparation and teaching. Training program objectives were broadly defined as understanding of basic quality theories, principles, and application of problem-solving methods. To reinforce this basis for developing knowledge and skills among employees, the authors'

pedagogy was through case study analysis, reinforcing comprehension, and integrating practical applications to the shop floor environment.

X_5=GB/YB project launch. During GB/YB projects launch, classroom training and practical applications toward projects were integrated with tutoring as noted below (Figure 6). Projects followed the most common problem-solving methodologies (DMAIC) and final presentations (auditions) conducted by the tutors, themselves Master Black Belts.

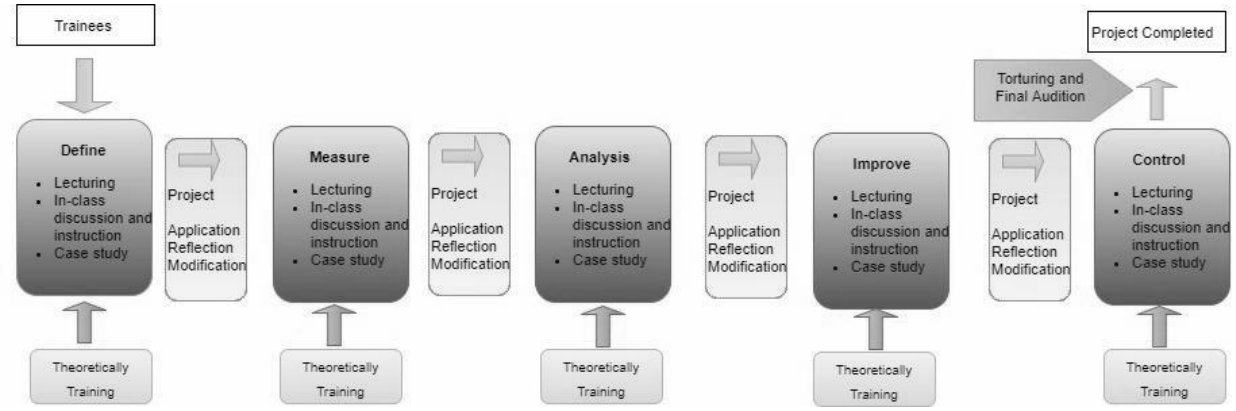

Figure 6 Process Mapping for Project launch progress

X_6=GB/YB project tutoring. Project tutoring primarily covered three categories, including quality tools application, project management techniques, and a standard reporting procedure. In project management, tutors covered how to plan an entire project in limited time frame, introduced project format reporting, establishing a team framework, and a mind map of the DMAIC process. In the standard reporting procedure, tutors introduced standardized documentation procedure methods, and basic procedures needed to be followed in order to generate a standardized final project report. The following quality tools covered in each phase in DMAIC personnel training:

Define (Opportunity identified): QFD, COPQ, Gantt Chart, SIPOC, Pareto Chart, Project Charter
Measure (Current state assessed): Process Capability Analysis, MSA, QC seven tools, Brain Storming, process flow chart, Cause & Effect Diagram and analysis, FMEA

Analysis (Root causes identified) Central limit theorem, ANOVA analysis, Hypothesis Testing, Normality Testing. Test for equal variances, multivariable analysis, non-parametric testing, correlation analysis, regression analysis

Improve (Improvement strategies developed): DOE, partial factor analysis, Taguchi design, EVOP, multi-linear regression, Response surface analysis

Control (Main improvement results): Statistical Process Control, Control Charts, Poka Yoke, 5S and visual management, control plan, SOP, standardization

X_7=Systematic quality tools application in the prototype plants. The quality tools application system established in the selected prototype plants followed the PDCA methodology for overall quality control purposes (Figure 7). The rationale for establishing this system is long term, similar to the cost/benefit calculation for establishing a quality culture.

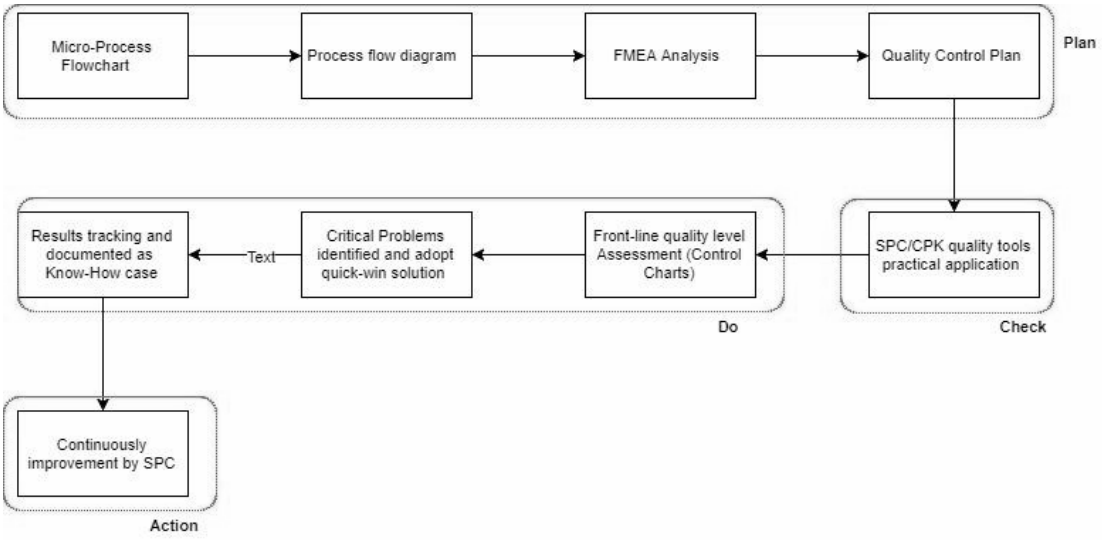

Figure 7 Process Map for establishing a system of quality tools applications

The BB team identified critical to quality characteristics according the definition of "Good Product" based on VOC analysis. Next, the BB team located critical related manufacturing processes by a Micro-Process flowchart and process flow diagram to locate the critical output in these manufacturing processes. Following critical output(s) identification, the BB team located the potential input factors that were closely related to the critical output identified by FMEA,

where the critical input factors were finally identified according to the value of Risk Priority Number (RPN). A quality control plan was developed according to the critical input factors identified. Front line managers were trained in control charts where the managers created and documented statistical quality control to critical manufacturing process(es) and among relevant personnel. These frontline workers are responsible for tracking operational data regularly, with shop floor managers collecting and inputting quality control data for further analysis of daily performance. Measurement system analysis (MSA) were conducted and assessed for validity of current measure system(s) with any quick-win improvements identified and conducted. Once completed, quick-win projects were documented in a Know-How format. Finally, data collected from frontline were monitored by production and quality inspection engineers and chiefs.

In this phase of DMADV, the creation of value for the customer was determined to be a reduction of product defects through training of workforce personnel, a systematic process that did not previously exist. The BB team analysis of the primary project objective (Y) resulted in three smaller objectives (y_x) and using QFD to identify seven key process indicators (X). Subsequent activity resulted in identification and analysis of key factors for success for each indicator accordingly.

3.4 Design Phase

In the design phase, the BB team designed that training processes according to the seven key process indicators identified from the QFD.

X_1=Project and personnel selection. 3 to 4 trainees worked as in a group and selected a project topic according to their interest(s), background, position, and experience. According to the degree of sales losses incurred, trainees were assigned to different branches, as needed. Project topics were carefully selected according to the complexity of the root causes sources noted above.

X_2=Curriculum schedule. The timing and amount of curriculum was determined by GB/YB designation. For GB's, based upon DMADV project investigation results thus far, and work schedule of trainees, the BB team designated 10 days of curriculum, based upon the training

content noted above. After daily classroom training, trainees were assigned self-study time for individual reflection and group discussion. For YB's, the BB team designed 5 days of 'boot camp' style training. In this frontline boot camp, trainees were released from production or regular work to attend classroom instruction with a focus primarily upon quick-win improvement. The objective was to enhance the body of knowledge of basic quality tools problem-solving technique and principles, encourage trainees' practical application abilities in a short time frame and establish employee morale based upon quality improvement in the shop floor.

X_3=Resource allocation. In order to support this BB project, the Champion (CEO) launched a reward system for quick improvements in the entire company. The BB team got the commitment from branch managers to give all personnel the permission for off duty training in their respective divisions. Venues and scheduling was assisted by Human Resource (HR) in each division. Financial support was assisted by a project coordinator in each division. Three Master Black Belts, including a quality Deputy Director in Quality Control department, were assigned as tutors from headquarters for teaching GB's and YB's.

X_4=Class preparation and teaching. The entire training process followed an adult learning process; starting from personal experience, to discussion and analysis, to generalization, and finally practical application. A summative evaluation was done as a trainee survey, including evaluation of teaching by tutors, curriculum design, and resources support of training.

X_5=GB/YB projects launch. GB projects followed the PDCA as the major problem-solving methodology. In the planning phase, a weekly plan for each project was created and followed. In the Do phase, trainees completed the project based on weekly plan goals. In the Check phase, project progress was assessed by tutors from the Improvement and Innovation department and feedback reflective of each team. In the Action phase, projects were assessed monthly to track progress, audit the improvement results, and identify risks and control plan development and dissemination.

X_6=GB/YB projects tutoring. Tutoring included teaching the content in classroom setting and project coaching, following the logical path of problem-solving (PDCA), frontline tutoring in the shop floor environment, and a question and answer (Q&A) session with trainees. Problem-solving tutoring included the application of appropriate quality tools in different situations was discussed in each phase of PDCA, along with project management techniques and obstacles. Front line tutoring included how to quantify problems seen, documenting improvement activities, and suggestions from management on opportunities. In Q&A sessions, difficult cases were discussed and shared among all trainees for working out improvement solutions.

X_7=Systematic quality tools application in the prototype plants. In selected prototype plants, a formal improvement promotion team was formed. Improvement promotion team includes quality control team, 6S Management Team, TPM Management Team, and Standardization Team, headed by a Plant Manager, Production chief, and Process Chief. The comprehensive quality tools application system noted above has to be lead and promoted by the basic daily quality management work and rooted in each corner of plant environment (Figure 8).

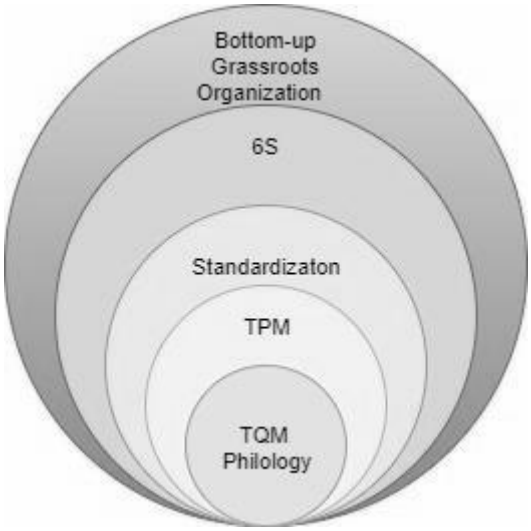

Figure 8 Structure of quality tools promotion on shop-floor

3.5 Verify Phase

In this phase, the BB team verified project results from three perspectives, which were GB training program, YB frontline boot camp, and prototype plant quality management establishment. For GB training, the average exam grade of DM phases was 76 percent and at the

AI phases 71 percent. Total number of attendees were 178 with 118 passing the GB exam. 93% of GB projects were completed, presented, and assessed by Tutors and the Improvement and Innovation department. Table 8 below is the survey results, with overall satisfaction level of 90 percent. The major areas needing improvement including improving the understanding of case studies, simplification of course content, and increased opportunities for practical application.

Table 8 Survey results of GB training

Category	Order	Questions	Responses (% Yes)
Content Assessment	1	Training content is easy to understand (Yes/No)	90.3
	2	Training content is useful to your daily work. (Yes/No)	80.7
	3	You will apply the techniques learned in the training camp to you daily work in the future. (Yes/No)	93.3
	4	Case studies are instructive. (Yes/No)	89.7
	5	Course content complement. (Yes/No)	80.4
	6	Course content reached your expected goal. (Yes/No)	91.4
	7	The length of this training program is appropriate. (Yes/No)	95.5
Tutors Assessment	8	Tutors' logic is clear and easy to understand. (Yes/No)	95.7
	9	Tutor has rich working experience and has strong communication skill. (Yes/No)	84.7
	10	Tutor can intrigue trainees' interest in learning. (Yes/No)	92.4
	11	Tutor can arouse trainees' enthusiasm. (Yes/No)	92.0
	12	Tutor can answer the questions effectively. (Yes/No)	93.3
	13	Tutor is well-prepared. (Yes/No)	92.0
	14	Tutor can encourage trainees to raise questions and be involved in class. (Yes/No)	91.2
	15	Tutor is professional in LSS area. (Yes/No)	91.4
	16	Tutor can associate course content with daily work and experience. (Yes/No)	90.75
	17	Tutor can provide effective explanation and cases. (Yes/No)	92.04
	18	Tutor can provide guidance and help to team discussion. (Yes/No)	91.74
	19	Training content doesn't have grammar and miss-spelling mistakes. (Yes/No)	90.11
	20	Course content and complementary materials are useful. (Yes/No)	84.73
	21	Training materials are distributed on time. (Yes/No)	90.97
	22	Training instruments are prepared in advance. (Yes/No)	89.89
	23	After class tutoring can fulfill trainees' need. (Yes/No)	84.30

Resources Assessment	24	Pre-work of this training program is on time. (Yes/No)	90.54
	25	After class tutoring can be provided on time. (Yes/No)	91.61
	26	You are satisfied with this training program overall. (Yes/No)	92.47

With regard to YB boot camp, two cohorts, consisting of 21 trainees were YB certified in a prototype plant. After 5 days, 6638 frontline problems were discovered, 1354 suggestions were made, and 608 quick win improvements in the shop floor conducted. One prototype plant was set up, and a front-line management system was promoted to other branches.

Table 9 below contains results with regard to overall project completion status. Target of certified Yellow/Green Belts is exceeded the objectives. Target of green belt projects fulfilled 93% of goal. Target of prototype plant was met.

Table 9 Project objective complementation assessment

Project Objective(Y)	Project Sub-objectives (y)	Score (Points)	Small y	Project Subobjectives (y)	Score (Points)	Indicator Definition	Category	Objective	Results	Completion Rate	Score	Total
Y: Quality tools learning and application (Total: 100 points)	y_1: Number of certified YB/GBs	4o points	y_{1-1}	Number of certified Green Belts	30	30* completion rate	# GB	100	118	115%	45.9	103.2
			y_{1-2}	Number of certified Yellow Belts	10	10* completion rate	# YB	20	21			
	y_2: Number of GB projects	40 points	y_{2-1}	Number of Green Belt projects	40	40×completion rate	# GB projects	30	28	93%	37.3	
	y_3 ：Number of prototype plants for quality tools application	20 points	y_{3-1}	Number of prototype plants for quality tools application	20	20×completion rate	# Prototype Plants	1	1	100%	20.0	

Tangible project benefits. Three training camps (GB training camp and YB boot camp) were developed, based on internal assigned resources where all tutors (MBB's) inside the organization. Internal training greatly reduced costs, with the consulting fee approximately 1800,000 RMB. The 28 GB projects conducted resulted in the branches in gains of 5600,000 RMB financial benefits.

Intangible project benefits. Notable intangibles include: a) Establishment of a Six Sigma quality management system inside the organization, b) a system of Quality Tools application initiated and established in a prototype plant, promoted to other branches, c) 139 trainees were trained as qualified GBs and YBs, who may utilize Six Sigma tools to resolve problems independently. Finally, morale of employees was improved, based upon the quality efforts, improvement and total involvement inside the organization.

Discussion - Problems and Barriers

There were problems and obstacles faced by this company in the effort to improve company reputation by establishing a quality improvement culture, through deployment of quality tools, applied and initiated by employees. In this specific DMADV Blackbelt project included a resistance to change, lack of experience and resources in quality management,

After two months of case study work in this Chinese manufacturing company, the authors found the biggest problem to a quality management establishment was from the organizational culture change, which was witnessed directly in this study. Culture is a pattern of shared tacit assumptions that are learned by a group as it solves its own problems by external adaptation and internal integration. This integration has to work well enough to be considered valid by the group and, therefore, be taught, in turn, to new group members as the correct way to perceive, think, and feel in relation to organizational problems (Schein, E. H., 2009). Culture is stable and difficult to change because it represents the accumulated learnings of a group (Schein, E. H., 2009). Schein (1999) mentions that culture is not a superficial phenomenon and cannot be manipulated or changed easily. While working with this BB team, the one of the researchers witnessed the prototype plant manger's eagerness and passion to transform, however as the plant manager was struggled deeply with "soft" resistance from middle management.

A team of outside quality experts was hired by the company at the initiation of the company's new quality strategy, including a quality director from an early adopter of Six Sigma organization in China, 4 MBB's and 2 BB's, who all have more than 10 years' experience in LSS, TQM, etc. However, the rest of internal company personnel in the Quality Control department were focused on quality inspection and control instead of prevention. Inside QC personnel and the work, they did was primarily based on empirical experience. QC personnel struggled in moving to a prevention-based system from detection-based system. Additionally, in order to support this large company transformation, the newly hired team worked more than 10 hours/daily, taking only 2-3 days off per month. Still, the personnel for quality management personnel are still in need. In the prototype plant, the plant manager and all middle management worked hard to learn techniques in quality management, with still time needed to for proficient shop floor application. For example, frontline workers followed the orders to document quality control charts but barely understood why they need to do so and how these QC charts could help them to improve their operational performance. Frontline personnel also complained that the time committed to SPC manually occupied even their short break time. Thus, education and training are still far from complete in this transformation.

Top management commitment may be the most important success factor in TQM establishment but may serve as a problem as well. While a CEO's commitment for transformation may come from desire to improve internally, but also from competitive pressures, quality-related problems, lost sales and resulting in poor financial returns. The CEO of this company was eager to see transformation results and visited the prototype plant multiple times monthly and tracking progress. The CEO's behavior also brought great pressure to plant employees. The CEO didn't realize, immediately, that transformation is a long-term journey. The CEO attempted to use product return rates as the key indicator for measuring project success of the transformation. However, the company A's business follows a cyclical product life cycle with return rates tracking production closely. In addition, return rates are not a valid indicator for measuring project success of this DMADV effort at employee transformation but are measures of strategic success, the main reason the CEO attempted to utilize these measures.

Struebing and Klaus (1997) point out that two factors that may improve the probability of TQM success in smaller businesses. Company should have realistic expectations. They should be able to seek immediate gains in short term but that greater benefits are achieved long term. This tension may seem impossible to resolve at once. This tension was present in this study as well. TQM is just one of the many philosophies that organizations may adopt to achieve their business goals (Barrier 1992). For future work, key success factors that recognize the tension of tangible and intangible benefits, especially as deployed as a strategic training effort via DMADV, could be applied at the planning stages.

4. Conclusions

This Black Belt project followed a DMADV approach with the objective to enhance quality tools employee applications inside the organization to support building a quality culture in a Chinese manufacturing company. The primary result of these efforts is how the strategic efforts were designed explicitly for employee development through learning and application, with comprehensive project measures. The major problems, including the persistent resistance from employees, lack of resources and experiences in quality management among company personnel, and misapplication of project goals from top management, which are all typical obstacles occurring in a systematic change effort toward total quality. These issues were observed in this Black Belt project. The results of the study could provide value and reference for other enterprises that are starting a total quality journey, from a Six Sigma position, designed as a DMADV project, with the overall goal operational excellence.

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