SYSTEMATIC APPROACH TO KNOWLEDGE ROUTINES AND KNOWLEDGE CREATION IN KAIZEN

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SYSTEMATIC APPROACH TO KNOWLEDGE ROUTINES AND KNOWLEDGE CREATION IN KAIZEN

by

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LIST OF ABBREVIATIONS

ALP	Advanced Lean Practitioners
BB	Black Belt
BSM	Bose systems Malaysia
CNX	Control-Noise-Experiment
DMAIC	Define-Measure-Analyze-Improve-Control
GB	Green Belt
Kaizen	Kaizen projects
KF	Knowledge Form
KPI	Key performance indicator
KT	Kaizen Template
LSS	Lean Six Sigma
Max	Maximum
Min	Minimum
PDCA	Plan-Do-Check-Act
R^2	Coefficient of determination
SECI	Socialization-Externalization-Combination-Internalization
SOP	Standard operating procedures
TPS	Toyota Production System
UPH	Unit per hour
WI	Work instruction
YB	Yellow Belt
6M	Machine, Man, Material, Measurement, Method, Mother Nature
|Coeff|	Absolute coefficient

LIST OF SYMBOLS

KR	Knowledge routine
KR_1	Meeting
KR_2	Gemba walk
KR_3	Mentoring
KR_4	Coaching
KR_5	Referencing
n	Sample size
P	Project
S	System
S_1	Basic knowledge routine system
S_2	Refined knowledge routine system
S_3	SECI-Ba knowledge routine system
S_m-KR_n	Knowledge routine n in system m
S_m-P_n	Project n in system m
SSO	Social system outcomes
SSO_1	Knowledge gain in Kaizen and LSS
SSO_2	Skills of idea generation and decision making
SV_1	Survey 1
SV_2	Survey 2
TSO	Technical system outcomes
TSO_1	Percentage of goals met
TSO_2	Impact on area
TSO_3	Overall business success
$\sum \mu_{SSO}$	Mean rating of social system outcomes

$\sum \mu_{TSO}$	Mean rating of technical system outcomes
$\bar{x}$	Sample mean
μ	Population mean

PENDEKATAN SISTEMATIK UNTUK RUTIN PENGETAHUAN DAN PENCIPTAAN PENGETAHUAN DALAM KAIZEN

ABSTRAK

Strategi bisnes yang sangat penting bagi sesebuah syarikat untuk mengekalkan kelebihan daya saing berbanding pesaingnya dengan penciptaan pengetahuan baharu secara berterusan. Di dalam organisasi Kejat Enam Sigma, Kaizen dilaksanakan sebagai projek, dengan metodologi asas seperti PDCA dan DMAIC. Sebagai aktiviti Kaizen yang berasaskan kumpulan dan didorong oleh matlamat, ia juga menyediakan dasar asas yang penting bagi penciptaan pengetahuan yang aktif. Secara khususnya, rutin pengetahuan yang berbeza akan dilaksanakan untuk mencipta pengetahuan dalam Kaizen. Lima rutin pengetahuan yang menarik minat kepada Kaizen adalah mesyuarat (KR_1), berjalan Gemba (KR_2), membimbing (KR_3), melatih (KR_4) dan membuat rujukan (KR_5). Hasil sorotan kajian yang ekstensif telah menunjukkan bahawa kajian lazim sering bertumpu kepada perangkuman rutin pengetahuan yang terpilih dalam Kaizen, dengan mengambil kira nilai pada rutin ini dan dengan sedikit pendedahan terhadap penggunaannya. Oleh itu, penyelidikan ini bertujuan untuk membezakan bentuk rutin ini dan kemudian untuk mengenal pasti kepentingan rutin pengetahuan tersebut secara individu atau kolektif kepada penciptaan pengetahuan melalui beberapa kajian kes. Secara khususnya, penyelidikan ini membentangkan tiga sistem rutin pengetahuan: Sistem rutin pengetahuan asas (S_1), Sistem rutin pengetahuan sulingan (S_2) dan Sistem rutin pengetahuan SECI-Ba (S_3). S_1 mewakili rutin pengetahuan yang digunakan dalam bentuk asal, kebiasaannya secara tidak rasmi dengan sedikit perancangan dan struktur yang telah ditetapkan sebelumnya. S_2 mewakili rutin pengetahuan yang

digunakan dalam sistem yang ditetapkan dan lingkaran maklumbalas. S_3 adalah sistem lanjutan S_2 dengan menjelaskan dua elemen yang berkaitan model penciptaan pengetahuan, SECI dan Ba dalam melaksanakan rutin pengetahuan. Lima kaedah pencapaian berkaitan penciptaan pengetahuan telah diambil kira: peratusan matlamat dipenuhi (TSO_1), kesan ke atas kawasan (TSO_2), kejayaan perniagaan yang dicapai (TSO_3), pengetahuan Kaizen dan LSS yang diperolehi (SSO_1) dan kemahiran penjanaan idea dan membuat keputusan (SSO_2). Kajian ini dilakukan dengan menggunakan kajian kes, kajian soal selidik dan analisis statistik. Dalam tempoh tiga tahun kajian, dua puluh kajian kes Kaizen telah dikumpulkan dan soal selidik telah dijalankan terhadap pelaksana-pelaksana yang terlibat dalam Kaizen ini. Dalam analisis statistik, analisis regresi berganda telah digunakan untuk menentukan hubungan antara rutin pengetahuan kepada penciptaan pengetahuan. Dua dapatan kritikal yang diperolehi daripada kajian ini. Pertama, kaji selidik menunjukkan nilai purata penciptaan pengetahuan S_2 mencapai 52.76% lebih tinggi berbanding S_1. S_3 mencapai nilai purata penciptaan pengetahuan yang lebih tinggi daripada S_2 dan S_1, dengan peningkatan sebanyak 25% dan 64.57%. Ini memberikan bukti yang kukuh bahawa memanfaatkan SECI dan Ba dalam sistem rutin pengetahuan secara konsisten dapat mengatasi sistem rutin pengetahuan yang lain. Kedua, walaupun analisis statistik menunjukkan bahawa lima rutin pengetahuan adalah berkaitan secara ketara terhadap penciptaan pengetahuan dalam kesemua sistem, pengaruh individu rutin pengetahuan menunjukkan keputusan yang bervariasi kepada ukuran prestasi penciptaan pengetahuan. S_1-KR_2, S_2-KR_1 dan S_3-KR_1 mempunyai pengaruh yang tertinggi kepada TSO_1. Dari segi TSO_2, KR_2 adalah yang tertinggi dalam semua sistem. KR_1 mempunyai pengaruh tertinggi kepada TSO_3 dan SSO_2 dalam semua sistem. S_1-KR_4, S_2-KR_3 dan S_3-KR_3 mempunyai pengaruh yang tertinggi kepada SSO_1.

KR_5 mempunyai pengaruh rutin pengetahuan yang kurang ketara untuk kesemua sistem. Sumbangan penyelidikan adalah pembangunan sistem and bukti empirical mengenakan SECI-Ba yang membolehkan keadaan dalam rutin pengetahuan untuk memudahkan penciptaan pengetahuan dalam Kaizen. Kekurangan kajian adalah saiz sampel kajian yang agak kecil, sebahagian besarnya berdasarkan satu organisasi, walaupun kajian kes adalah beraneka jenis dan melibatkan pelbagai ciri projek Kaizen.

SYSTEMATIC APPROACH TO KNOWLEDGE ROUTINES AND KNOWLEDGE CREATION IN KAIZEN

ABSTRACT

Continuously creating new knowledge is a vital business strategy for a company to sustain competitive advantage. In a Lean Six Sigma organization, Kaizen is performed as a project, with common underpinning of methodology such as PDCA and DMAIC. As a team-based and goal-driven activity, Kaizen also provides a regular base to actively create knowledge. Specifically, different knowledge routines would take place to create knowledge in Kaizen. Five knowledge routines of interest to Kaizen are meeting (KR_1), Gemba walk (KR_2), mentoring (KR_3), coaching (KR_4) and referencing (KR_5). An extensive literature review has shown that mainstream research often focused on incorporation of selective knowledge routines in Kaizen, presuming the value of these routines and with little disclosure on their deployments. In this sense, research aims to distinguish the forms of these routines and then, to measure their significances to knowledge creation through several case studies. Specifically, the research defines three different systems of knowledge routines: Basic knowledge routine system (S_1), refined knowledge routine system (S_2) and SECI-Ba knowledge routine system (S_3). S_1 represents knowledge routines deployed in a crude form, often informally and with little planning and predetermined structure. S_2 represents knowledge routines running in a defined and feedback-loop system. S_3 is an extended system of S_2 by making explicit the elements of two related knowledge creation models, SECI and Ba. Five performance measures appertaining knowledge creation are considered: percentage of goals met (TSO_1), impact on area (TSO_2), overall business success (TSO_3), knowledge gain in Kaizen and LSS (SSO_1)

and skill of idea generation and decision making (SSO_2). Study was performed by using case studies, questionnaire survey and statistical analysis. Twenty Kaizen case studies were collected and questionnaires were conducted with knowledge leaders involving in these Kaizens, over three years period. In statistical analysis, a multiple regression analysis was used to determine the relationship between knowledge routines to knowledge creation. Two critical findings were gained from the study. Firstly, the survey showed that S_2 achieved 52.76% higher mean rating of effectiveness of knowledge creation compared to S_1. S_3 achieved higher mean ratings of effectiveness of knowledge creation than S_2 and S_1, with increment of 25% and 64.57%, respectively. These provide strong evidences that system harnessing SECI and Ba consistently outperformed its counterparts. Secondly, while statistical analysis showed that five knowledge routines are significantly related to knowledge creation in all systems, their individual significances vary to measurement items of knowledge creation. S_1-KR_2, S_2-KR_1 and S_3- KR_1 have the highest significance to TSO_1. In terms of significance to TSO_2, KR_2 is the highest among all systems. KR_1 has the highest significance to TSO_3 and SSO_2 in all systems. S_1-KR_4, S_2-KR_3 and S_3-KR_3 have the highest significance to SSO_1. KR_5 is the least significant in all systems. The research contribution is the system development and empirical evidence underscoring SECI-BA enabling conditions in knowledge routines to facilitate knowledge creation in Kaizen. The main research limitation is case studies with relatively small sample size and based on a single organization, despite characteristically heterogeneous and diverse.

00CHAPTER 1

INTRODUCTION

1.1 Introduction

The chapter introduces general ideas and sets the scene for the research. It consists of six sections. First, the research background presents theoretical foundations of this research and an increased prevalence of Kaizen in the organization. Problem statements and research objectives are illustrated in the following sections. Then, the research scope and significance are described. Finally, the thesis outlines are indicated in the last section.

1.2 Research background

Organizations compete on the basis of knowledge since products and services are increasingly complex (Omotayo, 2015). Knowledge management is critical for organizational survival and competitive differentiation in the face of globalization (Budhwar and Debrah, 2009). Considering the management dynamics today, the onus of managing knowledge is the utmost focus on knowledge creation, as humans are at the center of all relevant knowledge activities. Succinctly, knowledge creation represents the process where new knowledge, ideas, and best practices are generated in the organization (Alipour et al., 2011; Brix, 2017); amplified and crystalized in the same system (Nonaka et al., 2006; Lee and Wong, 2015). It relates to continuous transfer, combination and conversion of the different types of knowledge, as users practice, interact and learn (Nonaka et al., 1996). Knowledge creation keeps organizational knowledge dynamic in equilibrium to offset the effect of knowledge

loss (Bratianu and Orzea, 2010), therefore a necessary life-long process to organization (Nonaka et al., 2000; Choi and Lee, 2002).

Lean Six Sigma (LSS) is an integrative concept of Lean Manufacturing and Six Sigma. Lean manufacturing is rooted in Toyota Production System (TPS) which was established in Japan shortly after Second World War by Taiichi Ohno (Maleyeff et al., 2012). TPS was adopted by Americans and known in the western countries as Lean manufacturing. Meanwhile, in the mid-1980s, Motorola invented Six Sigma quality improvement process and in the late-1980s, Six Sigma was extended to critical business process and became a formalized in-house methodology for performance improvement in organizations. In 1990s, Six Sigma was adopted by large-scale companies such as Allied Signal, Honeywell, General Electric, etc. The concept of LSS was created in 2001 (Albliwi et al., 2015). Since then, there has been a noticeable increase in LSS popularity and deployment in industrial world, regardless of large organizations or small-and-medium-sized manufacturing enterprises (SMEs). The adoption of the concept also expanded to other industries such as military, financial services, education, etc. Evidently, LSS contributes to improvements, as shown in many literatures, especially in the aspects of quality, timely delivery, cost, customer satisfaction, organization capability and maximizing value for stakeholders (Kumar and Bauer, 2010; Malik and Bluemenfeld, 2012; Ahmed et al., 2013; Che Ani and Chin, 2016). Figure 1.1 depicts a timeline related to the evolution of LSS and its prevalence in various industries.

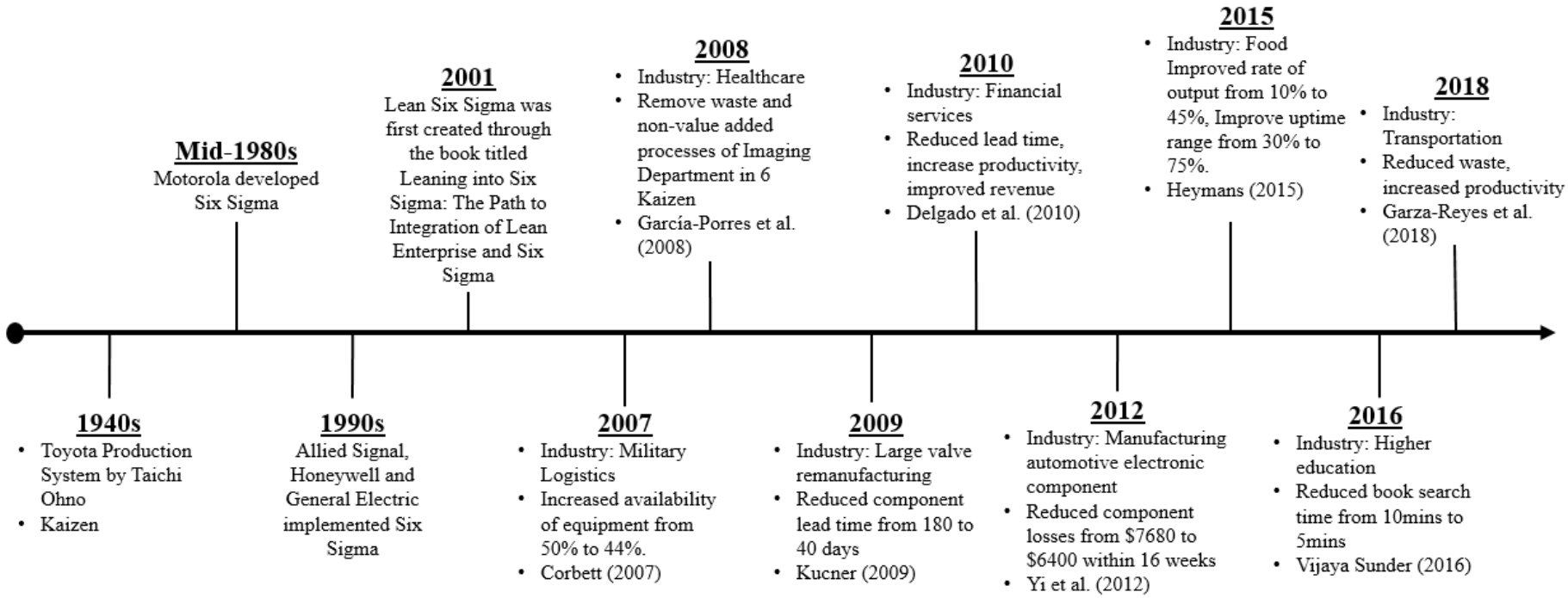

Figure 1.1: The evolution of LSS and its applications in various industries

Kaizen represents a concept in LSS that promotes continuous, small and incremental changes lead to larger changes and transformations. Its importance is widely reported in literature. A semi-structured interview by Zailani et al. (2015) with employees in upper management in two Japanese companies related the impact of Kaizen to organization's performance and capabilities. Improving organization capabilities drive both operational success and long-term adaptation in global market. They emphasized Kaizen is essential to dispel stagnation and complacency in organization. Cost reduction and quality improvement were two most popular Kaizen themes and they contributed to sustainable competitive advantage of organizations. Another survey by Goni et al. (2018) focusing on 100 senior managers strongly pointed to implementation of Kaizen as a culture leads to the success of organization in terms of customer satisfaction and profit improvement. Another case in point would be the account by Woods (2019) on a firm called First Source which has implemented two relevant programs within 2010-2011. The programs were called Kaizen corner and Process Excellence program. For Kaizen corner, the employees would write problems faced during working hours and suggest ideas to solve them. The ideas collected were evaluated by LSS experts once a week for further actions. In the first year, more than 6400 ideas were logged and 990 ideas implemented organization-wide. The efforts resulted in signed-off client savings of over US$1million. On the other hand, Process Excellence program executed Kaizen projects to deliver sustained quality net incomes for the business in the forms of revenue enhancement, cost avoidance, and cost reduction. Within one year, more than 130 Kaizen projects were conducted in the organization. Savings generated through these projects included signed-off benefits of more than US$2 million.

In the realm of epistemology, Kaizen relates to knowledge creation in three perspectives. First, Kaizen, a Japanese philosophy, which focuses on continuous improvement throughout all aspects of life. It aims to eliminate wastes in all systems of an organization. Kaizen contains iterative phases (Soković et al., 2010; Shoji and Kokubo, 2017), involving gathering information about a given problem, its root causes, and choosing an appropriate solution that would maximize utility (Nonaka et al., 2006). This situation is akin to knowledge creation proposed by Nonaka et al. (2016), where knowledge is made available and amplified by individuals as well as subsequently crystalized in organization. Second, Kaizen involves intensive interactions between different parties in organization, hence a nexus for knowledge creation. Finally, Kaizen running on the basis of project, inevitably contains a set of regular activities, or routines conducted by individual or team, intentionally or unintentionally to acquire, analyze, create and share knowledge. Clark (2000) denotes routines as recurrent action patterns that are consensually validated grammars for process and action, distributed by communication and authority, spread among several actors, interlocked by role sets, and operated on by tacit and explicit knowledge. The degree of knowledge creation potentially relies on the configuration of routines (Hershel and Jones, 2005; Chen and McQueen, 2010).

1.3 Problem statements

Today, the importance of knowledge for organizational success is well recognized (Dayan et al., 2017). Substantially high investment and fierce global competitions compel most organizations to look into effective knowledge creation, primarily to sustain competitive advantages of organization. The ability of organization to identify opportunities to create knowledge effectively than its

competitors is key to increase organizational success. A healthy organization is not only built to acquire, share, diffuse, and apply existing knowledge, but also to create specific knowledge or know-how in order to achieve a long-term success.

In LSS organizations, knowledge creation and Kaizen are highly correlated to underlie organization momentum to constantly drive and create knowledge. Knowledge creation relates to formation of new ideas or knowledge through interacting between easily searchable knowledge (explicit knowledge) and knowledge that exists in the employee's mind (tacit knowledge). While, Kaizen represents one of the business strategies to improve organizational performance and along the process, generate and capitalize ideas or knowledge. In Kaizen, knowledge routines play the roles to actionize knowledge creation.

Most organizations have yet to emphasize knowledge routines in Kaizen. Neither have they fully aware of the implication of knowledge creation, nor how to best treat knowledge routines to maximize knowledge creation as well as Kaizen goal attainment. Building on these premises, the research interests hence center on mechanisms to effectively enhance knowledge creation in prominent knowledge routines in Kaizen.

1.4 Research objectives

The objectives of this research are:

1) To form different structural enhancements to basic knowledge routines in Kaizen to improve knowledge creation.
2) To investigate and later compare the performances of knowledge routines in a series of Kaizen case studies in statistically manner.
3) To determine the significance of knowledge routines and their interrelationships to knowledge creation.

1.5 Research scope

The research scope is captured below:

- The primary focus is on the knowledge routines undertaken during Kaizen. In the case studies, Kaizen would be carried out as a team-based project, with formal initiation and closure which also mark the starting and end points of the case studies.
- The effectiveness of knowledge creation is measured based technical systems outcomes and social systems outcomes.
- The multiple case studies are carried out in single manufacturing industry with a high maturity level of LSS.

1.6 Significance of the research

The novelty of the research is on the development and formalization of knowledge routines and the affiliated systems in Kaizen, in hope to improve the effectiveness of knowledge creation. This research is significant to academics, researchers as well as practitioners such as organization comprehensively applying Kaizen. The knowledge derived from this research provides evidence and awareness of the importance of "knowledge-enhanced routines" in Kaizen. As part of continuous improvement at the system level, practitioners would invest to the initiatives to revamp their Kaizen process, in accordance with the findings from this research. It adds value to continuous improvement undertakings by improving the configuration of knowledge routines and improve knowledge creation in the organization.

1.7 Thesis outlines

Chapter 1 introduces background of the research. The problem statements are discussed. Next, research objectives, research scope, and significance of research are presented. Finally, a thesis outline is described to show the flow of chapters in the research.

Chapter 2 provides a literature review on knowledge routines and knowledge creation in Kaizen. The general background of LSS, Kaizen and knowledge creation are presented along with the existing issues of knowledge routines in Kaizen. Then, the literature of adopting knowledge routines and knowledge creation and its existing limitations in Kaizen are discussed to identify the need for further investigation.

Chapter 3 describes the methodology used in the research, including detailed descriptions on system identification, case studies and qualitative analysis, and survey and quantitative analysis. The software used, namely SigmaZone (SPC XL and DOE PRO XL) are also presented.

Chapter 4 presents systems identification and follows by the explaining of the three systems. Then, the details of survey setting, qualitative and quantitative analysis of case study are presented. The background of case study organization is also described.

Chapter 5 presents results from the implementation of knowledge routines and results for the three systems in Kaizen in terms of comparison of mean rating and significant relationship of knowledge routines to the knowledge creation.

Chapter 6 details the discussion regarding the results and findings obtained from the case studies.

Chapter 7 presents the conclusions of this research work and recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature review divides into six main sections. First two sections introduce LSS and Kaizen projects. They are followed by typologies of knowledge and knowledge creation including definitions of knowledge, classifications of knowledge, knowledge creation theory, knowledge in Kaizen and research works that study knowledge creation in Kaizen. This paves way to the last four sections which focus specifically on key elements of this research: the former examines knowledge routines in Kaizen, types of conversations in knowledge routines and knowledge creation, the effectiveness of knowledge creation in Kaizen and the latter describes the summary of findings.

2.2 Lean Six Sigma (LSS)

Derived from the study of TPS, Lean is a process improvement philosophy to optimize automotive industry (Womack et al., 1990). The concept was later extended beyond the industry (Womack and Jones, 1996). The philosophy is captured by five key principles, called Lean thinking, a term first coined in Womack and Jones (1996). They are identification of value, specification of value stream, achievement of flow through process, pacing by a pull signal and continuous pursuit of perfection. These principles stress the spirit of continuous improvement and waste elimination, which is relentless removal of everything that would increase cost without adding value to customers (Womack and Jones,

1996; Dahlgaard and Dahlgaard-Park, 2006; Sunder, 2013; Salah and Rahim, 2019).

Six Sigma principles were pioneered by Motorola Company in 1980s and 1995, Six Sigma became a central business strategy in General Electric. It is a data-driven process improvement methodology used to minimize process variation as well as to achieve optimal, stable and predictable process results. Statistical and non-statistical tools and techniques are deployed, to obtain critical knowledge of processes and products essential for both operational and business excellence (Antony, 2007). In the field of statistics, Sigma indicates the inherent variation in a studied population. In a same token, it implies how well a process variation meets customer's requirement (Pyzdek and Keller, 2009). Achieving a six-sigma level of quality (process capability) suggests the process produces only 3.4 defects per millions of opportunities.

LSS refers to integration of Lean and Six Sigma. The term LSS was first coined by Wheat et al. (2001) and has since gaining traction and popularity in industries and academia (Kumar et al., 2006; Laureani and Antony, 2012; Timans et al., 2012). As both concepts complementarily promote continuous improvement and enhance values to customers, LSS is inherently more effective to improve process performance, customer satisfaction and bottom-line results (Snee, 2010). Strong empirical evidences show LSS improves product and process performances, reduces defects and variations in business processes and product designs (Snee, 2010; Prakash and Chin, 2015; Ruben et al., 2018). Reduction of defects is the direct implication when services or products conform to what customer needs (voice of customer), removal of non-value-adding steps or wastes in business processes,

shortening cycle time and deliverance of correct products or services at right time in right place (Hess and Benjamin, 2015; Sreedharan et al., 2018).

2.3 Kaizen project

Kaizen project (here forth known as Kaizen) is a project-driven approach to eliminate waste by improving and standardizing process and product (Gitlow et al., 2006; Ray and Das, 2010). Pyzdek and Keller (2010) classified four project types, namely quick win, process improvement, process design and process redesign, as described in Table 2.1. Kaizen could be seen closely relate to process improvement where the undertaking is relatively gradual because of two reasons (Jacobson et al., 2009). First, the focus is to improve and perfect a process over time through incremental reduction of errors, defects, cost and other variables in small carefully thought out phases. Second, process improvement often lacks a known cause of error or defect. Consequently, professionals need to spend more time locating problem source and developing countermeasure.

Table 2.1 Types of Kaizen in LSS

	Kaizen type			
	Quick win	**Process improvement**	**Process design**	**Process redesign**
Description	Implementation of a simple countermeasure to a known issue.	The presenting issue has an unknown cause and countermeasures are not predetermined.	There is no existing process to analyze which requires benchmarking and collection of voice of customers.	The process exists but incremental improvements will not be able to satisfy requirements.
Example	Just-do-it Fast track	Kaizen (PDCA, DMAIC)	DFSS DMADV	Reengineering
Literatures	Ramakrishnan and Testani (2010); Grey (2010); Hardion et al. (2012)	Soković et al. (2010); Snee (2007); Soković et al. (2009)	Soković et al. (2009); Soković et al. (2010); Bañuelas and Antony (2003)	Lyu Jr (1996); Audenino (2012)

In a mature LSS organization, a steering committee (Davis, 2003; Chiarini, 2011) would be established to identify, prioritize, select, monitor and evaluate Kaizen. Commonly, Kaizen closely linked to business goal and objective of organization (McAdam and Lafferty, 2004; Choo et al., 2007; Metri, 2007; Russell and Tippett, 2008; Kumar et al., 2008; Ray and Das, 2010). It is also normative to priority Kaizen that will provide maximum financial benefits to organization (Adam, et al., 2007; Kumar, 2007; Kumar et al., 2008). In more detailed studies, Adam et al. (2007) proposed seven sources to identify potential Kaizen including customer, supplier, employees, benchmarking, development in technology, extension of other Kaizen project and waste. Brue and Howes (2006) suggested project selection approach in top down, bottom up or outside in. They further proposed different decision criteria for project selection: customer impact, financial impact, top management commitment, measurable and feasible, learning and growth, connected to business strategy and core competence.

PDCA and DMAIC are two most common methodologies of process improvement in Kaizen. PDCA is an iterative, four-stage approach to continually improve processes, products or services and for resolving problems (Soković et al., 2010). It involves systematically testing possible countermeasures, assessing results and implementing the workable countermeasures. The four stages are Plan (P), Do (D), Check (C) and Act (A). Snee and Hoerl (2007) elaborated steps in PDCA. In their account, Plan stage includes steps to define and breakdown problem, grasp current condition, set a target condition, conduct root cause and gap analysis and identify potential countermeasures. Do stage includes steps to develop and test countermeasures, refine and finalize countermeasures and implement countermeasures. Check stage includes steps to measure process performance and

Act stage includes steps to refine, standardize and stabilize process, monitor process performance and evaluate results and share learning.

In comparison, DMAIC is a process improvement occurs through a data-driven methodology based on analytical procedural practices called define (D), measure (M), analyze (A), improve (I) and control (C), which will gain the most dramatic changes and benefits to customers and organization (Thakore et al., 2014). Define stage includes steps of determining customer and process requirements and define the scope and goals of the project. Measure stage includes steps of establishing metrics of output, determine operational measures, defining critical elements to quality and to perform measurement system analysis or gage repeatability and reproducibility. Analyze stage includes steps of exploring the collected data, analysis, verification and prioritization of possible root cause and their relationships to outputs. Improve stage includes the steps of identifying, testing and implementing the countermeasures to eliminate the root causes. Control stage includes steps of establishing measures to standardize, monitor and integrate the changes within timeframe (Li et al., 2008).

2.4 Typologies of knowledge and knowledge creation

2.4.1 Definitions of knowledge

Multiple definitions of knowledge have been proposed in literature. Drucker (1993) defined knowledge as the only meaningful resource in a knowledge-based society, emphasizing that "Knowledge is not impersonal, like money. Knowledge does not reside in a book, a databank, a software program; they contain only information. Knowledge is always embodied in a person; carried by a person; created, augmented or improved by a person; applied by a person; taught by a person

and passed on by a person". Nonaka (1994)'s definition of knowledge is 'justified true belief' that increases an organization's capacity for effective action is more widespread and frequently coined in literature (Nonaka, 1994; Nonaka and Takeuchi, 1995). Grounded on Nonaka (1994)'s definition, Davenport and Prusak (1998) described "knowledge as a fluid mix of framed experiences, values, context information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices and norms". Comparatively less descriptive, Zack (1999) associated knowledge to meaningful information which is accumulated through experience, communication or inference. Bates (2005) referred knowledge as an information given meaning and integrated with other contents of understanding, while Chaudhry (2008) specified the knowledge in a business and organizational context: knowledge is know-how, a mixture of insight, perception, experience and foresight. It contains a special blend of intellect and intuition that enables someone to know-how to do something to determine the most appropriate action. Knowledge then is mainly collective experience of employees of an organization. Zagzebski (2017) defined knowledge as a cognitive contact with reality arising out of acts of intellectual virtue, associated with a combination of act from one's own and other rather than through a single act.

2.4.2 Classifications of knowledge

Knowledge has been categorized variously in literature. Polanyi (1966) proposed a seminal classification of knowledge which has two forms: tacit and explicit knowledge (Polanyi, 1966; Nonaka and Takeuchi, 1995; Woo et al., 2004; Park et al., 2015). The explanation would be covered in more depth, in Section

2.4.2(a) (page 19) and 2.4.2(b) (page 20). The remaining part organizes the review chronologically following publication date of literature.

According to Erhaut (1992), three types of knowledge contribute to professional knowledge and understanding: personal knowledge, procedural knowledge and propositional knowledge. Personal knowledge is the interpretation of experience and understanding of assumptions. Procedural knowledge is characterized as know-how to do something and defined as the ability to execute action sequences to perform tasks. Propositional knowledge refers to known-that concepts, fact, empirical and philosophical (Rittle-Johnson et al., 2009).

Blackler (1995) proposes five groups of knowledge: embrained knowledge, embodied knowledge, encultured knowledge, embedded knowledge and encoded knowledge. Embrained knowledge is dependent upon conceptual skills and cognitive abilities. Embodied knowledge is action oriented. Encultured knowledge refers to process of achieving a shared understanding. Embedded knowledge is knowledge that resides in systemic routines and shared norms and Encoded knowledge is information conveyed by signs and symbols.

Wiig (1997) defines four types of knowledge: factual, conceptual, expectational and methodological. Factual knowledge deals with data and casual chains, measurements and reading, which are typically directly observable and verifiable content. Conceptual knowledge involves systems, concepts and perspective (e.g. concept of track record). Expectational knowledge concerns judgments, hypotheses and expectations held by knowers. Finally, methodological knowledge deals with reasoning, strategies, decision making methods and other techniques.

De Long and Fahey (2000) argued there are at least three distinct types of knowledge: human knowledge, social knowledge and structured knowledge. Human knowledge constitutes what individuals know or know-how to do and it is manifested in skill or expertise and combines both explicit and tacit knowledge. Social knowledge exists only in the relationship between individuals or within groups and it is largely tacit, shared by group members and develops only as a result of working together. Structured knowledge is embedded in an organization's systems, processes, tools and routines and it is explicit and rule-based.

Meier et al. (2000) classified knowledge as technical and non-technical. Technical knowledge refers to logical understanding on how systems and process work and the required knowledge to perform specific tasks. Non-technical knowledge comprises the ability to carry out specific tasks. Aguayo (2004) distinguished substantive and entrepreneurial knowledge. The former relates to knowledge of subject matter that is specific to a field, while the latter refers to knowledge of how to monetize or commercialize substantive knowledge.

Akin to the breakdown of propositional and procedural knowledge in Erhaut (1992), Arumugam et al. (2013) introduced two types of knowledge: knowing-what and knowing-how. Knowing-what practices include seeking information with customers and supplier seeking information with people having a similar project experience, referencing similar projects and meeting with an external expert to seek information or knowledge, get narratives and histories. Knowing-how practices include carrying out a critical observation, using LSS tools to analyze data, meeting and brainstorm to gain more understanding, reflection and action cycle.

As aforementioned, the classification proposed by Polanyi (1966) is widely accepted by research mainstream (Cummings and Teng, 2003; Knockaert et al.,

2011; Eslami et al., 2018). It is fundament of the famous knowledge creation model proposed by Nonaka and Takeuchi (1995). Further effort would be made to expound the two types of knowledge under the classification.

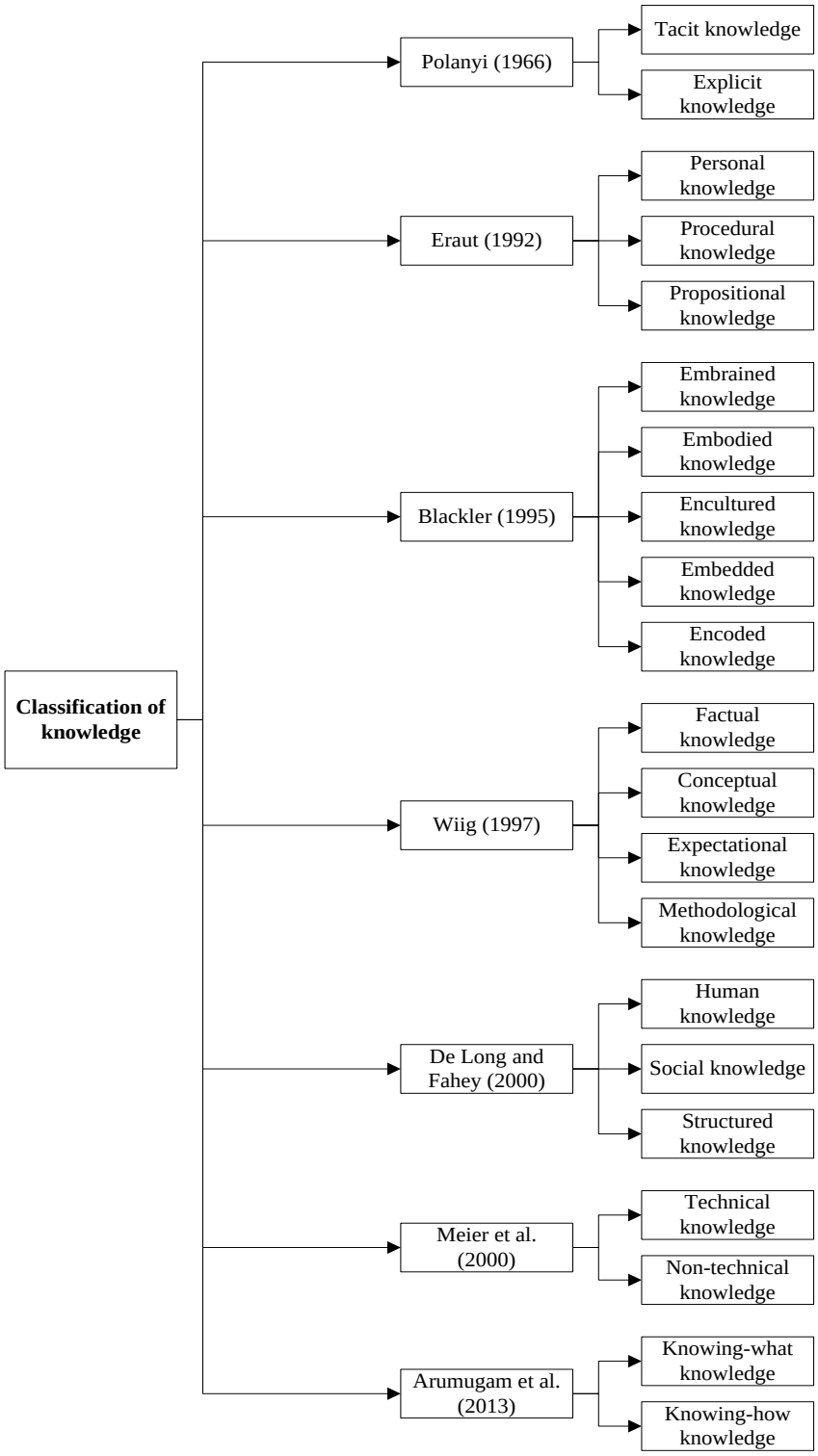

Figure 2.1: Classification of knowledge

2.4.2 (a) Tacit knowledge

Tacit knowledge includes beliefs, creative processes, hunches, individual experience, insights, intuitions, instincts, know-how, perspectives, skills, understanding of future state and values (Frappaolo, 2006; Sabherwal and Sabherwal, 2007; Nonaka and Von Krogh, 2009). Polanyi (2012) defined tacit knowledge as personal knowledge based on individual experience and influenced by perceptions and values. Nonaka (1994) divided tacit knowledge into two elements, cognitive and technical elements. Tacit knowledge is deeply rooted in action, commitment and involvement in a specific context. Cognitive elements include personal schemata, paradigms, beliefs and viewpoints that help individuals to form their perspectives to understand and define the world surrounding them. On the other hand, technical elements comprise concrete know-how, crafts and skills that apply to specific contexts (Nonaka, 1994).

Mason (2003) expanded Nonaka (1994)'s definition to include into tacit knowledge common senses which are concepts of values and facts, which are common, understand and known to a society or group. Common senses are usually constructed and transmitted through apprenticeships and broader cultural environment. Additionally, cultural environment such as a national or ethnic group can influence the construction of tacit knowledge and once it is built, it may be difficult to change.

Generally, tacit knowledge is difficult to articulate, express and formalize to others and it travels particularly poorly between organizations (Kogut and Zander, 1993). Tacit knowledge is more likely to be held by skilled individuals whose experiences form essential aspects of the production process. It is shared mostly through person-to-person contacts, therefore its transmission is informal and subtle

(Dyck et al., 2005; Sabherwal and Sabherwal, 2007). Lastly, since tacit knowledge is in a person's mind, it is continually changing and evolving (Nonaka and Toyama, 2015; Bolisani and Bratianu, 2018).

2.4.2 (b) Explicit knowledge

Explicit knowledge is knowledge that can be transmitted in the form of formal and systematic language (Nonaka, 1994; Nonaka et al., 2006; Shannak et al., 2012; Paulin and Suneson, 2015; Razak et al., 2016). It is usually stated in clear language formatted in individuals' minds, such as words, pictures, diagrams, computer codes, procedure manuals and the like (Dyck et al., 2005), so it can be stored in a knowledge database or managed by knowledge management systems (Stover, 2004; Nonaka et al., 2008). Often, explicit knowledge is referred to as information (Renaud, Lefebvre and Fonteix, 2004; Rego, 2005; Frappaolo, 2006). Transmission of explicit knowledge can be in synchronous or asynchronous ways (Frappaolo, 2006). Even though explicit knowledge is represented in articulated, shareable and symbolized forms, its meanings could be varied to different persons with various purposes (Weiss and Prusak, 2005). Therefore, people adopt, reject or rearrange explicit knowledge selectively based on their interests and purpose (Weiss and Prusak, 2005).

The two states of knowledge are not dichotomous and are mutually dependent and reinforce each other's qualities. Tacit knowledge forms the necessary background for assigning structures to develop and interpret explicit knowledge (Blumenberg et al., 2009). However, tacit knowledge has potential to be of substantial values to organization because it is more difficult to capture and diffuse (Frappaolo 2008; Anand et al., 2010).

2.4.3 Knowledge creation

Nonaka et al. (2006) defined knowledge creation as the process of making available and amplifying knowledge created by individuals, as well as crystalizing and connecting it within an organization's system. Knowledge is created in organization by using two dimensions of continuous dynamic process, which are epistemological dimension and ontological dimension (Bratianu and Orzea, 2010).

Nonaka (1994) stated that epistemology dimension differentiates tacit and explicit knowledge, as well as interactions between these two forms of knowledge. Four modes of knowledge conversion are created when tacit knowledge and explicit knowledge interact. The four modes are socialization, combination, externalization and internalization. Together, they make up the engine that drives knowledge creation process. These four modes of knowledge conversion are what individuals experience and are also the mechanisms to explain how knowledge is communicated and amplified throughout an organization (Nonaka, 1995).

The essence of dynamic theory of knowledge creation has to do with how this knowledge spiral emerges as shown in Figure 2.1 (Nonaka et al., 1994; Nonaka, 1995). While knowledge can be created by these four knowledge conversion modes individually, Nonaka (1995) underlined the importance of dynamic interaction between them. Once knowledge undergoes a conversation, it takes on new attributes and details; it expands or shrinks, gets filtered and solidified. An intimate connection between the processes of knowledge conversion and knowledge creation is rather apparent: It appears that the essence of knowledge creation is knowledge conversion and transfer among individual members of an organization.

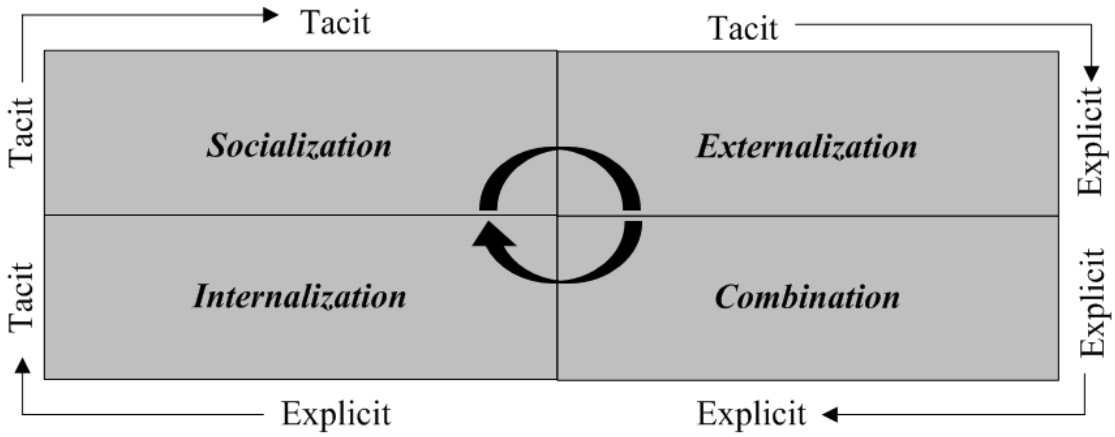

Figure 2.2: Knowledge creation spiral (*Source: Nonaka, 1995*)

2.4.3 (a) SECI model

Socialization, externalization, combination and internalization (SECI) describes the four processes of knowledge conversion in details.

Socialization is the process of creating tacit knowledge through shared experience (Nonaka, 1994). Linderman et al. (2004) stated that this mode of knowledge conversion requires that individuals interact with one another and in doing so, create tacit knowledge such as shared mental models and technical skills. Sharing of tacit knowledge through socialization can occur without using language such as the case with mentoring, observation, imitation and hands-on practice. Shared experiences promote socialization by enabling individuals to empathize with one another and incorporate the other's feelings and beliefs about a shared experience (Linderman et al., 2004).

Externalization is conversion of tacit knowledge into explicit knowledge (Nonaka, 1994). Nonaka (1994) stated that metaphor is an effective way to convert tacit knowledge into explicit knowledge and is the first step in transforming tacit knowledge into explicit knowledge. Consistent with Nonaka (1994), Linderman et al. (2010) argued that externalization is often facilitated by metaphor, analogies,

concepts, hypothesis and models that are created by teams when they create concepts triggered by discussion and collective reflection (Linderman et al., 2004, 2010).

Nonaka (1994) stated that combination involves use of social processes to combine different pieces of explicit knowledge held by individuals or information systems. It can be done through exchange mechanisms such as meeting, telephone conversations, emails, individuals exchange and combine explicit knowledge. Knowledge can be created by repurposing and recombining existing information through sorting, adding, re-categorizing and re-contextualizing of explicit knowledge. Thus, combination is process of systematizing concepts and combining different bodies of explicit knowledge (Linderman et al., 2004).

Internalization is conversion of explicit knowledge into tacit knowledge; has some similarity to traditional concept of learning is deeply related to action (Nonaka, 1994). Linderman et al. (2004) suggested knowledge to be verbalized or diagrammed into documents, manuals or oral stories to aid conversion of explicit knowledge into tacit knowledge. Documentation helps individuals to internalize their experiences, thus enriching their tacit knowledge. In internalization, an individual absorbs tacit knowledge through demonstrations and other means (Sabherwal and Becerra-Fernandez, 2003). Internalization often occurs through re-experiencing what was learned, as is often the case of in learning-by-doing (Linderman et al., 2004).

2.4.3 (b) Ba

Ba is a Japanese word means ‘shared space’. Nonaka and Konno (1998) defined Ba as a shared context in which knowledge is shared, created and utilized. As Friedrich Nietzsche argued, ‘there are no facts, only interpretations’. Ba is a place where information is interpreted to become knowledge. The key concept in

understanding Ba is interaction (Nonaka et al., 2000). Knowledge needs a context to be created. Nonaka and Konno (1998) conceived concept of Ba as a foundation for knowledge creation. Knowledge creation process is necessarily context-specific in terms of who participates and how they participate. Knowledge needs a physical context to be created; there is no creation without place. Rather than an individual operating alone, interactions amongst individuals or between individuals are able to create knowledge (Hautala, 2011). Ba lets individuals share time and space. In knowledge creation, especially in socialization and externalization, it is important for participants to share time and space. Close physical interaction is important in sharing context and forming a common language among individuals. Otherwise, Ba also can be mental and virtual place, where it does not be bound to a certain space and time (Nonaka and Toyama, 2005).

There are four types of Ba corresponding to the four modes of knowledge creation as shown in Figure 2.2 (Nonaka et al., 2002). First, originating Ba is a place where individuals share experiences primarily through face-to-face interactions and mainly offers a context for socialization (Nonaka et al., 2002; Nonaka and Toyama, 2015; Sujatha and Krishnaveni, 2018). It is a place where individuals share experiences, feelings, emotions and mental models. Originating Ba is an individual transcends the boundary between self and others, by sympathizing or empathizing with others. From originating Ba emerge care, love, trust and commitment, which form the basis for knowledge conversion among individuals (Rai, 2011).

Second, interacting Ba entails externalization mode of knowledge creation (Wu and Lin, 2009; Chatterjee et al., 2018). It is a place where tacit knowledge is converted to explicit knowledge and then shared among individuals through dialogue and collaboration. Interacting Ba is more consciously constructed than originating