Lean Six Sigma in Action: Problems and prospects of expansive learning in an international aircraft manufacturer

Master’s Thesis
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Objectives. This research addressed the problems and prospects of Lean Six Sigma (LSS), one of the world's most popular organizational development methods at present. The study enriched this method by suggesting a more sustainable way of organizational development. The previous research on LSS mainly focused on the technical tools in utilizing the production process. Drawing on the theory of Expansive Learning, this research evaluated the learning process of LSS by focusing on the practitioners. The purpose of the research was twofold. First, it analyzed the contradictions of LSS project activity in the research site. It was expected to uncover the problems that jeopardized the learning process of the practitioners. Second, it discussed the zone of proximal development (ZPD) of LSS project activity for the research site, with the purpose of shedding light on the possibilities of future development and learning.

Methods. The research site was an international aircraft manufacturer in China. Eleven LSS practitioners were interviewed, including eight Green Belts, one Black Belt, one Master Black Belt and one Green Belt team member. The data were analyzed by adopting three methods: the analysis of conceptions, the Analysis of discursive manifestations of contradictions, and the analysis of action-activity transformation in expansive learning. The ZPD was sketched from two dimensions: the first one by analyzing the action-activity transformation of the practitioners; the second one by evaluating the conception of “what have expanded” in the practitioners due to the project experiences.

Results and conclusions. The analysis uncovered eight contradictions in LSS project activity system. Five were scattered in the project activity itself between or within varied elements of activity. Three were between the project activity, the department-based work activity and the LSS training activity. One case in which the GB’s trials in breaking the constraints in his own project resulted in collective expansive learning efforts across projects was analyzed as the representation of action-activity transformation. In addition, some practitioners had re-conceptualized their work motivation through the project experience, seeing Lean Six Sigma as a conceptual tool for understanding strategic work planning and gaining long-term work motivation. In conclusion, two dimensions of the ZPD were suggested: first, an integrated top-down and bottom-up approaches for organizational transformation; second, transcending from LSS as the “concrete tool in individual skill appropriation” to the “conceptual tool in collective work reconceptualization”. The organizations adopting the LSS method can reflect on this thesis to improve their LSS practices by paying attention to the “critical transition agent” for cross-functional processes’ interaction, the employees’ learning initiatives and work motivation.

Avainsanat – Nyckelord – Keywords
Lean Six Sigma (LSS), Green Belt project; DMAIC, theory of expansive learning, organizational transformation, activity theory, contradictions, zone of proximal development
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1. INTRODUCTION

1.1. Research interest: Lean Six Sigma: work facilitator or complicator

Business improvement approaches emerging out of operational practices are constructing new managerial concepts. It is commonly recognized that the modern business improvement approaches begin with Taylor’s scientific management (1911) and develop by “adopting the effective aspects of previous approaches and adding new concepts, methods and tools to remove limitations that have been identified” (Snee, 2010). In recent decades, Lean Six Sigma (LSS) has become one of the most popular approaches among industries all over the world, covering manufacturing, military, government, health care, IT, consulting, education, outsourcing, and service.

Snee describes Lean Six Sigma as an advanced business strategy and methodology that increases process performance, improves bottom line results, enhances customer satisfaction and develops leadership skills by using DMAIC, a disciplined systematic improvement approach (Snee, 2010). According to Snee (2000), Lean Six Sigma outperforms the previous approaches by “integrating the human and process aspects with process improvement”. The human aspects address the “bottom line focus, management leadership, sense of urgency, customer focus, project teams and culture change”. The process aspects emphasize on “the process improvement, analysis of variation, disciplined approach, quantitative measures, statistical thinking and methods and process management”.

Following this trend, researches on Lean Six Sigma have been widely carried out among scholars. However, the focus has been primarily on developing better methods and tools to improve performance and reduce variation in the target system, rather than on “understanding the cognitive landscape of the project team to enable increased collective learning and knowledge creation”(Choo, Linderman, & Schroeder, 2007; Wiklund &
Wiklund, 2002). Aboelmaged (2010) found that relatively few studies looked at the link between Lean Six Sigma and organizational learning (seven publications out of 417 surveyed).

The purpose of the thesis is to study Lean Six Sigma taking an international aircraft manufacturer situated in China as a case study. The thesis focuses on Expansive Learning (Engeström, 1987) – an innovative form of organizational learning. MD will be used as the abbreviation of the research site.

Lean Six Sigma is implemented in the form of project. According to projects’ scales and financial gains, they are divided into Black Belt (BB) projects and Green Belt (GB) projects. Black Belt project is led by full time Black Belt with the characteristics of high level of technical complexity, intensive cross-departmental communication, and high financial gains. Green Belt project, which is led by part time Green Belt, demonstrates less complexity and financial gains in comparison.

The study focuses on Green Belt project in MD for following reasons. First, Green Belt outnumbers Black Belt in quantity. For instance, until July 2012 there were 37 certified Green Belts and 16 Green Belts trainees in contrast with only 3 Black Belts. Second, Green Belt projects are with wider influences as Green Belts are teamed with part-time project workers who come from almost all departments while Black Belts are full-time employees from continuous improvement department. Third, Green Belt trainings are systematically carried out twice a year to new members aiming at cultivating more Green Belts; however, there is no such training for Black Belts. In the following of this thesis, the notion of “Lean Six Sigma project” only refers to “Green Belt project”, and “Lean Six Sigma training” to “Green Belt training”.

The motivation of this work derives from my work experience as a trainee and subsequently as Human Resources Officer from April 2008 to July 2012 in the research site. In April 2009, MD introduced Lean Six Sigma training to its management team. Since then, a 10-day LSS training is arranged company-wide twice a year. The trainees are
required to conduct their LSS projects at the completion of their training. After successful completion of the projects, they are certified as “Lean Six Sigma Green Belt”.

As a training intern then, I was quite impressed by the high attention the company put on LSS training, the training cost of which accounted half of the company year training budget. During 2010 and 2011, I was as involved in two Lean Six Sigma projects as a team member. To my understanding, the methodology itself seems to be seamless. It crystallizes the state-of-the-art tools and concepts. It speaks in the name of tangible financial gains. It reconciles both efficiency and effectiveness. Thus, it should be a work facilitator, the “logical thinking guider” as apprised by some GBs. However, contrary to these positive features and comments, what more often heard of was about criticizing LSS as “a burden and extra workload”, “the main source of headache”, “the complicated toolkit of uselessness”.

In an effort to understand what is jeopardizing Green Belts’ learning process, I picked Expansive Learning (Engeström, 1987). The theory of Expansive Learning argues learning as a long-term process that qualitatively transforms the object so that a horizon of wider possibilities and new actions are opened up. In other words, the ultimate goal of learning is “learning what is not yet there” (Engeström, 2001). In the language of theory, the object of activity and learning is expanding through many dimensions, such as socio-spatial, temporal and ethical-political. From social-spatial dimension, the object is disseminated to encompass more actors; from temporal dimension, the object becomes more durable and spans a longer period; from ethical-political dimension, the possible consequences of the new object require new kinds of responsibilities.

In Lean Six Sigma, however, I could not see Expansive Learning being applied and was concerned about the limited learning opportunities. A LSS project is very much goal oriented and it stops when the project goal is achieved. Therefore, it fails to be disseminated in a social-spatial dimension. The influence of Lean Six Sigma tools and concepts diminishes with the lapse of time after the project completion, so it fails to become more durable or span a longer period in the temporal dimension. Many of the Lean
Six Sigma project leaders, the Green Belts, resigned soon after finishing the projects for a better career opportunity, as the Green Belt certificate in MD is valuable in the job market. Thus, it fails to reach mutual benefit between the company and the Green Belts in ethical-political dimension. Often the shortsighted learning processes in companies are like an epidemic for organizations in general in today’s era-of-fast-food. Finding out the Expansive Learning possibilities takes much effort and is of significant importance to the success of the Lean Six Sigma projects as well as any other forms of organizational interventions.

1.2. Thesis structure

This thesis consists of nine chapters. In Chapter 2, the historical context of Lean Six Sigma is introduced, including the development of this methodology and its application in the research company. Chapter 3 presents the theoretical framework of this thesis. The description of the research case is displayed in Chapter 4. Chapter 5 brings the two research questions and their supporting data, followed by the process of data collection and methods of data analysis. Chapter 6 and Chapter 7 are the analysis part of this thesis, which adopt the methods and data introduced in Chapter 5. Each chapter aims at answering each of the two research questions respectively. Chapter 8 summarizes the main findings of the two research questions and extends the implications by combining my suggestion. Chapter 9 evaluates this research by elucidating its validity and reliability, strengths and limitations. It also discusses the research reflection and further research directions of this topic.
2. THE HISTORY OF LEAN SIX SIGMA

2.1. The integration of Lean and Six Sigma

Lean Six Sigma is a combination of Japanese Lean manufacturing and American Six Sigma System. Before the integration for several decades, the two approaches were applied separately. Lean manufacturing originated in Ford's Just-in-time (JIT) concept in manufacturing of Model T in 1910s and culminated in Toyota Production System (Womack et al., 1990) in 1960s. The Six Sigma System was born in Motorola in 1980s and popularized by General Electronic in 1990s. It is a well-structured approach used to enhance process performance and achieve high levels of quality and low levels of variability (Salah et al., 2010).

Lean manufacturing is defined as the systematic removal of waste by all members of the organization from all areas of the value stream, which includes all essential activities to transform raw materials to finished products (Womack & Jones, 1996; Worley, 2004). Lean aims towards process efficiency by reducing waste. Six Sigma aims towards process effectiveness by eliminating variations, which is achieved by using a set of statistical tools in achieving process improvement.

Due to the complementary relationship, namely efficiency in Lean and effectiveness in Six Sigma, a number of researchers attempted to bring these two methodologies together so that a more powerful continuous improvement tool could be produced. The George Group (a consulting group led by M. George) was the first to integrate and popularize Lean with Six Sigma (Salah et al., 2010). M. George (2002) finds that Six Sigma does not directly address process speed, so it leads to the lack of improvement in lead-time in companies applying Six Sigma methods alone. Nevertheless, Lean methods alone are not the work well either as they are not effective in implementation across the corporation at a rapid rate. The companies achieve some remarkable successes but only in small areas. The integration of Lean and Six Sigma was the solution to overcome the shortcomings of both, as they complete each other. The fusion of the two is the way for organizations to increase
their potential improvement (Bhuiyan & Baghel, 2005). Lean Six Sigma addresses issues that are overlooked by Lean and Six Sigma when applied separately. It provides methods to “achieve significant simultaneous cost, quality, variability and lead-time improvements” (Bhuiyan & Baghel, 2005).

Lean Six Sigma can be defined as a methodology that focuses on the elimination of waste and variation following the DMAIC phases, to achieve customer satisfaction concerning quality, delivery and cost. A detailed description of DMAIC phases will be introduced in Chapter 4. The goal of Lean Six Sigma is to reach “a customer focused, employee empowered and flexible organization” (Martin, 2006). Figure 1 shows the history and time-line of Lean Six Sigma development.

Figure 1: History and time-line of Lean Six Sigma

2.2. The history of Lean Six Sigma in MD Company

MD Group is the world leader in aircraft landing and braking systems. Corporation capabilities encompass the full life cycle of its products, ranging from design and manufacture to in-service support, repair and overhaul. The head office is in Paris. MD China, opened in 2002 in Suzhou Industrial Park Jiangsu province, is a wholly owned

http://www.leansigmacorporation.com/history-of-six-sigma
subsidiary of MD Group. MD China started to launch the Lean Six Sigma campaign company-wide in 2009, which was cascaded from the Group due to the pressing needs for new continuous improvement approaches to cope with the new challenges in the aerospace industry.

In the midst of a revitalization of its new approach for better business, in January 2008, the group Executive VP declared that in order to install and sustain dynamic of continuous improvement with respect to productivity, the group has committed to deploy the Lean Six Sigma initiatives in a systematic approach for all of its entities. Targeted improvements are lead-time reduction, quality improvement and productivity gains. The areas concerned are: production, development, sales and support functions. The deployment of Lean Six Sigma is realized in the framework of a plan applicable to the whole group. It defines the content of the training of Green Belt and Black Belt project managers, certification procedures, human resources policies, and the main tools to conduct workshops. The group determines annual quantifiable targets for certification of Green Belt and Black Belt project managers and training of those concerned. In this framework, the implementation of actions is the responsibility of the different group companies. The group plan is based on the following:

- A network of Lean Six Sigma Green Belts and Lean Six Sigma Black Belts
- Group University training and certification courses
- The executive seminars and the “Manager Lean Six Sigma” training’
- Green Belts and Black Belts Group procedures
- The Group toolbox
- The Lean Six Sigma club
- A list of selected providers in consulting and training

Group training for executives and managers was established in 2008. The entire top management from executive committees of the companies was trained. In addition, the Group planned to train in 2009/2010 at least one-third of all managers from the Group companies. The objective is to certify, by 2010, 250 Black Belts and 750 Green Belts. The long-term objectives are: 1% of staff certified Black Belt, 5% Green Belt.
All of these training and coaching courses of candidates for certification are done under the auspices of a company contracted named MD Conseil, guarantor of the whole plan. In addition, the systematic search for synergies within the Group is based on the following two elements. The first is the use of tools and methodologies of the Group toolbox, which is accessible via group intranet. The second is intensive exchange of best practices, including the Club Lean Six Sigma, prefiguring the Black Belts network of the Group, is responsible for causing the exchange of experiences between professionals involved in the implementation of Lean Six Sigma.

The Group defines Lean Six Sigma as the tool and resource for implementing reflection, generating ideas, organizing a project by means of a method. Lean accelerates execution, Six Sigma augments process control; Lean Six Sigma at the Group combines speed, rigorous execution and quality. A four to five day training program is available for every manager or business initiative coordinator involved in the approach of Lean Six Sigma manager. A Green Belt runs a project of his/her sphere of influence and will devote 30% of his/her time to it. A Green Belt project lasts from three to six months. An eight to ten days’ training program is designed to suit this profile. A Black Belt is capable of taking charge of a complex project, and he will devote 100% of his/her time to running the project. The Black Belt program needs to incorporate eight to ten days’ additional training. A Master Black Belt guarantees that the method is correctly understood and used. He/ She will mentor and train the Black Belt.

In February 2009, the Lean Six Sigma Movement in MD Chinese site started with five days’ Lean Six Sigma management training. The trainer was from the Group Conseil, the prime contractor. To become a Group Lean Six Sigma trainer, one needs to get the MBB (Master Black Belt) certificate from the group. The trainees were managers from all departments, including Engineering, Quality, Planning, Machine Shop, Special Process, Supply Chain, Logistic, Human Resources and Finance. This training was called as Lean Six Sigma management training, the aim of which was to get management awareness of and support to the incoming Lean Six Sigma champion company-wide.
In April 2009, the first Lean Six Sigma training was conducted to the first batch of 11 Green Belts. Even since then, it takes place twice a year for different employees. The trainees were selected mainly from the production related department, those whose work directly affect production quality and on-time delivery. After five days’ off-the-job training, they will start to carry out their LSS projects. Another five days’ training will take place during the project deployment period. The trainees need to commit 30% of his/her working time on the LSS project, supported by the full time site Black Belt. The project proceeds according to DMAIC phases. Figure 2 shows a scene of LSS project workshop in MD.

Figure 2: LSS project workshop in MD (Company internal material)

In MD, the site champion is General Manager, Deputy General Manager and Master Black Belt. The two full time Black Belts report to Master Black Belt. They were recruited externally after the introduction of Lean Six Sigma. Their main responsibilities are providing professional Lean Six Sigma knowledge support to the Green Belt, monitoring and assisting Green Belt projects, conducting Lean Six Sigma related training and cultivating Lean Six Sigma culture in the organization. The Green Belts are with twofold identities in the company. On the one hand, they are cadre men of their own department and directly report to their department managers; on the other hand, they are required to
commit 30% of working time to perform Green Belt project and functionally report to MBB or BB, depending on their projects.

An important change in the Chinese site followed by the Lean Six Sigma introduction was the management team shifting from Asian-majority to European-majority. Many of the Chinese managers were either replaced by their European counterpart, or were assigned with less responsibility at work (see table 1). Before Lean Six Sigma era, the management team in MD was comprised by thirteen Asians and one European. Usually, it is uncommon that the management team of a European company is teamed up with Asians. In case of MD, it is because this site used to be a Singapore-French joint venture. Only in the year of 2006 that the French partner purchased the rest shares from the Singaporean and ever since then it became a French solely owned subsidiary. However, the managerial structure remained the same. During May to July 2009, five French managers were appointed to the local site by head office shortly after the first Lean Six Sigma training. They are Depute General Manger/ VP operations, Continuous Improvement Manager, Production Program Manager, Supply Chain Manger and IT Manager. The Continuous Improvement Manager is responsible for Lean Six Sigma champion, and the Depute General Manger is in a full-LSS-supporting role.

Table 1: Management team change

<table>
<thead>
<tr>
<th>Management Positions</th>
<th>Nationally before Lean Six Sigma</th>
<th>Nationally after Lean Six Sigma</th>
<th>Position change description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depute General Manager (DGM)</td>
<td>-</td>
<td>French</td>
<td>New position</td>
</tr>
<tr>
<td>Continuous Improvement Manager</td>
<td>-</td>
<td>French</td>
<td>New position</td>
</tr>
<tr>
<td>Supply Chain Manager</td>
<td>Asian</td>
<td>French</td>
<td>Contract termination with the Asian manager</td>
</tr>
<tr>
<td>Production program manager</td>
<td>Asian</td>
<td>French</td>
<td>Previous Asian manager was assigned as depute manager</td>
</tr>
<tr>
<td>IT Manager</td>
<td>Asian</td>
<td>French</td>
<td>Previous Asian manager was assigned as depute manager</td>
</tr>
<tr>
<td>Special Process Manager</td>
<td>Asian</td>
<td>Asian</td>
<td>Position no change but responsibility contracted</td>
</tr>
<tr>
<td>Machine Shop Manager</td>
<td>Asian</td>
<td>Asian</td>
<td>Position no change but responsibility contracted</td>
</tr>
<tr>
<td>Manufacturing Engineer Manager</td>
<td>Asian</td>
<td>Asian</td>
<td>Position no change but responsibility contracted</td>
</tr>
<tr>
<td>Quality Manager</td>
<td>Asian</td>
<td>Asian</td>
<td>Position no change but responsibility contracted</td>
</tr>
<tr>
<td>HSE Manager</td>
<td>Asian</td>
<td>Asian</td>
<td>Position no change but responsibility contracted</td>
</tr>
<tr>
<td>General Manager (GM)</td>
<td>Asian</td>
<td>Asian</td>
<td>No Change</td>
</tr>
<tr>
<td>Engineer Manager</td>
<td>UK</td>
<td>UK</td>
<td>No Change</td>
</tr>
<tr>
<td>HR Manager</td>
<td>Asian</td>
<td>Asian</td>
<td>No Change</td>
</tr>
<tr>
<td>Finance Manger</td>
<td>Asian</td>
<td>Asian</td>
<td>No Change</td>
</tr>
</tbody>
</table>
2.3. Summary

In this chapter, I have introduced the relationship between Lean and Six Sigma with the purpose of addressing Lean Six Sigma as a historically evolving and practically embedding methodology. Lean focuses on efficiency while Six Sigma on effectiveness. The integration of them should be generating the seamlessly powerful continuous improvement tool. However, does it mean this tool is universally powerful and adaptable? The answer is will be discussed in Chapter 5 and 6.

The history of Lean Six Sigma in MD shows that the Lean Six Sigma intervention is a comprehensive top-down approach. It is manifested in the following two aspects, the outer infrastructural core and the inner managerial core. The outer infrastructural core is equipped with the standard, mode and target from the head office directly streaming into the local site. In other words, the site LSS champion is a linear implantation from the group. The inner core is staffed with a salient management team that shifted from Asians to Europeans and the management style change from humanization to rationalization. The Asian managers in MD are generally more egalitarian in management style, with the emphasis on flexible working hours and human relations; while the French managers incline to disciplines and work efficiency - a more Lean Six Sigma style.

The historical analysis of Lean Six Sigma methodology triggered my reflection on the following way. If the popular approaches in former times, such as Lean manufacturing or Six Sigma System, could be evolved and replaced (at least partially) by Lean Six Sigma; then it is foreseeable that Lean Six Sigma, the now buzzword, should be further developed and enriched.

Maanen argues that methods without theoretical substance can be sterile, representing technical sophistication in isolation (Maanen et. al, 2007). Kilduff (2006) further advocates that a good theory comes from engagement with problems in the world, not gaps in the literature. Therefore, the question comes to finding out such “good theories” in guiding and enriching Lean Six Sigma methodology. In next chapter, four “good theories” which are
deep-rooted in human practices, namely activity theory, theory of expansive learning, developmental contradictions and zone of proximal development will be presented.
3. THEORETICAL FRAMEWORK

3.1. Theory of Expansive Learning

The theory of Expansive Learning has been developed by Engeström (1987) based on the cultural-historical activity theory (Leont’ev 1978; Engeström et. al, 1999; Sannino et al. 2009). Since its introduction, it has been applied and further developed in a large number of studies on workplace learning and organizational change (Engeström et. al, 2013).

Traditional theories incline to study organizational learning by “analyzing separately individual learning, development of cultural artifacts and collective transformations of organization” (Virkkunen & Kuutti, 2000). For instance, constructivism (Rumelhart & Norman, 1981; Gardner, 1985) argues that learning is taking place primarily in individuals in order to understand how the existed knowledge can be used. New knowledge is created by synthesizing prior experience and is utilized by reconciling with existing ideas and experience through questioning. Exploration and assessment what is already known also contributes to knowledge creation. Argyris and Schön claim that learning takes place in individuals of the organization, whose learning result must be stored in the organization’s memory. Organizational learning is defined as detecting and correcting errors, and learning is gained through questioning of the underlying objectives and policies by interaction and brainstorming (Argyris & Schön, 1978).

Theory of knowledge building (Scardamalia & Bereiter, 2006) went further by bringing about “collective efforts” of learning. Learning aims to create new knowledge and to develop more complete and coherent understandings. Practitioners learn advanced knowledge, both procedural knowledge and declarative knowledge, explicit and implicit knowledge by collaboratively engaging learners in the full process of knowledge creation, to discuss, interconnect, revise and supersede. However, the subject of learners is still confined as individuals in this theory. Nonaka and Takeuchi, the founders of knowledge creation, see learning happening in the living organism of community because of the needs to make personal tacit knowledge available to others in the organization so that the
community existing knowledge grows. Learners learn from each other by sharing knowledge that stored in others memory, but not yet explicit through a continuous dialogue between tacit knowledge to explicit knowledge following the steps of socialization, externalization, combination and internalization (Nonaka & Takeuchi, 1995).

These theories are all important and with practical application to a certain point. However, due to the lack of historical embodiment and analytical unit, they have little to explain learning process while new forms of practice are created, and organizations are transformed. Rooted cultural-historical activity theory, theory of Expansive Learning upholds the idea that learning happens by means of historically evolving expansive learning actions that together form expansive cycles. Learning is constructed during the expansive cycles. The basic model of expansive learning may be depicted as an ideal-typical cyclic sequence of epistemic learning actions (Figure3).

![Expansive Learning cycle](image)

Figure 3: Expansive Learning cycle (Engeström, 1987)

An ideal-typical expansive cycle consists of seven epistemic actions, namely questioning, analyzing, modeling, examining the new model, implementation, reflecting on and evaluating the process, and consolidating and generalizing.

The first action is the need statement. It usually happens by individual's initiative of questioning the existing norms and practices, by thinking out of the box. The second action is analyzing the situation both historically and empirically. The historical analysis
vertically traces where the situation is originated from and how it develops. The empirical analysis horizontally scrutinizes its inner systemic relations. The third action is constructing a simplified model of the new idea that potentially offers a solution to the problematic situation. The fourth action is that of examining the new model. The model is examined in order to fully grasp its dynamics, potentials and limitations. The fifth action is that of implementation. The model is implemented by means of practical applications, enrichments, and conceptual extensions. The sixth and seventh actions are those reflecting on and evaluating the process and consolidating its outcomes into a new stable form of practice.

The Lean Six Sigma project in MD proceeds by neglecting the first action, the questioning. The project comes from managers’ assignment instead of Green Belts’ questioning and urges. The team members start doing the project by defining the goals of the current problematic situation, or the improvement activity empirically, measuring the current situation by tracing its historical data and evolution and then analyzing the gap between current performance and desired goal. By analyzing, team members will gain a visualized image of how the current problematic situation has been evolved and how it is connected with other systems in the organization.

In Lean Six Sigma project, the third, fourth and fifth actions are blurred and overlapped largely. Project implementation usually takes place by means of “trial spots”. The new practices breeding from the analysis are implemented by selecting one or several operation cells as trial spots, departments instead of across the whole organization. By experimenting on these trail spots, these practices will be tested and modified. Team members could strengthen their theoretical knowledge with empirical practices in this period. The sixth and seventh actions for Lean Six Sigma project is that, after certain period of implementing new practices in the trial spots, more effort will be made on controlling the new system and generalizing the new practices to a broader level. These new practices will inevitably encounter resistance from workers who are still used to the old way of working or who suffers loss from these changes in the beginning. However, as time passes and new habits form, these new practices become ingrained in the workers.
What noteworthy here is that the cycle of expansive learning is not a universal formula of phases or stages. In fact, one probably never finds a concrete collective learning process, which would clearly follow the ideal-typical model the multiple scales of learning cycles (Engeström & Sannino 2010). The occurrence of a full-fledged expansive cycle is not common, and it typically requires concentrated effort and deliberate interventions (Engeström, 1999).

### 3.2. Third generation activity theory

Activity theory is full-named cultural historical activity theory (CHAT). It was initiated in Russia in the 1920s and 1930s by Vygotsky, Leont'ev and Luria. In the 1980s, researchers from Finland pioneered by Engeström further enriched this theory. Engeström suggests that the CHAT tradition has evolved through three generations (Engeström, 1996, Engeström, 2001). The focus of this thesis is on third generation. The first two generations will be briefly introduced as they lay foundation to the third one.

The first generation is centered around the ideas of Vygotsky, who created the idea of mediation. According to Vygotsky, an individual never reacts directly to the environment. The relationship between human agent and objects of environment is mediated by cultural means, tools and signs (Vygotsky, 1978, p. 40). The constraint of the first generation activity system is that it merely deals with individuals and little is said about collective as a whole.

Leont'ev, the representative of the second generation, developed this theory by distinguishing between collective activity and individual action. In his famous example of "primeval collective hunt" Leont'ev (1981, p. 210-213) explicated the crucial difference between an individual action and a collective activity. His construction of three-level model of activity, namely operation, action and activity is the symbol of the second generation. The bottom level operation is adaptive to physical conditions; the middle-level action is individual goal-directed, and the upper-level activity is collective object-oriented. The dynamics between these three levels are, collective activity is realized by
constellations of goal-directed action, while actions may be decomposed into (are realized by a chain of) operations. An action could become automatic with practices, thus turn into operations\(^2\).

Based on the work of Vygotsky and Leont'ev, Engeström enriched the activity theory by constructing the well-known triangular model including six components in human activity system (Figure 4) to illustrate the collective social interactions, namely subject, object, mediating-instrument, rules, community and division of labor.

![Figure 4: The structure of a human activity system (Engeström, 1978, p.78)](image)

Subject refers to the individual or sub-group whose agency is chosen as the point of view in the analysis. They are the main actors engaging in the activity in the pursuit of the object.

Instrument: Vygotsky defined two types of instruments: tools (practical tools) and signs (psychological tools). Tools are oriented outwards, towards objects while signs are oriented inwards, towards the subject (Vygotsky 1978, 55). Kuutti (1996) argues that the instrument itself is both enabling and imitating, “it empowers the subject in the transformation process with the historically collected experience and skill crystallized to it but it also restricts the interaction to be from the perspective of that particular tool or instrument only - other potential features of object remain invisible to subject”.

\(^2\) [http://lchc.ucsd.edu/mca/Paper/leontev/activity/arne2.htm](http://lchc.ucsd.edu/mca/Paper/leontev/activity/arne2.htm)
Object: The object of an activity is its true motive (Leont'ev, 1978). It is the object that “distinguishes one activity from another” (Engeström, 1987). Thus, object gives direction and purpose to an activity. An object is not an “end” in the traditional sense (Foot, 2001), rather, it is a moving target, which is never fully accomplished, as described by Engeström: “an activity system constantly generates actions through which the object of the activity is enacted and reconstructed in specific forms and contents. Nevertheless, being a horizon, the object is never fully reached or conquered. The creative potential of the activity is closely related to the search actions of object construction and redefinition” (Engeström, 1999).

Rules: Rules are used in an activity system to “regulate the subject’s actions toward an object and relations with other participants” (Foot, 2001). It could be formal and explicit, such as regulations, laws, standard manuals; or informal implicit, such as conventions, moral norms, cultural custom.

Division of labor: Division of labor sheds lights on how the responsibilities are assigned in achieving the object, including both “the horizontal division of tasks” and “the vertical division of power, positions, access to resources, and rewards” (Foot, 2001).

Community: The community includes all people who are involved in the activity with interests in the same object (Foot, 2001). It carries the meaning that an activity is carried out in a social context as a collective form.

The third generation activity theory expands the unit of analysis from a single activity system to multiple, minimally two, interacting activity systems (Figure 5). In this mode of research, the basic model is expanded to include minimally two interacting activity systems (Engeström, 2001, 2005; Engeström & Sannino, 2011).
3.3. Contradictions within and between activities

Contradiction is often regarded as problems, conflicts, arguments in daily life. Oxford dictionary defines contradiction as “a combination of statements, ideas, or features which are opposed to one another”. However, in activity theory, contradictions are judged from a more positive and holistic perspective, they “are seen as “tensions between two opposing forces and dynamics that trigger learning and development” (Ilyenkov, 1977; Leont’ev, 1978; Engeström, 1987; 2005). Contradictions are not points of failure or deficits in the activity system in which they occur, nor are obstacles to be overcome in order to achieve goals. Rather than “ending points”, they are “starting places” (Foot, 2001). In other words, contradictions are considered as driving-force for change and manifestations of innovations in activities, as pointed out by Ilyenkov - inner contradictions of an activity system are "the principle of its self- movement and (...) the form in which the development is cast" (Ilyenkov, 1977, p. 330).

Contradictions need to be seen in a historical context, as they are “historically accumulating tensions within and between activity systems”, rather than just problems or conflicts (Engeström 2001, p. 137). The analysis of contradiction is of critical importance in activity theory since the development of an activity is seen as “attempts to resolve the

http://www.helsinki.fi/cradle/chat.htm
pressing inner contradictions within the activity system” (Engeström, 2000, p. 152). Development, in turn, can be understood by “tracing disruptions, troubles, and innovations; the analysis of such data leads to hypothetical identification of the internal contradictions of the activity system” (Engeström, 1996, p. 72).

According to Engeström (1987), there are four types of contradictions areas activating in different phases of the expansive learning cycle, namely the primary contradiction, the secondary contradiction, the tertiary contradiction and the quaternary contradiction (Figure 6). They are markers to indicate misfits within and between the elements of activity, between the old and the emerging new mode of activity, and between different activities.

The primary contradiction is located within each constituent component of the central activity. It is due to the “double nature” or the genuine inner conflict between exchange value and use value within each element of activity. For instance, the primary contradiction in Lean Six Sigma project activity could exist in the object, the LSS project itself. The use value of the object is that the LSS project would offer a better chance of promotion for Green Belts. It is stipulated in the company policy that a prerequisite for being promoted to

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4 http://www.helsinki.fi/cradle/activitysystem.htm
supervisor level is getting a Green Belt certificate. The exchange value of the object, however, would be the springboard for Green Belts’ job-hopping, since the MD Green Belt certificate is well recognized among manufacturing industry and it offers Green Belts a good platform to seek better positions in other companies.

The secondary contradictions often take the form of double binds in an activity, and they emerge between two elements of an activity system (Kerosuo, 2006). The term “double bind” is originally suggested by Bateson (1972) as “a situation in which no matter what a person does, he can't win”. In activity theory, the double bind is seen as “a contradiction which uncompromisingly demands qualitatively new instruments for its resolution” (Engeström, 1987, p.175). In Lean Six Sigma project activity, one important rule is that the project should be finished within six months. However, 7 out of 8 GBs interviewed did not finish their projects on time due to various reasons, e.g., reasons from lacking of tools, inefficiency division of labor… Then the contradictions between rule and tool, rule and division of labor would be the secondary ones.

The tertiary contradiction emerges when a new form of object/motive is introduced to the central activity. It is scattered between the object/motive of the dominant form of the central activity (old) and the object/motive of a culturally more advanced form of the central activity (new). In the introduction phase of Lean Six Sigma project, when the department-based work activity is still dominated for Green Belts, it is easy to assume that the object this new activity (finishing the project) may contradict with the object of the old activity (finishing department-based work).

The quaternary contradictions are those between the central activity and its neighbor activities. The neighbor activities include object-activities, instrument-producing activities, subject-producing activities, rule-producing activities. For example, after a certain period of Lean Six Sigma practices, the LSS concept is gradually accepted, the tertiary contradiction might be not that salient, at least within Lean Six Sigma community. Instead, the Lean Six Sigma project activity becomes the central one, while the accustomed department-based work activity is becoming one neighbor activity for Green Belts.
Contradictions might still exist between these two activities, and this kind of contradictions would be the quaternary contradictions.

3.4. The zone of proximal development

The zone of proximal development originally described the potential for individual learning, especially kids’ learning. Vygotsky described the zone of proximal development as “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (Vygotsky 1978, P. 86). According to Vygotsky, the zone of proximal development defines those functions that will "mature tomorrow but are currently in an embryonic state", i.e., the 'buds' of development (Vygotsky 1978, P. 86).

However, Vygotsky's definition of zone of proximal development is itself in need of development as it offered little help with the creative processes in learning. It merely concentrated on individual development while the more meaningful collective organizational or society development was being neglected. Engeström enriched this concept by reformulation the zone of proximal development as “the distance between the present everyday actions of the individuals and the historically new form of the societal activity that can be collectively generated as a solution to the double bind potentially embedded in the everyday actions” (Engeström, 1987, P.174). The double bind is as mentioned before, a state that individual actions seem to be “no way out”- whatever he or she does is considered wrong. Transformation could only be achieved by collective activity. Thus, in effect, the zone of proximal development was re-defined as the space for expansive transformation from actions to activity (Engeström, 2000).

In expansive learning, the measure of learning is the historical space of change the organization is facing- its movement in the zone of proximal development. In the zone, there are several alternative directions and paths; it is a relatively open field of uncertainty and struggle. When analyzing the zone of proximal development in multiple activity
systems, such as Lean Six Sigma activity system in MD that includes Lean Six Sigma project, daily work, Lean Six Sigma training. It is always tricky to assign the zone, or the future vision to any of the activity system involved. One possible solution might be firstly sketching the zone of proximal development for each key activity, then creating a shared zone by means of negotiation and co-design among the activity systems.
4. LEAN SIX SIGMA PROJECT AS RESEARCH CASE

4.1. Lean Six Sigma project overview

In this section, an overall description of Lean Six Sigma project will be drawn, including LSS infrastructure, project selection and DMAIC- the five phases of LSS project. In order to give a concrete image of this methodology, an illustration of the DMAIC phases by using a LSS project in MD as an example will also be displayed.

Lean Six Sigma infrastructure

Lean Six Sigma infrastructure is composed by three hierarchical levels in MD: the leadership level, the guidance level and the operation level. The leadership level includes LSS champion, the high-level executives, usually is the General Manager or Deputy General Manager/ VP Operations. LSS sponsor includes the middle-level department managers to whom the project concerns or influences. The LSS champion forms the executive committee that provides resources to projects and audits the result and benefit by establishing the Lean Six Sigma strategy, setting projects objectives and removing barriers. The sponsor is the guardian of project execution who expects results and business impact by providing projects list, supporting and encouraging the project team, reviewing systematically projects and identifying issues for future projects.

The guidance level includes Master Black Belts and Black Belt. Master Black Belt is also assigned as continuous improvement manager and is in charge of the overall improvement projects. He guarantees that the methodology is well understood, widely deployed and properly used in the company by ensuring coherence between the group projects and local Lean Six Sigma initiatives. He also manages Black Belts and Green Belts coaching sessions and maintains Lean Six Sigma competencies. Black Belt reports directly to Master Black Belt. His main responsibility is to provide technical support to the Green Belts, monitoring and assisting Green Belt projects, conducting Lean Six Sigma training and cultivating Lean Six Sigma culture in the organization. He acts as the guardian of change.
by being 100% dedicated to projects, taking ownership for projects objectives and facilitating Lean Six Sigma deployment across the company.

The operation level is teamed with Green Belts. They are the guardian of Lean Six Sigma culture by dedicating 30% of their time on Lean Six Sigma projects, taking ownership of Lean Six Sigma objectives in their department and applying the methodology rigorously. They are with twofold identities in the company. On the one hand, they are cadre men of their own department and directly report to their department managers; on the other hand, they are required to commit 30% of working time on performing Green Belt projects and functionally report to Black Belts. Figure 7 shows the Lean Six Sigma infrastructure in MD organizational chart.

![Figure 7: MD Organization chart and Lean Six Sigma structure](image)

**Project Selection**

In MD, the Lean Six Sigma project selection is globally standardized, and it is highly appraised by the BB.

*BB: We have the standard project selection process. For example, once you have an idea, whether it can be turned into a project is decided after an overall evaluation of the feasibility, profitability, and the relationship*
to company strategy. The standardization makes the whole picture clearer. First, the project selection does not come from whatsoever; it is evaluated and the evaluation standard is globally the same. Then the types of the projects are also determined by the head office. The third one is the intellectual support, which I told you just now.

The project selection follows the principle of “from strategy to execution”. It starts with broad goals for the company such as “quality improvement”, “cost down”, “work efficiency improvement”… Those goals are then cascaded down to business units, and then to specific processes, which will be targeted as project pool. Thus, the Lean Six Sigma project selection is a top-down process, as pointed by one Black Belt, “Green Belt have no right to choose their projects”. In MD, the project is initiated by department manager in a tabular form called “Six- Pack”, including the six areas of a potential project as below.

- The impact of project on business: main impact and collateral impact need to be stated.
- Description of the problem: what is the current problem? Is there any supporting data demonstrate the problem?
- Objectives: What is the project target? By what standard the target is generated?
- Scope: Which interested parties are in and out of the project?
- Action plan and milestones: List the actions and deadlines for critical phases.
- Project team and steering committee: It includes project leader (Green Belt), sponsor (top management), and steering committee (all managers from project related department). Steering mode or the steering meeting frequencies is also clarified. The most common steering mode is weekly meeting between project team members and steering committee with the formal report; monthly among all related members for overall project progress and quarterly with VP Production.

Once completion the Six Pack form, it needs to be submitted to Lean Six Sigma executive committee for approval. Only the approved ones can be selected as Green Belt projects. This selection usually takes place during or just after Lean Six Sigma training.
DMAIC: An example of phases of Lean Six Sigma project

Lean Six Sigma project is conducted by DMAIC, an acronym representing 5 phases for problem solving, namely define, measure, analyze, improve and control. The purpose of define is to understand the problems by clearly articulate the business problem, goal, potential resources, project scope and timeline. The objective and team members are also confirmed in this phase. The purpose of measure is to objectively establish current baselines as the basis for improvement through comprehensive data collection. The purpose of analyze is to identify, validate and select root cause for elimination. A large number of potential root causes of the project problem are identified via a constellation of complex root causes analysis tools in analyze phase. The purpose of improve is to identify, test and implement a solution to the problem. Identify creative solutions to eliminate the key root causes in order to fix and prevent process problems. Finally, the control phase is to sustain the gains by monitoring the improvements to ensure continued and sustainable success.

The example chosen is “Improve 5S in machine shop aluminum cell”. It is one of the few non-technical Lean Six Sigma project. Thus, it is supposed to be more clear and understandable by general readers. Tim, the then administration supervisor in HR department is the project team leader. His team members include aluminum cell leader, machine shop supervisor, machine shop manager, Black Belt and Master Black Belt. The project started from August 2011 and ended in December 2011.

**Define phase**

In define phase, the team leader stated the problems and urges for change by collecting voice of customer and voice of business. He found that from March 2010 to August 2010 the 5S score in the Aluminum Cell was very low according the monthly audit results. The production situation was in a mass, and it affected the operators' work motivation and efficiency. In general, the company did not have a satisfactory 5S level in line with the business needs. Accordingly, they set up their project objective by using SMART principle:
improve and sustain Aluminum cell 5S score above three at the end of year 2010 and above four by June 2011.

They then scheduled the DMAIC phases into five months, starting from August to December. The project scope was delimited by including aluminum cell, HR department, maintenance department, quality department, 5S audit and cleaning process, while excluding other work cells, as well as unexpected situations. The project benefits were highlighted as supporting MD production system deployment and improving operational efficiency. The project was also expected to bring assets as the replication opportunity to other work cells, which could generate the 5S policy applicable in the entire company and cultivating continuous improvement culture.

A communication plan specified each team member’s roles and responsibilities, types of contributions (fully support, strictly implement, resource contact, coach, audit), weekly time need and communication modes (group meeting, individual face to face communication) and was agreed among team members. After completing all the above, the define phase Gate Review was held among all project related members, including project champion (VP production), project sponsor (HR manager) and team members. Tim, as the project team leader would summarize define phase findings, and what was the plan for the next step. The project champion audited the result and plan. The project could only be proceeded to the next phase with his approval.

**Measure phase**

In measure phase, Tim depicted the current state process based on IPO model (input-process-output) and collected historical data. After a preliminary analysis of process and data, the team targeted the major problems as unclear definition of tools/gauges positioning, excessive objects in working areas and label missing. They also found a big gap between auditors in scoring the same object. By adopting the Cause-and-Effect diagram, they tried to find out causes through six aspects: personal, machine, material, method, measurement and environment.
According to the impact and complexity, the causes were further classified into two categories, “quick win” and “analysis further”. The countermeasures for the quick win were taken immediately with the aid of the project sponsor; including standardization of the 5S audit process, train to the auditors, completion of missing documentation. An incentive plan for operators to sustain the 5S result was also drawn by linking the 5S audit result with their monthly bonus. Those complexity causes such as poor management of tools and gauges, excessive WIP (wait in process) required cross-departmental collaboration and process re-engineering. Thus, they would be analyzed further in the analyze phase. Before entering into the analyze phase, the Gate Review for measure phase was carried out in the same form as the define phase Gate Review.

**Analyze phase**

In analyze phase, the team then use a tool called “five why tree” to reveal the results of root cause analysis. Take the factor of “the operators have no habit of returning tools back” as an example, the first “why” would be: why the operators have no habit of returning tools back in the toolbox? It was because they had no awareness. The second why would be following the answers of the first why: why they had no awareness? It was because, 1) there was no 5S training to tell them how and why to return tools back, 2) there was no reward and punishment for these actions. Then another two whys should be followed respectively, and the corresponding answers were 1) there was no training budget allocated to 5S from HR department; 2) there were no rules to regulate these actions in operation departments. Following this logic, the team identified all the root causes of the problems found in the measure phase.

**Improve phase**

In improve phase, the team aimed to continuously tracking the quick win implementation and find the best solution for root causes. They began with charting the improvement actions implementation plan, listing the name of the issue, the quick win actions or the root cause solutions, the responsible person for the solutions and the deadline. E.g., for the factor “the operators have no habit for returning tools back”, the team added 5S training to
operators company-wide by collaboration with training department. A weekly-based meeting on reviewing the action implement status and update the action plan were agreed among production manager, supervisor and Black Belt.

A series of improvement plan actions were implemented in this phase, involving conducting 5S training to educate and motivate the operators, linking 5S score to operators’ monthly. The implementation of these improvement actions witnessed a dramatic change in working environment in aluminum cell. In December 2011, five months after the project proceeding, the 5S score for aluminum cell reached 4.1, reaching the setting target 4.0. The improve phase Gate Review was held for the closure of this phase and entrance of the last step, the control phase.

**Control phase**

In control phase, while keeping close attention to the implementation of the improvement plan, the team put more effort on standardizing and routinizing these plans. They reinforced the 5S standardization by finalizing the company 5S standard documentation, standardizing the cleaning process and the parts storage. They seek ways to improve 5S management system by updating the cell meeting agenda weekly and reviewing 5S results and 5S training on a regular basis was critical for the sustainability of the result.

A concrete control plan including all the 5S maintenance actions, the action owner, the review frequency, the reviewer, the validator and the documentation storage area were listed and approved by management team. The formulated training materials and audit documentation were:

- MD 5S Visual Management Manual (word, A4 24 Pages)
- MD 5S standard training (ppt format, 30 slides)
- Daily checklist (excel format, two pages)
- Weekly checklist (excel format, two pages)
- 5S training record (excel format, one page)
- Cleaning checklist (excel format, two pages)
In summary of the control phase, the team members validated all improvement actions, further clarified the 5S responsibility, brought new concepts and tools to support 5S sustainability, defined the audit principle and standardized the 5S rules. In the final phase Gate Review, the project team leader made a conclusion of his project; and he was certified as “Lean Six Sigma Green Belt” in January 2012, after the completion of this project.

4.2. Lean Six Sigma project activity system

As described in Chapter 3.2, the essential elements in an activity are subject, object, instruments, rules, community, division of labor and outcome. In the following, I will elaborate the elements in Lean Six Sigma project activity system and then fulfill the elements with concrete analytical contents.

Subject: Lean Six Sigma Green Belts. The Green Belts hold double identities. On the one hand, they lead their team members towards the project goal as team leader, reporting to their project sponsors; on the other hand, as the card men of their department, they are committed to their own daily work and report to their department managers. The time contribution for their projects is at least 30% of their total working time.

Object: Lean Six Sigma projects. Lean Six Sigma project is highly result-oriented. All the activities are towards the project.

Instruments (tools and signs): The main tools are Lean Six Sigma training, Lean Six Sigma methodological tools and Black Belt coaching. These are practical tools oriented outwards, toward the object, the completion of the Green Belt project. However, another important instrument, the inwards-oriented sign that is towards the subject is also with the same value. It is the subject’s sensation as a Green Belt. Generally, the employees in MD have a sense of honor being named as Green Belt. Being selected as Lean Six Sigma trainees would mean they are critical to the company, as the company is cultivating them by allocating more resources to, as well as putting more expectations on them. Compared with their colleagues, they will have a better chance to actualize their value and gain personal growth in company. It also provides the platform to displace their personal capability. It is
this sense that drives Green Belt to spare no effort for their projects. Failure in completion the Green Belt project would even bring them personal shame. I call this as “self-actualization needs” according to Maslow’s hierarchy of needs (Maslow, 1943).

Rules: The Green Belts and their team members need to meet the project target by time commitment in the form of meetings and presentations.

Community: The Lean Six Sigma Green Belt community includes project team members, stakeholders, sponsor, Master Black Belt and Black Belt.

Division of labor: In this activity system, the division of labor is made according to different work responsibilities among team members. The Green Belt will lead his/her team members while each team member is committed to make their own contribution to the project. The Black Belt is responsible for coaching the Green Belts in terms of Lean Six Sigma technical problems, such as tools selection and usage, project progress.

Outcome: Continuous improvement with more efficient and effective business process.

The Lean Six Sigma project activity can be depicted in Figure 8.

Figure 8: Lean Six Sigma project activity system
4.3. Summary

In this chapter, I have described the hierarchical structure in Lean Six Sigma (LSS) organization, the roles and responsibilities of each Lean Six Sigma member. The champion is the guardian of LSS strategy; the sponsor is the guardian of project execution; the Green Belt is the guardian of Lean Sigma culture; the Black Belt is the guardian of organizational change and the Master Black Belt is the guardian of the LSS methodology and the local champion representative. The project selection is globally standardized. It takes place during or right after Lean Six Sigma training so that the project can get started as soon as possible. The project implementation follows DMAIC phases, starting from defining the business problem and project goal, then measuring the current situation, analyzing potential root causes, and continue with improving the situation by implementing solutions, and finally controlling variation in sustaining the result.

The Lean Six Sigma activity system is depicted in the second subchapter. This lays foundation to the analysis of contradictions in LSS activity system in Chapter 6. In the next chapter, I will elicit the main research questions of this thesis, how and when the data were collected and how they were analyzed.
5. RESEARCH METHODS AND DATA

In this chapter, I will first present the research questions of this thesis. I will then introduce the method of data collection, and how they contribute to my research questions. This is followed by a de-coding process of how the data were transformed from raw data to analytical data. After that, I will introduce the methods of data analysis, namely analysis of conceptions, analysis of the discursive manifestation of contradictions, and analysis of action-activity transformation. In the end, I will summarize and evaluate the data and methods.

5.1. Research questions

As has been stated in the introduction part, the main problem in Lean Six Sigma projects of MD is an inclination towards conservative learning approach. It manifests itself in the problems of expansion in three dimensions: spatially as the learning object will not be transformed bigger and more influential, temporally as the knowledge diminishes instead of accumulating with time, and ethically in terms of the subject's failure of shouldering more meaningful job responsibilities. In order to unfold a comprehensive discussion of the problems, and find the learning prospects in this complex activity system, I have formulated my two research questions as following.

1. What are the contradictions of Lean Six Sigma project activity in MD?

2. What is the zone of proximal development in Lean Six Sigma project activity in MD?

In the first research question, the contradictions are detected by applying “the Analysis of discursive manifestations of contradictions” to examine the interviewees' discourses. They are further studied under the activity theory context by tracing the historical embodiment of the problems. This analysis looks at the historical context by focusing on the company events, cases, and policies made before that affect the LSS project activity. It is more like a “root-cause” searching process.
In the second research question, the zone of proximal development is explored in two dimensions. The first one draws on findings of the first research question by analyzing the “action-activity transformation” initiated by the LSS practitioners to cope with the contradictory situations. The second one sees through the conceptions addressing expansions during the practitioners' project experience. The zone of proximal development is not the concrete countermeasures to go beyond all the contradictions found in the first research question, but a possible zone drawn by the current developmental momentum opened up by the practitioners themselves. It is a promising area that is not yet there.

### 5.2. Interviewees and methods of data collection

The data for this thesis were collected between June and October 2013 through questionnaire and interview. I begin with my data collection by contacting the Lean Six Sigma practitioners in MD. I selected 20 potential interviewees and sent them emails individually by stating my research purposes and inquiring their interests in receiving interviews for my research data collection. I also enclosed a questionnaire with a list of deliberately selected interview questions. The purpose of sending questionnaire in advance was to help the interviewees be familiar with the interview content so that they could have better preparations; as most of the questions required recalling or summarizing. The questions are listed below.

1. Please briefly describe your LSS project. (What it was about, when it started and ended, how many people/ department were involved…)

2. Why did you choose this project? Who determined this project?

3. How well do you understand the LSS training?

4. How do you evaluate the importance of LSS training to the implementing of your LSS project?

5. Have you encountered any difficulties while doing your LSS project? What are the difficulties?
6. How did you cope with the problems? Could you give a concrete example of how you tackled with the most frustrated crux that you had during your LSS project?

7. Has the LSS project benefited your work? Have you ever implemented the LSS concept to anywhere else other than your LSS project?

8. If you had another chance to re-start your LSS project, what changes will you make?

9. Are there any follow-up actions after the completion of the LSS project?

10. What is your overall evaluation of your LSS project?

The first interview question introduces the project background, while the last concludes the interviewee’s general attitude about Lean Six Sigma project. The questions 2, 3, 4, 5 aim at the first research question (What are the contradictions of Lean Six Sigma project activity in MD?) by dissecting the relevant aspects of Lean Six Sigma project, so that a holistic data collection concerning the problems could be gained. The questions 6, 7, 8, 9 aim at the second research question (What is the zone of proximal development in Lean Six Sigma project activity in MD?) by collecting information on what the endeavors the LSS practitioners had in order to transform the current status quo and how the LSS project experience influences the participants.

After sending the emails, I got 11 respondents who were interested in providing data for my research, including 8 Green Belts, 1 Green Belt team member, 1 Black Belt and 1 Master Black Belt. I have summarized the background of interviewees in Table 2.

Table 2 indicates that the interviewees are from different hierarchical levels in the organization, including front-line operator, engineer, supervisor and manager. They are with varied educational background from vocational school to MBA, and most are holding bachelor’s degree. Four Green Belts have served rather long time in the company, almost ten years on an average, while the other four have experience less than five years on average. Most Green Belts (six out of eight) are from production unit, as this unit is the focus of Lean Six Sigma champion. Therefore, in general, the result of the respondents is
satisfactory, as the hybrid backgrounds would largely ensure a rather comprehensive analysis of the Lean Six Sigma project activity.

Table 2: Interviewees background summary

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Unit</th>
<th>Code</th>
<th>Position*</th>
<th>Join time</th>
<th>Educational background</th>
</tr>
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<td>Administration Officer</td>
<td>07-2008</td>
<td>Bachelor degree</td>
</tr>
<tr>
<td>Green Belt Team Member</td>
<td>Support</td>
<td>GBTM</td>
<td>HR Officer</td>
<td>04-2010</td>
<td>Bachelor degree</td>
</tr>
<tr>
<td>Master Black Belt</td>
<td>Lean Six Sigma</td>
<td>MBB</td>
<td>Master Black Belt</td>
<td>04-2009</td>
<td>Master degree</td>
</tr>
<tr>
<td>Black Belt</td>
<td>Lean Six Sigma</td>
<td>BB</td>
<td>Black Belt</td>
<td>05-2011</td>
<td>MBA</td>
</tr>
</tbody>
</table>

Remark: * Position means the position the interviewees had when doing the LSS project.

After collecting all the responses, I started to conduct individual thematic interview by phone according to the agreed schedule. In general, the interview followed the question sequences in the questionnaire. However, modifications such as adding or reducing certain questions were flexibly in the light of the real interaction situation. I audiotaped all the 11 interviews, then translated and transcribed all the content literally. In total, the interviews lasted 302’46”, and the transcription took up 69 pages.

There were three follow-up interviews to Black Belt, GBS2 and GBP1 when I was analyzing the second research question. These interviews were about mutual discussions and crosschecking if my understanding follows the interviewees’ original thoughts. Information on first round 11 interviews data and the second round follow-up interviews are presented in Table 3 and Table 4.
Table 3: First round interviews data collection

<table>
<thead>
<tr>
<th>S/N</th>
<th>Interviewee</th>
<th>Interview Time</th>
<th>Length</th>
<th>Project Name</th>
<th>Project duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GBP1</td>
<td>June.2013</td>
<td>20'09&quot;</td>
<td>Improve the Overall Equipment Efficiency of MAKINO</td>
<td>7 months</td>
</tr>
<tr>
<td>2</td>
<td>GBP2</td>
<td>Oct.2013</td>
<td>25'31&quot;</td>
<td>Reduction scrap rate in machine shop</td>
<td>17 months</td>
</tr>
<tr>
<td>3</td>
<td>GBP3</td>
<td>Sep. 2013</td>
<td>28'19&quot;</td>
<td>Balance high runner input for NDT</td>
<td>Not finished yet</td>
</tr>
<tr>
<td>4</td>
<td>GBP4</td>
<td>June.2013</td>
<td>20'13&quot;</td>
<td>Reduce lead time of side stay between anodise and sub-assembly</td>
<td>21 months</td>
</tr>
<tr>
<td>5</td>
<td>GBP5</td>
<td>June.2013</td>
<td>26'59&quot;</td>
<td>Floor to floor time reduction</td>
<td>15 months</td>
</tr>
<tr>
<td>6</td>
<td>GBP6</td>
<td>June.2013</td>
<td>23'08&quot;</td>
<td>Decrease the defects of chrome plating</td>
<td>9 months</td>
</tr>
<tr>
<td>7</td>
<td>GBS1</td>
<td>July.2013</td>
<td>30'15&quot;</td>
<td>Test coupon lead time reduction</td>
<td>20 months</td>
</tr>
<tr>
<td>8</td>
<td>GBS2</td>
<td>July.2013</td>
<td>29'31&quot;</td>
<td>Improve 5S in machine shop aluminium cell</td>
<td>6 months</td>
</tr>
<tr>
<td>9</td>
<td>GBTM</td>
<td>Oct.2013</td>
<td>20'23&quot;</td>
<td>Improvement of travel procedure</td>
<td>--</td>
</tr>
<tr>
<td>10</td>
<td>BB</td>
<td>Sep. 2013</td>
<td>34'11&quot;</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>11</td>
<td>MBB</td>
<td>Sep. 2013</td>
<td>44'07&quot;</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 4: Follow-up interviews data collection

<table>
<thead>
<tr>
<th>S/N</th>
<th>Interviewee</th>
<th>Interview Time</th>
<th>Length</th>
<th>Interview theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BB</td>
<td>Aug. 2014</td>
<td>11'05&quot;</td>
<td>The possible future development of LSS project activity in MS.</td>
</tr>
<tr>
<td>2</td>
<td>GBP1</td>
<td>Aug. 2014</td>
<td>5'49&quot;</td>
<td>The collective endeavors taking place between/among project teams in dealing with the same problems.</td>
</tr>
<tr>
<td>3</td>
<td>GBS2</td>
<td>Aug. 2014</td>
<td>10'46&quot;</td>
<td>The collective endeavors taking place between/among project teams in dealing with the same problems.</td>
</tr>
</tbody>
</table>

5.3. **Transforming raw data into analytical data**

The data from the first round 11 interviews are served as my main data. The data collected from three follow-up interviews are the auxiliary data. They are not transcribed as the content has already woven with the analysis. I used three steps to elicit my main data from raw data into analytical data:

Step 1: Translate and transcript the audio interview.
Step 2: Split data according to research questions. I put all meaningful content into excel sheet1, following the sequences of interview questions. The questions were put in the first row, and the answers were put in the respective column under the row. All the 11 interview contents were presented in sheet1. I then extracted contents from sheet1 that relating to research question No.1 into sheet2 and research question No.2 into sheet3.

Step 3: Find out analytical points for each research question. The analytical points were searched from sheet2 and sheet3.

In the following, I will describe these three steps in detail.

**Step 1: Translate and transcript the audio interview**

The interviews with Green Belts, Green Belt team member and Black Belt were carried out in Chinese, as they are Chinese natives. Only the one with Master Black Belt, the French, was in English. Although all the Chinese interviewees are with English language skill, I believe conducting interviews in one’s native language will enable the full expression of oneself. However, this required additional effort for translation.

In order to maximally preserve the original expressions from the interviewees, I tried my best to translate and transcript the content word-for-word. However, due to the differences of linguistic expressions, especially those slangs with cultural bearings, it would be difficult for readers to fully grasp the meaning with the word-for-word translation. I have also modified some literal translations into interpretation in a more understandable way.

My previous knowledge on the interviewees and the research object and my similar cultural background largely facilitated this translation process. This facilitation further enables me to get rich-in-content but comparatively small-in-scale set of data (69 pages of transcript). I could spare enough effort and time on carefully studying each sentence.
Step 2: Split data according to research questions

After the translation and transcription, I put all interview content from word to excel sheet1, and named it as “Interview summary”. The first horizontal row was filled up with interview questions, and corresponding answers were put into the columns under the row. I then emphasized on finding the analytical data. As explained in subchapter 5.2., the interview questions 2,3,4,5 aim at providing data for my first research question and 6, 7, 8, 9 to the second. I thus accordingly put the answers addressing to the first research question into Sheet2 and second into Sheet3.

However, this was not merely copy-paste actions, as I had to concentrate on the content of the answers, rather than the sequential number of the questions. For instance, the No.6 question (could you give a concrete example of how you tackled with the most frustrated crux that you had during your LSS project?) was designed for the second research question. I would like to know what effort the Green Belts took in coping with the most difficult problems during their projects. These efforts could be the potential stimulus or impetus towards a broader zone of proximal development. However, GBS1’s answer to this question was more emphasis on the difficulties (to the first research question) rather than efforts in transforming the difficulties (excerpts below). Therefore, this content was put in Sheet2 for analyzing the first research question.

Researcher: Could you give a concrete example of how you tackled with the most frustrated crux that you had during your LSS project?

GBS1: Errr, the most frustrated crux... Yea. Previously all the test coupons were placed in and managed by Quality department. But then they didn’t want to take charge of all the test coupons. They only wanted to accept those have already done heat-treatment. For those haven’t done treatment, they said they should not accept them. So for us (buyers), it’s a matter of where to place these test coupons after purchasing from the supplier (without heat treatment). Should we put them in MCL (a laboratory in Quality department) or in store (being in charged by
Planning Department)? If the test coupons were placed in store, the heat treatment people will go to take them from the store. This indirectly impacted my project. Because the test coupons and the raw materials should be matched one by one; if the people in charge carelessly mismatched them, it would cause big trouble. Because MCL is more experienced and knowledgeable. Therefore, in terms of the process, we choose the one which is easier in control and lower in risks.

Step 3: Find out analytical points for each research question

After the preliminary sorting, I began with splitting the content in Sheet2 and Sheet3 into analytical points. Each point should comprise a full expression of addressing to the same meaning. The search of analytical points for the first research question (what are the contradictions in Lean Six Sigma project activity in MD?) is by focusing on the discursive linguistic cues and the features behind the discussions, the stops and turns, the emotional shifts and linkages between contexts. This method will be introduced in detail in session 5.4.2. The search of analytical points addressing expansion is by focusing on words or phrases that hint potential qualitative changes brought by LSS projects. Those words/ phrases could be expanded, improve, increase, I now have realized..., I had a better/ broader view of...

Here are examples of 2 points from GBP5 and GBP6 in the data corpus of Sheet2 concerning the contradictions in LSS project activity, and 2 points from GBP1 and GBS2 in Sheet3 concerning the ZPD in LSS project activity.

GBP5: Frankly speaking, what they (refer to operators) cared was the overtime pay, the income. (...) But when I increased the production capacity, (...). It meant no OT on weekend, no OT pay. They worked almost all the time without stop and got so tired at the end of the day but eventually they even got income decreasing. Some employees even showed the extreme of being absent during my project, claiming they were sick and needed rest at home.
GBP6: It’s true that everyone was super busy. Therefore, I did the majority work. (...) Maybe they (team members) gave some advices but I did most of the work. (...) They are all busy men. (...) What they did was giving attending the meetings and giving some suggestions. They all had their own projects.

GBP5’s point is to express why his project was against by the workers while GBP6’s point is to highlight how busy his team members are.

GBP1: But when I found i needed these tools to help me during my project, I consolidated my knowledge with the help of Black Belt. So I got a better understanding of LSS by using them into practice.

GBS2: I want to say, the 5S in our company now is super good after this project [Improve 5S in machine shop aluminum cell], the 5S concept and method is transmitted to the other cells and departments. If you revisit our machine shop now, I bet you won’t believe what you will see. The plant is as clean as the Japanese plant.

GBP1’s point is that the LSS project experience enables him a deeper understanding of LSS knowledge. Thus it is a LSS knowledge increment experience. GBS2’s point is the LSS concept has been expanded to other work units by the influence of his project.

Following this principle, 61 points were found concerning the difficulties or problems in LSS project, and 20 points were found concerning the potential or possibilities in LSS project. These 81 points are my analytical data.

5.4. Methods of data analysis

Three methods are adopted in analyzing the two research questions. The methods applied against their corresponding data and research questions are displayed in Table 5.
For the first research question, I used the analysis of conceptions to categorize the 61 analytical points addressing problems and difficulties in LSS project activity into different “conceptions” (The method will be introduced in the following section, the analysis of conceptions). I then focused on the discursive features of each conception by applying the second method, the analysis of the discursive manifestations of contradictions in order to scrutinize the contradictions in Lean Six Sigma project activity.

Table 5: Research question, data and methods

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Data</th>
<th>Methods of data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the contradictions of Lean Six Sigma project activity in MD?</td>
<td>61 analytical points concerning the difficulties or problems in LSS project</td>
<td>Analysis of conceptions &amp; Analysis of discursive manifestations of contradictions</td>
</tr>
<tr>
<td>What is the zone of proximal development in Lean Six Sigma project activity in MD?</td>
<td>20 analytical points concerning the potential or possibilities in LSS project</td>
<td>Analysis of conceptions</td>
</tr>
<tr>
<td></td>
<td>3 follow-up interviews</td>
<td>Analysis of action-activity transformation</td>
</tr>
</tbody>
</table>

For the second research question, the zone of proximal development is explored in two dimensions. The first dimension is analyzed by applying the method “the analysis of conceptions” to categorize the 20 analytical points addressing potentials and possibilities into different “conceptions”. However, in this way, by paying attention to the categorized conceptions, the data are analyzed fragmentedly. Nordi (1996) suggests that looking at smaller episodes can be useful, but further attention needs to be paid to broad patterns of activity rather than narrow episodic fragments that fail to reveal the overall direction. In this vein, the second direction of the zone employed the analysis of action-activity transformation and is discussed by connecting the dots, or in other words, unfolding the condensed analytical points into full stories with contexts. Three follow-up interviews provide extra data for this analysis by introducing the contexts of transformation.

In the following, I will introduce these three methods respectively and how they would be applied to my data analysis in detail.
5.4.1 Analysis of conceptions

Conception is a relatively stable and identifiable understanding of a given phenomenon or aspect of the world. It can be separated from and contrasted with other qualitatively different understandings of the same phenomenon. The analysis of conception is explored by a qualitative research method called phenomenography which appeared in publications in the early 1980s by Ference Marton. It is the research that aims at description, analysis, and understanding of experiences (Marton, 1981). According to Marton (1986), “phenomenography is a qualitative research methodology, within the interpretivist paradigm, that investigates the qualitatively different ways in which people experience something or think about something”.

Different people experience a phenomenon in different ways, therefore, there are various ways in which people experience or understand a given phenomenon. Phenomenographers seek to identify the multiple conceptions that people have for a particular phenomenon. The conception of researchers about a given phenomenon is not the focus of the study, because the focus of phenomenographical study is about the conceptions that people have on certain phenomenon (Ornek, 2008). Its emphasis is on the description. Its data collection methods typically include close interviews with a small, purposive sample of subjects, with the researcher “working toward an articulation of the interviewee’s reflections on experience that is as complete as possible” (Marton & Booth, 1997). Marton (1981) argues that central to phenomenology is the notion of “essence”, which refers to the common, inter-subjective meaning of that aspect.

During data analysis in phenomenographic research, the researcher will identify qualitatively separate categories that describe the ways in which different people experience a different concept (Ornek, 2008). These categories can be found in interview transcriptions. Sjöström and Dahlgren (2002) expatiate upon seven steps in the analysis of conceptions in the following:

The first step is familiarization. The researcher becomes familiar to the material by means of reading through the transcripts many times.
The second step is the compilation of answers from participants to a certain question. The researcher should identify the most significant elements in answers given by participants.

The third step is a condensation, or reduction, of the individual answers to find the central parts of a dialogue.

The fourth step is preliminary grouping or classification of similar answers.

The fifth step is a preliminary comparison of categories and identification key characteristics and expressions of the different categories.

The sixth step is the naming of categories.

The seventh step is a contrastive comparison of categories. It includes a description of the character of each category and similarities between categories. Now the categories can be named and described as available conceptions.

My data analysis followed the seven steps of forming conceptions. Taking the data in sheet2 addressing research question 1 (what are the contradictions of Lean Six Sigma Green Belt project activity in MD?) for example, the first two steps are done by finding points as described in subchapter 5.3, where 61 points were found concerning the difficulties or problems in LSS project. I will again use the following two points from GBP5 and GBP6 to illustrate how conceptions are formed out of these 61 points.

*GBP5:* Frankly speaking, what they (operators) cared was the overtime pay, the income. (...) But when I increased the production capacity, (...). It meant no OT on weekend, no OT pay. They worked almost all the time without stop and got so tired at the end of the day but eventually they even got income decreasing. Some employees even showed the extreme of being absent during my project, claiming they were sick and needed rest at home.

*GBP6:* It’s true that everyone was super busy. So I did the majority work. (...) Maybe they (team members) gave some advices but I did most of the
They are all busy men. (...) What they did was giving attending the meetings and giving some suggestions. They all had their own projects.

In the third step, I summarized all the points in short sentences by focusing on the central meanings. For example, I condensed these two points stated above into following.

GBP5 in summary is: The LSS project changes the workers’ benefit.

GBP6 is: Every team member is very busy.

Through step 3, 61 concise sentences describing problems of LSS project were obtained. Then I started to categorize them according to the core meaning/words. GBP5’s core word is “change” and GBP6’s core word is “busy”. I grouped up all the points with the similar core words together, and they comprised to one preliminary “conception”. As the conceptions would be vague and confusing if only being expressed by words, I extended them into short sentences again, which should maximally cover the central meaning of all the points of this conception. Seven preliminary conceptions were formed: “cross-departmental communication”, “lack of incentive”, “low effectiveness of LSS training”, “poorly defined project scope”, “resistance to change”, “time allocation” and others. After many rounds’ of studying and sorting the responses and identifying the key characteristics of each category, I refined them and their characteristics again and again, until all the responses found their suitable categories. The refined categories are reduced from seven to five, and these are seen as conceptions. These conceptions are “They are all busy men causes inadequate time allocation”, “LSS training brings only basic awareness”, “Resistance to change as it is comfortable in old ways”, “Poorly defined project scope leads projects to an impossible mission” and “Data collection was very laborious and difficult”.

Following the same way of categorization, four conceptions were formed out of the 20 analytical points of the second research question. They are, “LSS project brings LSS skill
expansion”, “LSS project brings LSS concept expansion”, “LSS project brings work skill expansion” and “LSS project brings work concept expansion”.

5.4.2 Analysis of discursive manifestations of contradictions

Organizational change could be seen as a sequence of events around which practices are transformed following a process of resolution of contradictions (Engeström, 1987; Bonneau, 2013). In organizational change interventions, contradictions are largely manifested in discourse (Engeström & Sannino, 2011). Lean Six Sigma project activity, aiming at achieving continuous improvement, introduces projects to the current operational process, thus it is a process of organizational change with heavy-loaded contradictions.

From activity theory point of view, contradictions are seen as historical and systemic accumulated phenomena (Engeström, 2001). They cannot be directly observed and recorded, but can only be studied indirectly through their manifestations. Researchers find four types of discursive manifestations of contradictions by paying attention to the linguistic cues and expressive features, namely dilemma, conflict, critical conflict, and double bind (Engeström & Sannino, 2011).

Dilemma does not refer to the agonized mental states of the decision-maker who is faced with a difficult choice, but to aspects of socially shared beliefs” (Billig et. al, 1988). In dilemmas, socially shared representations and values oppose to one another (Billig et. al, 1988). Thus, a dilemmatic situation is fully demonstrated by the actor's expression of incompatible evaluations of the same beliefs. During discussions, it may appear by using phrases such as “yes...but...”, “from one aspect..., from the other aspect...”

Conflict occurs when the actions of one person/ group are interfering, obstructing or in some other way making another’s behavior less effective” (Tjosvold, 1997, p. 24). As a result, conflict is always paired with denying, criticizing from one person/ group to another. In verbal conflict, participants oppose the utterances, actions, or selves of one another in successive turns at talk (Vuchinich, 1990, p. 118) and by using negative words or phrases such as “no”, “I disagree”...
Critical conflicts are situations in which people face inner doubts and contradictory motives (Vasiliuk, 1988) and feel violated or guilty. Thus, it usually echoes with the personal and emotional expressions. The vivid metaphor is a useful cue in discussions.

Double bind is a situation that individuals alone feel helpless, and individual efforts are useless in changing the status quo. Practical transformation is pressingly needed through collective efforts. In this situation, the pressing rhetorical questions, such as “what can I do?”, or expressions of helplessness, such as “It is impossible for me...”, “I cannot...” is regarded as the helpful cues.

After forming the five conceptions addressing problems and difficulties in Lean Six Sigma project activity, namely, “They are all busy men causes inadequate time allocation”, “LSS training brings only basic awareness”, “Resistance to change as it is comfortable in old ways”, “Poorly defined project scope leads projects to an impossible mission” and “Data collection was very laborious and difficult”, I used four steps listed below in scrutinizing contradictions of Lean Six Sigma project activity in MD.

1. Find out linguistic cues, the expressive features of each conception.

2. Analyze the historical context to understand how the current problematic situations generate. Trace the root causes of the problems.

3. Find out incompatible factors in pairs from the findings of step 2.

4. Locate the paired factors in activity system by identifying which elements of the activity (subject, object, instrument, rule, division of labor, community) or which activity they belong to in the LSS project activity system.

5.4.3 Analysis of action-activity transformation

The actions are goal-directed and individuals initiated. The activity is object-oriented and collectively achieved. According to Leont'ev (1978), the distinction between individual goal-directed action and collective object-oriented activity is of central importance in
activity theory. Engeström (2000) points out that the collective activity is driven by a deeply communal motive, and the motive is formed when a collective need meets an object that has the potential to fulfill the need.

The zone of proximal development, as formulated by Engeström (2000), is the distance between actions embedded in the current activity with its contradictions and the foreseeable activity in which the contradictions are expansively resolved. He further clarifies the differences between the zone and the goal, claiming that the goal is a fixed end-point or end-state, while a zone is the distance or the area between the individually experienced present and the collective generated future (Engeström, 2000). Finding out the transformation from individual actions to collective activity in Lean Six Sigma project is thus of great inspiration in charting the zone of proximal development. This process follows Ilyenkov's definition of action-activity transformation in the following.

Having emerged as an individual exception from the rule in the labor of one or several men, the new form is then taken over by others, becoming in time a new universal norm (Ilyenkov 1960).

In this thesis, I used five steps in finding and analyzing action-activity transformation.

1. Examine on contradictions that are manifested as the double bind, as this is the situation when collective effort is pressingly needed, as described in session 5.4.2.

2. Find what actions the practitioners took individually in breaking the current rule that confines the activity by paying attention to the answers to the two interview questions: No.5. Have you encountered any difficulties while doing your LSS project? What are the difficulties? No.6. How did you cope with the problems? Could you give a concrete example of how you tackled with the most frustrated crux that you had during your LSS project?

3. Further delve if the actions are transmitted to a broader scale, e.g. cross LSS projects, cross departments, production units.
4. Identify if the actions involve more actors and the new actors are collectively contributing to the resolution of current problems.

5. Find out if the new form has become a universal norm (new rule in activity) or not. This defines if the foreseeable activity is realized or not. If yes, the zone is ideally transformed. If not, the distance between the actions/activity eased and the foreseeable activity in which the contradictions are expansively resolved is the place where the zone needs to be further developed.

5.5. Summary and evaluation of the methods

In this chapter, I introduced two research questions of this thesis: “What are the contradictions of Lean Six Sigma project activity in MD?” and “What is the zone of proximal development in Lean Six Sigma project activity in MD?” The data collection was combined with questionnaires and interviews from 11 Lean Six Sigma practitioners with varied backgrounds. Three follow-up interviews were carried out for further analysis of the ZPD. The audio data were transformed into analytical data by means of finding out meaningful points, which were then further categorized into conceptions.

The methods used for data analysis were analysis of conceptions and Analysis of discursive manifestations of contradictions and analysis of action-activity transformation. The analysis of conceptions was used in both research questions. For the first research question, it serves as the facilitator for further analysis of contradictions by categorizing different conceptions addressing problems. The Analysis of discursive manifestations of contradictions is further applied on this basis by the anatomy of each conception for the first research question. For the second research question, the analysis of conceptions addressing potentials and possibilities provides one dimension where the zone expands, the analysis of action-activity transformation provides another.

These three methods were selected by the virtue of the data property and the research object. As Ornek (2008) pointed out, studying the conceptions that people have on certain phenomena is the focus of phenomenographical study. As a qualitative research
framework, phenomenography is not aiming at finding the singular essence, but the variation and the architecture of this variation by define the phenomena (Walker, 1998). The aim of this method is well suited for my research purpose, which is to find the different views (concerning problems, prospects) of how different people experiencing Lean Six Sigma projects. In the following, I will unfold the advantages and limitations of these three methods, and how the limitations would be largely mitigated.

The advantage of the first method, the analysis of conceptions is that it offers effective tools for analyses of the interview data. The step-wised formation of conceptions paves the way of de-coding the vast data towards my research questions. However, as pointed out by Engeström (2007), this method tends to present thinking as static, since instability, movement, emergence and change are not easily captured. Furthermore, researchers might risk themselves into an overall mentalistic and Cartesian view if conceptions categories were separated from practical actions such as materials and discussions.

The first risk could be alleviated by designing particular interview questions on the transformation of thinking towards the same phenomenon. For example, in the interview questionnaire, two questions are designed specifically to capture the “movement, emergence and change” in conceptions. They are, “have you ever implemented the Lean Six Sigma concept to anywhere else other than your Green Belt project?” and “if you had another chance to re-start your Green Belt project, what chances will you make?” The transformation of researcher’s thinking is with the same importance; as phenomenographic data analysis, such as analysis of conceptions focuses on variations: variation in both the perceptions of the phenomenon, as experienced by the actor, in the “ways of seeing something” as experienced and described by the researcher (Pang, 2014).

The second risk, the risk of being mentalistic and Cartesian would be eliminated by repeated study of the materials and discussions. When I was categorizing the conceptions, in order to avoid being mentalistic, I used three times in categorizing the same data through comparison and reflection. The time gap in between was at least one day, so that I would not be effect by the previous way of categorization. I then compared the three times’
categorizing by retaining the same ones and modify the different ones until reaching the consensus. The conceptions were drawn upon by the concise description of each category.

For the second method, the discursive manifestations of contradictions, there are two main limitations. The first one is the limitation of the method itself, as claimed by its founders, a discursive identification of systemic contradictions is in itself only a hypothesis, to be tested and revised in practical transformative actions (Engeström & Sannino, 2011). It is in the rudimentary phase but at the same time requires cross-disciplinary knowledge and skills, such as linguistics, psychology, interview and intervention skills. The linguistic cues are very tricky to catch. Very easily, it inclines to researcher’s subjective feelings and pre-dominated self-explanation. In other words, it has a risk of losing objectiveness of the raw data. However, this limitation would be largely alleviated by concentrating on the features of the manifestation, keeping them in mind when analyzing the transcription. Having full understanding of the story context also helps to grasp the data on the right point.

The second limitation is related to the data, which are based on LSS practitioners' recall. As some projects were carried out years ago, the Green Belts might have difficulty in remembering important details. One may propose the easiest way of alleviating this constraint is to choose the most recent projects as research target. However, my presumption is that the recent deployed LSS projects could not demonstrate the expansive learning in Green Belts and the organization, as the result of expansive learning requires a rather long time to be realized. I used psychological skills to help with memory retrieval, such as creating context cues, closely questioning details of actions during the interview.

The author summarizes the third method, the analysis of action-activity transformation. It complements with the first method, the analysis of conceptions by viewing the data as a whole rather than being segmented as different conceptions. A lucid understanding of the differences between action and activity in activity theory context is a prerequisite in using this method, which makes this method as double-edged. One the one hand, it is very useful in analyzing transformational development in an activity. One the other hand, it could lead to the analysis in vain if the action and activity are not properly defined.
6. CONTRACTIONS OF LEAN SIX SIGMA PROJECT ACTIVITY

In the previous chapter, I categorized five conceptions addressing the problems and disturbances in Lean Six Sigma project activity, which are “‘They are all busy men’ causes inadequate time allocation”, “LSS training brings only basic awareness”, “Resistance to change as it is comfortable in old ways”, “Poorly defined project scope leads to an impossible mission” and “Data collection was very laborious and difficult”. The distribution of these conceptions is displayed in Figure 9. In the following, I will analyze these five conceptions in detail, aiming at answering the first research question: What are the contradictions of Lean Six Sigma Green Belt project activity in MD?

![Conception distribution](image)

**Figure 9:** Distribution of conceptions addressing problems of LSS project activity

**Conception 1: “They are all busy men” causes inadequate project time allocation**

The problem in time allocation is frequently addressed by the word “busy”, such as “it’s true that everyone was super busy”, “Yeah. They are all busy man”, “Jerome [Master Black Belt] is super busy obviously. Eugene (Black Belt) is also busy, as he also has other Green Belts to guide. machine shop manager and supervisor were very busy too”, “They are already busy with their daily work, and sometimes even need overtime for it”, “I was very very busy all the time during the DMAIC phases”… On the one hand it is the fact that
“they are all busy men”, both the Green Belts and their team members; on the other hand, Lean Six Sigma projects do require time commitment from Green Belts and team members. What was described by GBS2 in the following revealed this mismatching situation.

GBS2: At that time, Jerome (Lean Six Sigma Manager) did a lot of endeavor on Lean Six Sigma, but in reality, most people disregarded his emails and announcements and directly dragged them to the trash bin, because it was too much time-consuming. The time I had most OT (overtime) was during this period.

Lean Six Sigma project requires 30% of work time from Green Belts. Seemingly the time allocation between LSS project and department-based work is obvious - 3:7. However, in real working environment there is no such simple and clear-cut ratio for time distribution. As for project team members, there is even no stipulation about time commitment for the projects. A direct consequence of the inadequate project time allocation is the delay of the project. Some Green Belts take this as their personal problem or incapability of time management, such as GBP4 and GBS1.

Researcher: How long does your LSS project last?

GBP4: Woo, I really feel sorry to answer this question because it took me two years to finish my project. We say in the company Jerry (GBP3) is the monitor, cos his project lasted longest and I am the vice-monitor. One reason was (...) frankly speaking, it's too time consuming for everyone. The reason why this project lasted so long is actually my problem. I stopped doing my LSS project for a while. Moreover, have no good sense about time management The only pity I have for my LSS project is about the time management.

GBS1: My project was started very early, errr, it should be in April 2010. And I finished it at the end of 2011. Theoretically one LSS project should
be finished within three to six months, but my project lasted for 1.5 years. (It) was my personal reason. I had many business trips during that period thus I didn’t have enough time for this project. Also Green Belt project was only an auxiliary task to my main job responsibility, I got huge amount of other things to do.

The metaphors of “monitor” and “vice-monitor” in GBP4’s narrative and the sense of self-criticizing in both GBP4 and GBS1 are in conformity with critical conflict features, when subject is facing contradictory motives in social interaction, feeling violated or guilty (Engeström & Sannino, 2011). This feature helps to find the first contradiction; that is between the new Lean Six Sigma project activity and the conventional department-based work activity as shown in Figure 10 in red lightning arrow. This agony stems from Green Belts' double identities, as the and as the backbone of their departments simultaneously. These two identities ostracize each other in terms of Green Belts own time allocation. Although the LSS provision clearly stipulates 30% working time commitment to LSS project, in reality where can Green Belts wring 30% time when they already have almost 100% workload from their own departments?

![Figure 10: Contradiction between LSS project activity and department-based work activity](image)

Unlike GBP4 and GBS1, who blame themselves for not having enough time for projects, some other Green Belts tend to see this problem as failing to get help from team members, as “they are all busy man” too. GBP3 and GBP6 pointed out the lack of effort from team
members to their projects. The discontentment from GBP3 appeared when he divided his team members into “the good ones” and “others”.

GBP3: The team members are, well, the good ones may help you to think some ideas, but others might not even do that... So I need to do everything by myself...When you ask your team members to do something, they may be very busy with their own stuff and have no time to help you at all...it is a rather headache thing to let them do something for the project...

However, GBP6’s tone about the “busy team members” was more neutral rather than criticizing. His emphasis about “all the team members were super busy” uncovered his helpless in this situation.

GBP6: It is true that everyone was super busy. Therefore, I did the majority work. (...) Maybe they (team members) gave some advices but I did most of the work. (...) They are all busy man. (...) What they did was giving attending the meetings and giving some suggestions. They all had their own projects. There were way too many Green Belt Projects at that time, too many at one time.

The interview from Black Belt not only further augmented the difficulty for Green Belt’s time balancing, but also pointed out why this situation could not be alleviated by his own effort.

BB: The biggest one (problem) is the proceeding of the project. Our GBs are always busy, they are not able to allocate enough time on their projects... I can’t whip behind them. (...) They are already busy with their daily work, and sometimes even need overtime for it. Therefore, in this situation, if you ask them to spend more time on LSS project, I don’t think they can handle their time for it.
The notion “I can’t whip behind them” indicates the helplessness of Black Belt, since one of his main responsibility is to ensure the Green Belt project to proceed on the right time track; however, in practical he could do nothing to ensure this duty. It is not only because the Green Belts are busy, as analyzed in the first contradiction, but also he could not whip behind them, or pushing them effectively. Interestingly, the same pain also happens on Green Belts when pushing their team members to spare time on Lean Six Sigma projects. The expressions of helpless by Black Belt and Green Belt, such as “I can’t whip behind them”, “it is a rather headache thing” are clear indicators of “double bind situation”, when actors facing pressing and equally unacceptable alternatives in an activity system (Engeström & Sannino, 2011).

In order to understand the situation, it is necessary to know the organizational structure in MD. Figure 11 shows part of the organizational chart with hierarchical levels in MD, and the distribution of the Green Belts interviewed.

![Organizational Chart](image)

Figure 11: The Green Belts interviewees’ hierarchical levels in MD

Figure 11 indicates that the majority Green Belts are scattered in hierarchical level 4 and 5. Usually, they are engineers or officers whose main work is collaborating with people rather than leading people. In other words, they have very few or even no direct subordinates.
This means they could only rely on their own for their department job and LSS project. In contrast, GBP2 is the only exception among the interviewees. As the machine shop supervisor then, he led 11 cell leaders and 150 operators. Not surprisingly, he was the only person saying, “It was easy for me to proceed with the project, because at that time, most of team members were my subordinates, also I could ask my assistant to collect data and arrange meetings…”

As a French company, MD strictly follows the conventional hierarchical reporting flow. The direct supervisor or manager determines the performance evaluation of his/her subordinates, the result of which has high influence on one’s interests such as annual salary increase, promotion opportunity. The Black Belt explicitly pointed it out.

*Black Belt:* Actually everyone knows that their salary increase is determined by their direct manager, so the assignment from their direct manager is always the most priority. (...) when the managers are writing their yearly PDP(personal development plan), they have already fixed the projects that must be completed in the coming year. For example, Ben should complete project A and Jerry B...But this is still in the hand of their own managers and the final evaluation is also in the hand of the managers.

The excerpt from the interview with a Green Belt team member shed light on the same issue from different standing point.

*GBTM:* Well, I do not think this project had taken too much time from me. As I had some discussions with other team members as well, we all believed it was the team leader who spent most time. Maybe he felt unauthorized to give much work to us, he took the majority of the work. Therefore, I did not feel much pressure as a member. But as a leader, there should be a lot of pressure for him.
A successful Green Belt project or any other project requires effective collaboration among team members. The prerequisite for this effectiveness is a clearly articulated rule, under which team members follow the overall plan by team leaders and contribute their due time and effort. It is the conventional rule— the direct supervisor/ manager determines the performance evaluation of LSS project members that hinders the effectiveness of project proceeding. Therefore, Black Belt as project driver has no whip in-hand, Green Belt as project leader fell unauthorized to assign work to team members.

In sum, this “double bind” situation in team members’ time allocation to LSS project reveals the second contradiction, the one between the rule drawn by conventional department-based power distribution and the emerging LSS project, shown in Figure 12.

![Figure 12: Contradictions between old rule and LSS project activity](image)

**Conception 2: LSS training brings only basic awareness**

As described in the introduction, MD puts high attention on Lean Six Sigma training. Its training expenses account half of the company total training budget. However, my interview showed that the training effect was not satisfactory. Most Green Belts did not understand half of the training content and two of them only understood 20%. The data shows that the difficulties in understanding the training content come from three reasons, the barrier of English as training language, the complexity of Lean Six Sigma tools and the way of guidance from trainers.
The barrier of English as training language

The interview data shows that 7 out of 8 Green Belts disclosed the language constraint. The only one Green Belt (GBP5) claimed English language was not a problem for him was because “although the trainer spoke English, we have Black Belt to translate the training simultaneously”. I therefore assume 100% of Green Belts, at least those I interviewed, are with English language barrier in understanding the training. After all, not only the trainees are non-native English speakers; but also the trainers. The statement of GBS2 and GBP6 pointed out the language barrier as bottleneck of understanding the training.

**GBS2**: I do have difficulties in understanding some content. I guess 60% understanding is an optimistic estimating. You know I already have broken English myself, but in our training group, we were extremely unlucky because we had a Mexican trainer. *His accent was so terrible that I had no idea of what he's talking about. However, well he's a nice guy indeed...* You remember? We had a barbecue after the training.

**GBP6**: Language was the biggest barrier. After all, we are not native English speakers and the use of LSS tools contains a large amount of statistics calculation. Although I am very good at mathematics, it's still different to learn in English (...) the coaching from Black Belt and the knowledge I gained by myself were all very helpful. But the training, I say, helped me 10% maximum. If you don't have any idea about this area in prior and jump into it, the maximum of understanding is 30%, or even less, 20%.

GBS2’s transition from the trainer's “terrible” accent to his “nice” personality is interesting enough to sense the dilemma he faced. According to Engeström and Sannino (2011), dilemma is expressed by incompatible evaluations within the discourse of a single person. Here, the very irrelevant evaluations on the trainer's accent and personality actually indicate the dilemmatic situation GBS2 had in understanding the training.
In a mutual interactive onsite training process, language should be the knowledge carrier and facilitator. The trainer externalizes his explicit knowledge (Nonaka, 1991) to trainees through articulation. Trainees internalize new knowledge by de-coding the training content from the trainer and transforming it to their own knowledge. However, in the case of Lean Six Sigma training, language actually poses a big hurdle to trainer’ externalization and trainees’ internalization of Lean Six Sigma. For such a complicated statistical-based methodological training, it is even difficult to comprehend in one’s native languages, let alone to say conducting by non-native English trainers to non-native English trainees in English. Apparently, the importance of language to achieve successful communication is neglected in the Lean Six Sigma training.

In fact, some trainees indeed questioned training department about the language issue; some even suggested the local training agencies, which can provide expert level LSS training in Chinese. However, feedback from the managers was that for the sake of standardization, the local site could only adopt the group’s contracted partner, which was a French consultant agency located in Paris, near the head office. It indeed formalizes the training content and certification process globally; however, restrains the flexibility and adaptability of the local site. This dilemma illuminates the third contradiction, the inner contradiction of “rule” within Lean Six Sigma project activity as shown in Figure 13. The rule of arranging standardized training by head office is both a promotion and obstruction to the training quality.
The complexity of Lean Six Sigma tools

Besides the language barrier, another hurdle for Green Belts’ comprehension of Lean Six Sigma training is the complicated tools. The extracts from GBP1 and GBP5 uncover this point.

GBP1: **But as for some LSS tools, I could not fully understand them during the training process, because they are way complicated. (…) Still many tools I could not fully understand even now such as Pareto Chart, MSA…What I have used are mainly simple ones like Fish-bone diagram and Brainstorming.**

GBP5: I gained some Lean Six Sigma concepts after the training, **but for some parts I could not understand, so only awareness about the core tools of Lean Six Sigma, how to use them etc. (…) even I had training, but when I was actually doing the project, I still felt puzzled of using these tools. So I proceeded very slowly.**

GBP1 and GBP5’s problem lies in understanding the tools, and how to utilize them in their projects. Understanding these complicated tools requires one with high level of mathematical and statistical knowledge bases. Therefore, a proper educational background
is very essential. However, in MD the Lean Six Sigma training is oriented to heterogeneous groups, consisting of first-line cell leaders from vocational school, office officers in art major and engineers in science major. People with different educational backgrounds do have different levels of difficulties in understanding Lean Six Sigma tools. Engineers with solid mathematical knowledge and statistical analysis work experience would find it “not a matter” in using the tools, as stated by GBP4, “After all, I am from Engineer background and the technical thing is not a matter”. On the contrary, others may find it very hard to understand. The consequence for those non-engineers is, as claimed by some interviewees that the training merely provided them the basic concept of Lean Six Sigma, other than offered them substantial method of tools in practical project implementation.

The constant usage of “but” in GBP1 and GBP5’s narratives carries the dilemma in expressing the incompatible evaluations of those complicated tools. The dilemma reveals the fourth contradiction, the inner contradiction between the necessities of tool-using versus the difficulties of tool-grasping displayed in Figure 14 below.

![The way of guidance from trainers]

Besides dominate complains about the language, the complexities of the tools, only GBP1 and GBP5 pointed out the way of guidance from the trainer, but in quite opposite viewpoints.
GBP1: Although the trainer presented some examples, those are not very much relevant to our company case. (...) those cases are not only simple but quite irrelevant to our company situations. Probably it’s a matter of guidance from the trainer.

In terms of “the quite irrelevant cases”, GBP5 gave a different explanation in supporting the guidance of the trainer, rather than criticizing.

GBP5: We played a lot of games during the training, like drawing pigs. I still remember what the pig looks like now. It showed the interactive atmosphere. I think the reason why the trainer arranged it like this was to help the trainees to gain the Lean Six Sigma skills more easily through mutual interaction.

But when I further asked if this simplified way of demonstration was helpful for the future implementation of his project, he changed his tone and said, “Errr. Hard to answer... But I didn’t comprehend [the training] all, only a part of it”.

Originally he supposed that the guidance was designed for the trainees’ easy understanding of the training content. However, should this be accounted as effective guidance? Maybe still remembering what the pig looks like now is not the proper criteria for judging after he heard my question on how this guidance contributed to his project implementation.

The hesitation and tone transition using “but”- but I didn’t comprehend all, only a part of it-in his answer uncovered the reformulation of GBP5’s evaluation about the guidance from the trainer. This is a typical expression of dilemma, an expression or exchange of incompatible evaluations within the discourse of a single person (Engeström & Sannino, 2011). On the one hand, the trainer tried to simplify the training and at the same time mobilize the atmosphere by assigning vivid cases to trainees, such as “drawing pigs”; one the other hand, although impressive, these mutual interactions were “quite irrelevant to the company situations”, thus hardly helped in actual practices of the projects. The guidance from trainers further explained the difficulties in tools grasping. Thus, this dilemma
uncovers the fifth contradiction, the one between the LSS project activity and the LSS training activity (Figure 15). On the one hand, the trainer tried to simplify the training for trainees’ understanding; on the other hand, these trials hardly helped in actual practices of LSS projects.

![Figure 15: Contradiction between LSS project activity and LSS training activity](image)

**Conception 3: Resistance to change as it is comfortable in old ways**

It is widely accepted fact that change is everywhere at any time, and change opens up opportunities and possibilities. However, when facing a changing situation, resistance seems to be the one’s inertia even with the awareness that this change is towards to future work facilitation. The resistance of change came forth repetitively in Lean Six Sigma project activity. According to the informants’ talk about the changes bought by LSS projects, I found three types of changes that lead to resistance, namely change of work process, change of work habit and change of work benefit.

**Change of work process**

Change of work process here refers to the modification of previous technical processes or standards brought by Lean Six Sigma projects. This is the change of provision, the tangible hardware change. It usually requires collaboration and communication among technical engineers, internal and external customers and, last but not least, approval from authorities.
GBP5’s project is a typical representative of this technical standard and process change. As a manufacturing engineer, GBP5 aimed to reduce the parts’ waiting-for-processing time in his project. After the data collection and analysis, he found that the fitting cell took up the majority waiting time because the fitters polished the whole surface of the parts. “If the part needed 5 hours’ processing time, fitting took 2.5 hours”. So he decided to act on shortening the processing time of fitting by reducing fitting areas. This initiative for technical change brought him unexpected challenges.

GBP5: Those were quite headache when we dig into the technical part.(…) But it required a standard, how much should be reduced. So I invited quality engineers, Jim [Manufacturing Engineering Director] and our customer to discuss about this standard together. But the realization endeavor was very difficult. Finding out better ways of processing was technically hard too.

GBP1 further described why changing the current process by finding out “how much [the standard] should be reduced or modified” in doing his project. In order to meet the project target, he needed to change the inspection process from quality department to his own department by self-inspection.

GBP1: When we changed the process to self-inspection by our workers, it means risks in quality. In the beginning, the communication with quality guys seemed impossible. As you know, our aerospace industry always put quality first and foremost.

The words “headache” from GBP5 and “impossible” from GBP1 uncover the critical conflict in changing work process or standards. Take GBP1’s case as an example, on the one hand, in order to meet the project target which was increasing work efficiency, he needed to change the current inspection rule by shifting the inspection action from quality department to production department; on the other hand, this meant risks in quality, as the aerospace industry always put quality first and foremost.
Change of work habit

GBP1’s project gives a full display of the resistance come from the change of work habit. In order to improve the machine operation efficiency, GBP1 needed to optimize the procedures. When the machine was running, the operator had to stop and wait. He investigated the rhythm of the running time and made full use of the gap time. Through a “multiple skills training” plan along with the corresponding incentives, one worker could take charge of two or three machines. When one machine is running, the worker can operate on another machine(s). Therefore, the efficiency could be improved. Although there were “multiple skills training” and incentive plans going along with this change in order to alleviating the resistance, it was by no means smooth sailing when facing change of work habit.

GBP1: The biggest problem was the resistance of change from the operators. How to have their support through negotiation was a quite headache thing. They felt easy and comfortable when only overseeing one machine previously. Now they need to take charge of 2 or 3 machines it means they seldom have time to rest. (...) We even had some resignation from senior employees because of this.

Here the word “headache” reveals the critical conflict. The change of work habit aggravated the difficulties in GBP1’s project proceeding. The workload increase caused resignation from senior operators went against his project as new employees always needed more time for training and made more mistakes. As supplemented by GBS1, claiming that their [the workers] inherent customs, their work habits would be broke down. How to let them realize the benefit of this new process and finally accept it required a lot of investigation and proof.

Change of work benefit

The change of work benefit directly relates to the re-distribution of people’s personal interest. In the case of GBP1’s project, he compensated the operators' workload increase by
monthly incentive plan, which means the operators’ extra work got paid. Even though, he suffered from challenges and even had employee resignation. However, when it comes to decreasing of work benefit, the situation is foreseeable to be more intractable, as was in GBP5’s project.

GBP5: So the biggest problem was the resistance from the operators. Frankly speaking, what they cared was the overtime pay, the income. Previously if 100 parts were needed to produce per week according to planning, they made 80 on working days and completed the other 20 by overtime in weekend. [The pay for OT on weekend is 2-3 times of their basic salary]. But when I increased the production capacity, they had to finish 100 in working days. It meant no OT on weekend, no OT pay. They worked almost all the time without stop and got so tired at the end of the day but eventually they even got income decreasing. Some employees even showed the extreme of being absent during my project, claiming they were sick and needed rest at home.”

In his project, this extra workload brought by his project was not mitigated by any compensation. The workers in his team were not only busier but also endured from income decrease. It is not surprising to hear that “the biggest problem was the resistance from the operators”.

Based on the analysis of challenges from the above three kinds of changes, the essence lies in the impact of Lean Six Sigma project to its community. The LSS projects posed obstructions to LSS community. The change of work process diverges from the inherent quality assurance processes, thus influences the quality department. The change of work habit breaks the workers’ comfort zone, thus triggers grievance or even resignation. The change of work benefit, especially the decrease of income, further aggravated the discontentment among workers, becoming the biggest obstacles of the project. The two critical conflicts discovered in these three sources of changes uncover the sixth contradiction, the one between the object (LSS project) and the community (Figure 16).
Conception 4: Poorly defined project scope leads to "an impossible mission"

Poorly defined project scope means the iterative changes of project object or condition during project progress. It causes deadly waste in time and effort. The direct consequence is the repetitive subversion of the previous findings due to new conditioning to the project, thus making the previous effort inutility. GBP4 changed his project 3 times until the finalized one, because after a certain degree of implementation, he found the project unnecessary or impossible.

GBP4: I changed my Six Pack three times with my manager. Because after a certain degree of implementation, I found the project unnecessary or impossible, so I changed 3 times. (...) The most difficult thing was about the lead time reduction. Quite long time ago, the assembly and painting were divided into two road cards. After machining the parts will be sent to store; then from store to assembly. The WIP (waiting in process) time during this period was very long. It included the FQA (final quality assurance) inspection, the receiving by store and then sending out from the store, then painting and FQA inspection again. So the lead time was very long and it greatly affected the on-time-delivery rate. So this huge problem was decided to be included in my project. But it turned out to be an impossible mission.
Taking 19 months in completing her project, GBS1 described the twists and turns of this long process.

GBS1: When I defined my project scope in the beginning, I only included the pin of Airbus320 and Aisbus340. But later on, Eric [VP. Operations] asked me to enlarge my scope to all the test coupons in all the 5 programs, including A320, A340, A350, Falcon and Bombardier. And my head got big. (...) I really wanted to escape from Eric by holding the gate review meetings when he was out of office so that I could finish it as soon as possible. But well, what can I do, he is my boss and he has to be there...

GBP4’s articulation of “an impossible mission” as well as GBS1’s “what can I do” unbosomed their feelings of helplessness. It is a typical manifestation of double bind, according to Engeström and Sannino, when actors in the activity system facing pressing and equally unacceptable alternatives in an activity system (Engeström & Sannino2011).

Going for a deeper scrutiny, the central problem comes from the reliability and accountability of the project scope which is sketched in define phase. In MD, the project scope is defined by Green Belt’s manager before the project starts by a form called “Six Pack”. Then at the beginning of the project, in the define phase, the Green Belt would analyze the project scope in a more detailed way and this will be effective after the Gate Review meeting including champion, sponsor and team members at the end of define phase. The defined scope should be stable after define phase so that the project could proceed within a well-bounded framework.

However, there is no clear rule to guarantee the effect of the collectively defined project scope. The Gate Review at the end of define phase is more like a formality rather than affirmation. Hence, here comes the situation that a project has to restart after going through the previous phases, because it was proceeding with a vaguely defined scope. Such as in GBP4’s cases, when he recalled, “after a certain degree of implementation, I found the project unnecessary or impossible, so I changed 3 times”. Or it is because the project scope
is re-defined arbitrarily by managers as in GBS1’s case, when her project scope was expanded from the original two programs to five programs. Not surprisingly, it took GBP4 20 months to finish his project, GBS1 19 months to finish their projects.

Thus, the double bind here uncovers the contradiction between the rule and the object. The lack of the proper rule in defining the project scope is deconstructive to the LSS project progress (Figure 17).

Figure 17: Contradiction between rule and object in LSS project activity

Conception 5: Data collection was very laborious and difficult

Lean Six Sigma is characterized by speaking with data. Ensuring the reliability and sufficiency of data collection is of critical importance to the success of the project. However, this process for some Green Belts is by no mean smooth due to the practical constraints. Both GBS1 and GBP2 suffered from these constrains.

GBS1: You know, in 2008, the company didn’t use ERP, so many data for test coupon were not in the ERP system. They were only manually recorded. I have to say honestly, there are so many mismatching in the manual recordings. Therefore, it was very laborious in data collection.

GBS1’s problem was that, she needed a large amount of historical data corpus for her analysis. However, it seems impossible to get the data before year 2008, since the ERP system was not introduced to the company before then, and the manually recorded data
was neither complete nor correct. This made the data collection very laborious and difficult.

GBP2 suffered from the procedural mismatching between the data he needed for his project - 10 batches parts at one time, and the actual production capacity - 5 or 6 batches at a time. He claimed that although the missing matching in between, he could not change it, as it is “a rule of the project”. Again, this is the tool, the actual production capability of the machine that contradicts with the rule of testing 10 batches data at one time.

GBP2: I think the biggest problem then was the R&R test. I was asked to organize 10 operators to test 10 different batches of the same parts and collect the data from it. (...) However, we usually only produce 5 or 6 batches of the same products, then we produce other products. Therefore, the cycle time for 10 batches is very long. It made my data collection very difficult.

In summary, both situations, manifested by conflict in the form of actors’ criticizing and arguing unveils the eighth contradiction, the one between tool and rule in LSS project activity (Figure 18). The requirement set by the rule is beyond the availability the tool.

![Figure 18: Contradiction between tool and rule in LSS project activity](image)
Conclusion

In this chapter, I analyzed the five conceptions induced from the 61 points addressing problems and disturbances of LSS project activity. After going through the data corpus by paying close attention to the linguistic cues and discursive features of the transcription, eight contradictions in Lean Six Sigma project activity system were found out as shown in Table 6. What worth noticing here is that the ratio of conception and contradiction is not in a one-to-one relationship. For example, the first conception “they are all busy men’ causes inadequate time allocation” carries two contradictions while the second “LSS training brings only basic awareness” carries three contradictions. It is reasonable as these two conceptions comprise the majority analytical points (38) out of the total 61 points.

The first contradiction, manifested by critical conflict, is distributed between LSS project activity and department-based work activity. The fact of department-based work taking up almost 100% of Green Belts’ work time contradicts with the 30% time commitment of LSS project.

The second contradiction is manifested by double bind. It is distributed between the rule of department-based work activity and the LSS project activity. One of the distinctive rules in department-based work activity is the hierarchical power distribution and the rigorous reporting line based on so, which hinders the effectiveness of LSS project.

The third contradiction is manifested by dilemma. It is the inner contradiction of “rule” within the Lean Six Sigma project activity. The rule of arranging standardized training by head office is, on the one hand, ensures the conformity of the training quality in a global level, on the other hands, and poses difficulties to the local sites in understanding the training due to the English language barrier.

The fourth contradiction, also manifested by dilemma, is the inner contradiction between the necessities of tool-using versus the difficulties of tool-grasping in LSS project activity. Lean Six Sigma is characterized by complexes tools, and only using simple tools such as “cause and effect diagram” and “brainstorming” would render the projects to lose LSS
Table 6: Contradictions in Lean Six Sigma project activity system

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<td></td>
<td>LSS training activity</td>
<td>on the other hand, these trials hardly helped in actual practices of LSS projects.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance to change as it's comfortable in old ways</td>
<td>LSS project Vs community</td>
<td>Change of work process, work habit and work benefit brought by the object impede the community’s interests</td>
<td>critical conflict</td>
<td>facing contradictory motives in social interaction</td>
<td>“Those were quite headache…” “In the beginning the communication with quality guys seemed impossible.”</td>
</tr>
<tr>
<td>Poorly defined project scope leads an impossible mission</td>
<td>rule Vs object</td>
<td>The lack of proper rule in defining the project scope is deconstructive to the LSS project progress.</td>
<td>double bind</td>
<td>Facing pressing and equally unacceptable alternatives in an activity system, sense of helplessness.</td>
<td>“it turned out to be an impossible mission” “But well, what can I do?”</td>
</tr>
<tr>
<td>Data collection was very laborious and difficult</td>
<td>rule Vs tool</td>
<td>Requirements set by the rule go beyond the capability of existing tools.</td>
<td>conflict</td>
<td>Arguing, criticizing</td>
<td>“It was very laborious in data collection.” “It made my data collection very difficult.”</td>
</tr>
</tbody>
</table>

characteristics. However, the reality is that those tools are so recondite that few of them could be fully understood and put into use, as is described by GBS2, “(The tools) require too many advanced mathematics, they are very difficult. (...) and are essential for the project.”

The fifth contradiction lies between LSS project activity and the LSS training activity with the manifestation of dilemma. On the one hand, the trainer tried to simplify the training for
trainees’ understanding; on the other hand, these trials hardly helped in actual practices of LSS projects.

The sixth contradiction is manifested by two critical conflicts and lies between the LSS project and the community in LSS project activity. This contradiction is drawn by the third conception- resistance to change as it is comfortable in old ways. The change of work process bring turbulences to other policies and processes, the change of work habit breaks the workers’ comfort zone and the change of work benefit, further aggravated the discontentment among workers, becoming the biggest obstacles of the project.

The seventh contradiction is the inner contradiction within the “rule” of LSS project activity with the manifestation of double bind. It is in accordance with the fourth conception, namely poorly defined project scope leads “an impossible mission”. The lack of legislated rule in consolidating the project scope is one of the biggest causes of project delaying, which is against another rule – the six months’ period for a project.

The eighth contradiction manifested by conflict and drawn by the fifth conception- data collection was very laborious and difficult, is the one between tool and rule in Lean Six Sigma project activity. The requirements set by the rule for data collection go beyond the capability of the existing tools in getting the valid data.
7. ZONE OF PROXIMAL DEVELOPMENT IN LEAN SIX SIGMA PROJECT ACTIVITY

In expansive learning, the measure of learning is the expansive transformation towards the zone of proximal development (Chapter 3). In the zone, there are several alternative directions and paths; it is a relatively open field of uncertainty and struggle. In this light, the zone of proximal development of LSS project activity could be constructed from different directions by focusing on the mentality of expansive development.

In Chapter 6, I analyzed eight contradictions in Lean Six Sigma project activity system. From activity theory point of view, contradictions are considered as the driving force of expansive transformation from actions to activity. In Chapter 5, I addressed the double bind is a situation that individual alone feel helpless in changing the status quo, and transformation is pressingly needed through collective efforts. In view of this, I looked into the two double binds drawn in Chapter 7 and retrieved from the original transcription to find clues of action-activity transformation by using the method in Chapter 5.

In Chapter 5, I introduced four conceptions deducing from the 20 analytical points embodying expansion in LSS project activity. These expansions took place out of the change pressure in the disturbances of LSS project.

In the following, I will try to sketch the zone of proximal development from two dimensions, namely transformation from actions to activity, and the conceptions embracing expansion. The first dimension is explained by a case, which actualized the “action-activity” transformation in LSS project activity. The second is analyzed with the elaboration of “what expands” in the four conceptions. This chapter aims at answering the second research question, “what is the zone of proximal development in Lean Six Sigma project activity in MD?”
7.1. Transformation from actions to activity

There are two double binds identified in Chapter 6. The first one concerns the problems of team members’ time allocation to LSS project. According to the project leader, the team members do not contribute in due time since the conventional hierarchical rule in department-based work is still in dominant in the LSS project. This hinders the effectiveness of Lean Six Sigma project. The contradiction is situated between the rule drawn by conventional department-based power distribution and the LSS project activity. The second double bind relates to the constant change of project scope that makes the project proceeding very difficult. According to project procedure, the project scope should be clarified at the beginning of define phase by team members. However, there is no rule to guarantee the effect of the collectively defined project scope, which could be changed by managers in the middle of project deployment. The contradiction is between the rule and the object.

By examining the raw data and going through the three follow-up interviews, one case in GBS2’s project was found to demonstrate the action-activity transformation. In this case, the individual actions emerging out of contradictions eventually resulted in a qualitatively new mode of joint activity.

GBS2 was the administration officer when he was doing his LSS project, improving 5S in machine shop aluminum cell. He was agonized by the time balancing between his department-based work and his project. As described in the previous chapter, although the provision of Lean Six Sigma projects stipulates 30% working time is required from Green Belts; in real project implementation period, Green Belts spare much less time on their projects and still concentrate much on their daily work. When having difficulties in preceding the project during work time, many Green Belts chose to do their projects after work voluntarily. GBS2 was one of them in the beginning.

GBS2: At that time, I was the only person responsible for the whole company's administration issues, from everyday shuttle bus arrangement
to lunch delivery and plant cleaning, from office stationary booking to business airplane ticket booking, from supplier negotiation to visitors’ reception... I have my cell phone open for 24 hours because even in midnight I get calls from employees in the night shift. I just could not spare time during my work time, so I have to do it after work. I sometimes stayed 3 or 4 hours extra and sometimes even until mid-night if meeting materials were needed urgently.

However, he broke this constraint when he realized that it would not be the sustainable way of working because “if LSS projects had to be finished by large amount of OT voluntarily, there wouldn’t be people who want to do a second project in future (GBS2)”. He then initiated a discussion about this issue with his team members on how to well utilize the time allocation. One team member was the aluminum cell leader (GBP1), and he was also doing his project at that time. After discussion, they found that they spent a large amount of time on 5S data collection, especially when some data were in other departments. “It was exactly following the 2-8 principle: 80% of what we do was non value added simple repetition and recording, only 20% work requires Lean Six Sigma professional knowledge”, noted by GBS2.

After further discussion, GBS2 and GBP1 found their projects even shared an overlapped database. GBS2’s project aimed to improve the 5S in aluminum cell while GBP1, the cell leader of aluminum cell realized his project also required 5S data. In this sense, collecting data by joint effort would benefit both of them. Then they decided to hire an intern to help with the data collection. GBS2 proposed this idea to HR manager, and it was approved very soon. An intern from a local university was filled into this position. With his assistance, the updated information constructed the shared database and complemented to the two projects. These two projects finished much earlier than other projects. By reaching the project target, GBS2 took six months and GBP1 seven months, while the average project duration of others I interviewed was 13 months.
After finishing their projects, the intern was transferred to quality department to help with the quality-engineer Green Belts in sorting data and constructing shared database. Based on the platform provided by the shared database, some Green Belts in quality department created their “LSS project Q&A forum” in company intranet, a place allowing free discussion of project questions and answers, sharing data and experiences. This greatly enhanced the communication and collaboration within and between project teams. As one Green Belt pointed out, “I feel like I am not in the battle alone anymore”.

Originating from GBS2’s idea in breaking the accustomed rule of relying on OT (over-time) for LSS project, a new way of time allocation was proposed by hiring an intern to collect shared information and create shared databases. This practice was eventually spread into a multiple-interactive way of working based on the shared database in another department (Quality department). In this process, the collective effort gradually emerged and dominated in the latter phases of the LSS projects in this department. However, the initiatives created by the participants in the grassroots level only expanded in a limited scale in quality department, as it failed to reach company-wide influence.

However, I highly doubt the sustainability of this model constructed and maintained voluntarily. Lacking of the managerial support and operational mechanism is very likely to make it opportunistic rather than sustainable. In contrast, it is also difficult for the top-down oriented Lean Six Sigma practices to be deployed without the proactive initiatives in the grassroots. The confined “action-activity” transformation calls for a platform where top-down decisions meet with bottom-up ideas.

The interview with the Black Belt indicates that the Innovation Contest in MD can be seen as one platform.

The Contest is organized annually by the group to irrigate every level of the enterprise, including operations, customer support, and project management. Participants are encouraged to take part as a team, and each team can propose one or more projects in any area of activity and not just restricted to their own field. It is also highly encouraged to cooperate with external partners, e.g., suppliers, customers; international teamwork and so
on. The group highly supports the participation by highlighting that “all ideas, no matter big or small, will be awarded”. The employees see it as a place where their voices can be heard and appreciated. The group CEO describes it as “the continuous improvement of the Group’s performance by moving forward as a team”.

Due to its openness and flexibility, the Innovation Contest is actively participated by employees across varied hierarchical levels and production units. The Black Belt further emphasized the team combination with first-line operators and engineers.

**BB:** _In 2013, MD collected 59 proposals from 198 participants with more than 60% participation rate. The teams comprised by first-line operators and engineers are especially vigorous. After all, first-line operators are the practitioners of production, and they see more hidden problems in the seemingly well-planed and organized production stream._

The contest ends with the champion-selection and gift presenting; while most of the innovative ideas remain to be merely ideas. However, the ideas proposed by the Contest would be valuable references for managers' project selection for their department Green Belts as suggested by Black Belt.

**BB:** _Department managers should first look at the Innovation Contest proposals. If the proposal addresses key issues, it should be considered as a high potential LSS project. The team members who proposed would be motivated to actualize it as well._

The notion of “be motivated” addresses one important factor in organizational work transformation. In the Lean Six Sigma project that aims to bring change to the current work, the needs for change from the grassroots have already been expressed in another company-wide event, the Innovation Contest. However, the voices were not heard. The LSS project are selected by the department managers to their GBs without the awareness of the change plans the GBs had drawn before. It is believed that if managers can take the change needs from the practitioners into consideration, the motivation will be accelerated
and will be one of the most critical factors for project success. In contrast, the transformation initiated by the participants themselves will also be enhanced and expanded to a more influential scale, if the managers are motivated for supporting. Thus, the dimension of action-activity transformation, the zone of proximal development in LSS project activity is suggested towards the integrated top-down and bottom-up approach for organizational transformation. Finding a platform where the top-down decisions meet with bottom-up initiatives addressing change motivations, such as the Innovation Contest is the key.

7.2. The four conceptions embodying expansion

In the second dimension, the zone of proximal development is studied by evaluating the four conceptions addressing expansion, namely “LSS project brings LSS skill expansion”, “LSS project brings LSS concept expansion”, “LSS project brings work skill expansion” and “LSS project brings work concept expansion”. The term “LSS skill/ concept” differs from “work skill/ concept” in a way that the former emphasizes on the LSS knowledge and tools; while the latter on the broader work aspect.

Within each conception, there are two levels of expansion, the individual level and the community level. The individual level refers that the expansion happens only in Green Belts themselves, while the community level refers to the expansion happens on a broader scale and have affected other participants both in and out of the LSS projects. The points’ distribution is listed in Table 7 as below.

Table 7 shows that out of the 20 analytical points addressing potential expansion, only five demonstrate expansion in community level. In other words, the expansion takes place mainly in the individual level, in Green Belts themselves. Putting in an axis, the expansion areas can be depicted in Figure 19 below. The red area ABCD is the expansion area on the individual level, and the blue area EFG is on the community level. As we can see, the expansion in the community level is far less dramatic. It is still largely confined in the individual level. So quantitatively, the zone of proximal development is suggested to
expand towards the collection level. In the following, I will examine in each of the
collection, in order to sketch the ZPD by qualitative analysis.

Table 7: The distribution of points addressing expansion in LSS project activity

<table>
<thead>
<tr>
<th>Conception</th>
<th>Level</th>
<th>Level Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSS project brings LSS skill expansion</td>
<td>Individual level</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Community level</td>
<td>1</td>
</tr>
<tr>
<td>LSS project brings LSS concept expansion</td>
<td>Individual level</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Community level</td>
<td>0</td>
</tr>
<tr>
<td>LSS project brings work skill expansion</td>
<td>Individual level</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Community level</td>
<td>3</td>
</tr>
<tr>
<td>LSS project brings work concept expansion</td>
<td>Individual level</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Community level</td>
<td>1</td>
</tr>
<tr>
<td><strong>total points</strong>: 20</td>
<td><strong>Individual points</strong>: 15</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Community points</strong>: 5</td>
<td></td>
</tr>
</tbody>
</table>

LSS project brings work concept expansion

![Diagram](image)

Figure 19: The expansion areas in levels of individual and community

**LSS project brings LSS skill expansion**

LSS skill expansion can be understood as using LSS knowledge and tools in solving other
work problems. LSS skill expansion does not mean the vertical LSS knowledge increment
during or after the project. Instead, it refers to the horizontal LSS knowledge diffusion,
how the LSS skill is spread to other work activities. It is self-evident that the LSS training
and project experiences is a process in consolidating LSS skills and bring Green Belts a better understanding of LSS knowledge. However, if this knowledge is only confined in doing LSS project other than radically influences other activities; then the LSS knowledge fails to embrace the meaning of the expansion.

The data show that seven out of eight Green Belts demonstrate the LSS skill expansion from their project to their daily life. Five Green Belts further mentioned that the LSS tools facilitate their daily work by making them thinking more logically as addressed by GBS1.

**GBS1:** The stepwise concepts [DMAIC] are very helpful when I am doing something complex. I used LSS tools quite often in my daily life and work. They facilitate my daily work by making me thinking more logically and systematically.

GBP5 and GBP6, two previous engineers in MD, who resigned after the completion of their LSS projects, mentioned that the LSS skills they gained in MD are still very active for their current work.

**GBP5:** Now I am doing my Black Belt project in my company (he already resigned from MD after finishing his project). I am using the Lean Six Sigma knowledge from my past experience [in MD]. This reflection of the LSS project experience deeply impacted my recent three years' work.

**GBP6:** I am still using them [LSS tools] quite often. Now I am the production supervisor in my company and I use a lot of Lean Six Sigma improvement tools like VSM [value steam mapping] in my work.

The LSS knowledge expansion takes place largely in the individual level, in Green Belts work trajectory. What seldom mentioned by the Green Belts is whether/ how the LSS knowledge transcended by the project influences the broader community. Only GBP2 addressed this point.
GBS2: I want to say, the 5S in our company now is super good after this project [Improve 5S in machine shop aluminum cell], the 5S method is transmitted to the other cells and departments. If you revisit our machine shop now, I bet you won’t believe what you will see. The plant is as clean as the Japanese plant.

**LSS project brings LSS concept expansion**

LSS skill expansion is relatively easy to achieve and more apparent to identify. However, it does not tell how far this knowledge goes, or the distinctive influence the LSS project has on its practitioners. This distinctive influence could be reflected in the conceptual state that the LSS skills are used without the practitioners’ deliberateness. In other words, the LSS skills have been internalized by the practitioners, and it even “hard to avoid thinking about it” (BB).

GBS2 experienced this LSS concept expansion in work-based problem solving from “relying on intuition” to “habitual Lean Six Sigma thinking”. It is predictable that if this “habitual Lean Six Sigma thinking” is regularly practiced, it would become the “intuition” again.

GBS2: The biggest benefit for me is that when I meet problems in my work, I use LSS concept, other than merely rely on intuition. When I meet a problem, I know how to find the root cause by using “fish-bone diagram”; I know how to make immediate improvement by using “quick-win” method. I have formed the habitual Lean Six Sigma thinking.

**LSS project brings work skill expansion**

Work skills expansion means the improvement of general work ability brought by LSS project practices. Many Green Belts expressed that the project experience enabled them a broader view into the whole work process. It consolidated their general work skill that is beneficial for a long future as represented by GBP6.
GBP6: After finishing my Green Belt Project, I was more familiar with the production process, material WIP [waiting in process] time and cost accounting. It was a synergy process. I have improved my negotiation and communication skills among team members, as well as my problem solving and analyzing abilities.

Unlike the LSS skill expansion, which rarely happens in community level, the work skill expansion in community level is relatively more often. This expansion was often realized in the form of new skill trainings, which were originally developed to small experimental groups aiming at paving way for the project proceeding. However, the knowledge that was created was retained and popularized to a broader community after the project. Some trainings even became accustomed, such as the multiple skills training in GBP1’s project.

GBP1: We let one worker take charge of 2 or 3 machines. When this machine is running, he can operate on another machine(s). It is done by multiple skills training. For the new employees, when we recruited them, we told them clearly about their duties and so on. So gradually, it became a custom in our cell and many other cells are learning from us.

LSS project brings work concept expansion

The work concept expansion is also actualized in both individual and community levels. In the individual level, it is manifested by how Green Belts see their work differently through experimenting on the LSS projects. It can be the expansion of work concept on both how to do work and why to do work. In community level, it is how the community in general sees the work differently influenced by LSS projects.

GBP2’s experience witnessed the work concept expansion in individual level on “how to do work”. When he was doing his LSS project, he was the production supervisor in charge of the overall production. His concept on productivity has changed from the pursuit of production quality in each unit to the overall planning of process as inter-connected as described below.
GBP2: *It is the change of production concept.* Previously I thought the more parts we produced in one unit, the higher production efficiency. But now I have realized differently, that is, the bigger one batch is, the more waiting time the products will be, if the other processes remain the same level of productivity.

GBP5 demonstrated the work concept expansion on “why to do work”. He expounded the “future-oriented” work concept.

GBP5: *It [the LSS project] changed my concepts, my way of working. I had a broader view and better understanding of the company compared to my peers. For example, my colleagues they know their job responsibilities but now the company has changed. It needs one to think from the company strategic point of view. Some employees don't have the vision to see it; they only care about the current benefit, e.g., the monthly income. But what we care about is the future development of the company, what it will be after 3 or 5 years, or a decade, the sustainability of the company. I work for company's good future, that's why I work now.*

The community level of work concept expansion brought by LSS project only appeared in GBS2’s case. His project concerned about the 5S practices. By establishing new rules and policies, penetrating 5S concepts into work practices, his project has changed the way the whole company sees the 5S practices as described below.

GBS2: *We created many new paperwork and inspection policies, and we inspect every month. The result is directly related to the operators’ monthly bonus. You know when our 5S committee is doing the monthly inspection; the other employees are treating us like god, welcoming us by serving tea and coffee. They realized how important 5S is. But before, nobody cared about us.*
Herein, I have analyzed the four conception embodying expansion in LSS project activity. The analysis shows that LSS project experience has widely influenced the participants. The Green Belts in general had consolidated their LSS skills, and these skills were also appropriated in their daily work to improve the work efficiency. Some Green Belts achieved the LSS concept expansion by internalizing the LSS skill appropriation into “LSS habitual thinking”. The general work skills were also reinforced. The Green Belts had wider knowledge on the overall production process. The communication and negotiation skills were also improved. It was also a good chance to practice their leadership skills. Some training courses developed in the project originally for experimental units were spread to other units, and thus elevated the work skill of the community. Some Green Belts re-shaped their concept towards the overall strategy of planning work and meaningful motivation of doing work.

Engeström (2001) pinpointed that an expansive transformation is accomplished when the object is reconceptualized to embrace a radically wider horizon of possibilities than in the previous mode of the activity. Accordingly, among these four expansions, only the work concept expansion can be regarded as expansive transformation. By experiencing this expansion, Lean Six Sigma has been reconceptualized from a concrete tool that appropriates skills into a conceptual tool that builds up a vision of how to do work, a belief of why to do work.

As shown in Figure 19, the expansions are mainly addressed in the individual level inside the Green Belts themselves. Little influences are to neither the team members nor a broader community. Thus by combining both quantitative analysis of the levels of expansion and qualitative analysis of the four conceptions, the zone of proximal development in this dimension is suggested to transcend from “LSS as the concrete tool in individual skill appropriation” to “LSS as the conceptual tool in collective work reconceptualization”.

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8. CONCLUSION

In this thesis, I employed the Lean Six Sigma practices in an aircraft manufacturer as a case study to discuss the problems and prospects of Lean Six Sigma in modern industries. Unlike most of the previous LSS researches that focus on the statistical and analytical tool usage, the decrease of variations in the target system, this research attempts to explore LSS from the perspective of Expansive Learning, an innovative form of organizational learning. The purpose of this thesis is twofold. First, it identifies the contradictions in Lean Six Sigma project activity by analyzing the LSS practitioners' practical problems and disturbances during the projects through their discussions. Second, it explores the zone of proximal development of the LSS project activity by focusing on the practitioners' trials to make breakthroughs towards expansive transformations from the status quo, as well as by analyzing the conceptions, which embed expansions brought by the project experiences.

This thesis aims at answering the two research questions as below.

1. What are the contradictions of Lean Six Sigma project activity in MD?

2. What is the zone of proximal development in Lean Six Sigma project activity in MD?

8.1. Main findings

In order to find the contradictions in LSS project activity, two methods were applied innovatively, namely, the method of analysis of conceptions and the method of Analysis of discursive manifestations of contradictions. The former method was used in categorizing the conceptions addressing problems and disturbances in LSS project activity. Five such conceptions were induced, specifically, “They are all busy man causes inadequate time allocation”, “LSS training brings only basis awareness”, “Resistance to change as it is comfortable in old ways”, “Poorly defined project scope leads to an impossible mission” and “Data collection is very laborious and difficult”. The latter method was employed to each conception in tracing the contradictions by examining the linguistic cues and emotional feathers of interviewees’ discussions.
Eight contradictions manifested by three dilemmas, one conflict, two critical conflicts and two double bind were discovered in the LSS project activity in MD. Five were scattered in the project activity itself between or within varied elements of activity, and the other three were between the project activity, the department-based work activity and the LSS training activity. The analysis indicates that LSS project activity is heavily latent with contradictions. The Green Belts have encountered various problems in doing their projects. In practice, it is very difficult for Green Belts to balance how to allocate their time between the project work and their department work, as the latter still requires their full time commitment. Leading a LSS project do not decrease their department workload. However, the decrease of 30% time allocation from the same work to project work is required. The situation is aggravated when the performance evaluation is determined by the department managers other than the project managers (BB or MBB). Black Belts have no power to push the Green Belts, and Green Belts feel unauthorized to assign work to their team members. Many Green Belts proceed with their projects by working extra after work. The Green Belts' also have difficulties in understanding the training, as the training was conducted by non-native-English trainers to non-native-English trainees. The complicated statistical tools add extra hurdles to the Green Belts' knowledge acquisition and comprehension. The changes brought by the LSS projects are causing resistance from the broader community. In addition, the change of project scope in the middle and the difficulties in data collection make the completion of the project an impossible mission.

The identification of “the contradictions that need to be resolved in order to move beyond the existing contradictions” (Engeström & Sannino 2010) sheds lights on one promising zone of proximal development. In Lean Six Sigma project, in parallel with the contradictions, there also exist efforts in the form of “action-activity transformation” in moving beyond the current contradictions. As described in Chapter 7, one Green tried to break the constraints of “relying on work overtime for project progress” in his own project. By gaining support from another Green Belt, not only this contradiction was resolved by recruiting an intern externally, but a shared database represented by the “LSS project Q&A forum” was collectively created in another department in facilitating more projects.
However, this collective-participatory way of work development takes place as separate process with the management decision-making. The lack of managerial support and systematical operational mechanism may make the result opportunistic rather than sustainable.

In their book, the Change Laboratory: A Tool for Collaborative Development of Work and Education, Virkkunen and Newnham (2013) have specified the management-practitioner divide in transforming work activity as follows.

A sharp duality exists in the theories and model of carrying out transformations in organizations between management-led, top-down approaches of concept-driven change and participatory, community-centered Organization Development (OD) approach. In the previous, the process is owned by the management, which tries to sell a comprehensive new model in the implementation process to the personnel; in the latter, the personnel is involved in creating solutions, but mostly on separate problems in the activity. Management decision-making and the development of work practices take place as separate processes. (Virkkunen & Newnham, 2013, p.189)

This explains why the collective-participatory way of working, the “LSS project Q&A forum” failed to radically transform the contradictions in the top-down oriented Lean Six Sigma project activity in a broader level. It is because these two ways work separately. Thus, an integrated, rather than separated top-down and bottom-up approaches for developmental transformation is suggested to be the first dimension of ZPD in LSS project activity.

The second dimension of ZPD is discovered by analyzing the four conceptions embodying expansion in the practitioners due to the project experiences, namely, “LSS project brings LSS skill expansion”, “LSS project brings LSS concept expansion”, “LSS project brings work skill expansion” and “LSS project brings work concept expansion”.

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Through LSS project experience, the LSS skill expansion appears rather frequent. The participants appropriate their LSS knowledge and skills to the other work areas. In this sense, the LSS is a tool that is outside the participants. When they come across something complex, they will adopt LSS as it helps them to do the work more logically.

The LSS concept expansion took place only once. In this section, The LSS is a tool that is fused with the participants. The participants have gradually formed the LSS habitual thinking. It is internalized by the participants, and the LSS concept starts to expand.

Work skill expansion also appeared in a frequent rate. By doing the LSS project, the participants’ extended their knowledge and skills to multiple aspects, which could facilitate them in their general work. In order to finish the projects, the participants were required to learn other knowledge out of their realm (e.g., the process engineer learnt accounting skills), or beyond their previous work requirements (e.g., the operators’ multi-skills training). The LSS is tool that has extended its intrinsic function.

Work concept expansion brought by LSS project happens when participants have reconceptualized how to do work and why to do work. The LSS is functioned beyond the concrete tool into a conceptual tool for understanding strategic work planning and gaining long-term work motivation.

The analysis shows that LSS projects have brought both skills and concept expansions for Green Belts in multiple work fields. Some expansions have also reached a broader level, influencing the whole project team members and other work units. However, the expansion is largely confined in individual level rather than in the collective community level. Lean Six Sigma is mostly regarded as a concrete tool in skill appropriation, to help Green Belts to know what to do with the work by using LSS. The more profound concept transformation towards the way of planning work, the meaning of doing work seldom occurs in individual; and rarely in community level.
Thus in this dimension, the ZPD is the trajectory from transcending “LSS as the concrete tool in individual skill appropriation” to “LSS as the conceptual tool in collective work reconceptualization”.

In summary, the zone of proximal development in LSS project activity can be constructed by the combining the two dimensions (Figure 20), namely, the one of the “action-activity” transformation and the other of the four conceptions addressing expansions. Lean Six Sigma project activity is suggested to be ideally evolved towards the zone in which the top-down approach is integrated with the bottom-up initiative, and the Lean Six Sigma is seen as conceptual tool in shaping collective work reconceptualization of meanings in how to do work and why to do work.

![Figure 20: Zone of proximal development in LSS project activity](image)

### 8.2. The implications

Lean Six Sigma is a well-known advanced tool in process enhancement by focusing on process efficiency in a top-down approach (Hahn et al., 2000). Virkkunen and Ahonen
(2004) question the sufficiency of process enhancement in securing the grassroots’ desired competency development and brings about the idea of collective learning at the grassroots level. Engström takes a step further by advocating that the process efficiency and community building views needed to be brought into dialogue, and the key is to see processes not isolated but interacting and interfering with one another (Engström et. al, 2010).

The heavy-latent contradictions in LSS project activity have demonstrated the defects of the isolated processes in Lean Six Sigma practices. In the LSS project activity system, the department-based work activity and the LSS training activity are functioning individually without realizing the object of the LSS project activity. The LSS training is split from the project as “what learnt during the training was not used at all during the project (GBP3)”. Besides, it is “too theoretical-oriented (GBS2)”, and “quite irrelevant to the company real situation (GBP1)”. The LSS project is against with the Green Belts' department-based work, as “the LSS projects are taking up too much time from their daily work. And Green Belts are already busy with their daily work, and sometimes even need overtime for it (BB).”

Even in the LSS activity itself, the composing elements are also functioning in the isolated processes. The team members are detached from the projects as “the project leaders feel unauthorized to give much work to team members (GBTM)”, and “no one want to do the extra work (GBP4)”. The DMAIC phases are not in consistence as “the project was found unnecessary or impossible after a certain degree of implementation”(GBP4), or “the project was stopped in the middle as it turned to be a Black Belt project rather than a Green Belt project (GBP3)”. For MD, finding ways of bridging the isolated processes into an interactive system will be the key for resolving the contradictions. In Chapter 7, I have suggested the Innovation Contest as a platform where top-down decisions and bottom-up ideas gathers. Finding the integrated top-down and bottom-up approaches for developmental transformation in the organization should focus on investigating such platforms, which I call “critical transition
agent” for the cross-functional processes’ interaction. A critical transition agent in an organization such as the Innovation Contest carries the following characteristics.

- The agent itself must be relatively dynamic and sustainable so that the long-term expansive transformation can be achieved. That is to say, it should be an activity itself.
- The participants should be comprised with employees from both managerial level and operational level.
- The rule should address the meaning of transition, such as changes, improvements, better understanding…
- The outcome should be able to be retrieved.

This typical case may help organizations in reflecting on their processes by identifying or even creating the critical transition agent, which connect the seemingly “non-relevant” fragmented processes. Attention should be paid on the inner dynamics of processes.

Besides the identification of “critical transition agent”, employees’ learning initiatives and work motivation should be equally emphasized in the Lean Six Sigma practices. Seeing Lean Six Sigma as a concrete tool in enhancing work skills is not enough to cultivate the LSS culture. For organizations, instead of spending large amount of resource on the individual skill-based LSS training (e.g., MD spent half of its training budget on LSS training), more community-based activities, such as the LSS awareness trainings, the expertise experience-sharing forums are suggested to be developed and popularized to activate employees’ learning initiatives. A LSS culture would be cultivated by the collective work re-conceptualization in realizing the future-oriented vision of doing work. Naturally comes with the long-lasting work motivation.
9. EVALUATION OF RESEARCH AND FURTHER DISCUSSIONS

9.1. Validity and reliability

Validity and reliability are considered as key aspects to research and critical criteria to distinguish good research and poor research. Brink (1993) points out that “one of the key factors affecting validity and reliability in research is error” and he synthesizes four major sources of error, namely the researcher; the subjects participating in the research project; the social context and the methods of data collection and analysis. In contrast, triangulation and verification are typical strategies for improving the validity and reliability of research (Golafshani, 2003; Morse et. al, 2008). In the following, I will present how triangulation and/ or verification are applied to avoid these four major sources of error.

The researcher

According to Brink (1993), the status position of the researcher can be that of an outsider or that of a native participant group member. Researchers need to be on guard again either of the two positions, as “the outsider position could prevent the researcher from obtaining certain information and result in invalid interpretation of the data; while the native position may hinder the researcher's objectiveness and develop bias towards the research object”.

The researcher of this thesis, the author, worked in the research site for four years and thus has certain knowledge of the research topic, the Lean Six Sigma practices in the research site. However, when the research was carried out, the author already left the company. This position excludes the research from neither an outsider nor a native participant but enables the researcher to see the research object objectively and with insight.

The subjects participating in the research project

The subjects participating in the research project are eleven Lean Six Sigma practitioners from different hierarchical levels, including operator, engineer, supervisor, manager;
different Lean Six Sigma team structures, including Green Belt, Black Belt, Master Black Belt and team member; and different organizational units, including planning, production program, engineering, manufacturing, supply chain, quality, human resources. The hybrid backgrounds of participants are expected to contribute to a comprehensive and holistic research result.

Brink (1993) worries the participants may behave abnormally (Argyris 1952), and they may seek to reveal themselves in the best possible light or withhold or distort certain information. The countermeasure suggested by Leininger is that researchers need to be trusted before they will be able to obtain any accurate reliable or credible data (Leininger, 2002). The interviewee participants for this research are previous colleagues of the author. It is relatively easy to gain trust. The trust is further enhanced by the author's articulation of the purpose for the research. It is believed that the relatively sincere and authentic information from the participants is gathered, as the author no longer works in the company and the research will not affect any matter if they articulate the truth. Their articulation might be different and untrue if the author had continued the employment in the company.

**The social context**

The social context under which the data are gathered is important to the validity and the reliability of data (Brink, 1993). As individuals may behave differently under differing social circumstances, e.g., worries, doubts, unexpectedness. Therefore, construction of a comfortable context, which stimulates the natural and stress-free information delivery of the informants, is the key. For this research, the author contacted with the interviewees ahead of time to inquire their most convenient interview time. The skeleton of interview purpose and questions were also attached so that the interviewees could avoid being in an unexpected context when carrying on the interview.
The methods of data collection and analysis

Blink (1993) claims that researcher bias could be introduced by the tendency of the researchers to selectively observe and record certain data at the expense of other data.

In this thesis, two steps of triangulation are used to enhance the valid data collection and analysis. In the first step, the transcript was sent to the interviewee to cross check against misinterpretation or omission. The follow-up interviews were used when any confusions cropped up. The data analysis would not proceed until the full comprehension of the interviewees' intention. In other words, it was the data rather than author's interpretation that guided the research. The second step was by sending the preliminary analysis to another Lean Six Sigma expert in MD (not the interviewee) for validation, as this thesis concerns LSS backgrounds in both Chinese site and French headquarter, and he has LSS work experience in both places. His advices were also taken into consideration for further analysis.

In summary, the effort to ensure the validity and reliability of this thesis is made throughout the research process. It is expected that the triangulation and verification endow the credibility and reliability to the research result. The change of the author's cognition towards the LSS project activity in MD as described in the previous chapter can be as one example that this thesis, although using qualitative research methods, is not produced subjectively.

9.2. Strengths and limitations

There are two main strengths of this master's thesis. The first one is the methodical choices and the second is the empirical contributions. The innovative usage of the two research methods, the analysis of conceptions and the Analysis of discursive manifestations of contradictions enables the analysis a well-defined logical way. The author's familiarity with the research topic and research site reinforces the analyzing process and results.
From my own experience drawn by this thesis, the method of discursive manifestation of contradiction is a very effective tool in detecting contradictions. The critical point for using this method is by sensing and grasping the central meanings behind the expressions, rather than the words/ phrases expressed. The challenges would be for the researcher in how to process the data. The author's previous familiarity with the interviewees and the research object largely felicitated the data processing and analyzing. The understanding of the research topic helped to make detailed inquiries by tracing the historical evolvement of the problems in finding out the root causes, rather than just being perplexed in their literal expressions or complaints by the employees. Thus, this thesis is a deep anatomy of the contradictions of Lean Six Sigma project activity in MD, as I am not manipulated by the “linguistic cues” of the data but trying to seize the “central meanings behind the expressions”.

The second strength is that the analysis of Lean Six Sigma from organizational learning perspective which is quite rare and the adapting of expansive learning is unprecedented. As Leon (2012) points out that the previous research on LSS pays relatively little attention on learning, and even the existing studies related to this topic do not attempt to uncover the details of team-level learning. He adopts Dixon’s (1999) organizational learning cycle and Nonaka’s (1991) spiral knowledge components in discovering how the learning processes interacted with the DMAIC methodology, and the link between team learning practices and tool application.

Although Leon (2012) impressively singles out the importance of collective learning, there were three main drawbacks in his research. First, his research views Lean Six Sigma project in the organization as naturally smooth-sailing processes, without even mentioning any resistance or obstacles, let alone analyzing them to generate what have been learnt through the obstacle-struggling processes. Second, the term “team” is narrowly confined within the single project team members. How the knowledge generated within and across teams interacting with a broader scale community was neglected. Third, DMAIC is studied as fragmented processes and knowledge creation is only confined in each process. What happened in the transition phases and what knowledge is generated in the project that could
be transcended across boundaries between different levels in and across organizations (Toiviainen, 2007) remain unknown.

In view of the inadequacies of the previous studies, this thesis studied Lean Six Sigma practices by adopting activity system as unit of analysis (Virkkunen & Kuutti, 2000) and by focusing on expansive learning in the Lean Six Sigma project activity. The findings are not only applicable to LSS project but any other organizational interventions. Thus, it can be amplified to the general project management level.

The main limitation of this thesis is the quantum of data collection. Although the data collection encompasses varied LSS practitioners from very diverse backgrounds could be seen as the merit of this thesis, it also hinders the deep penetration into the overall LSS project process. When interviewing the Black Belt, he suggested, “If you want to have a thorough understanding and analysis of Lean Six Sigma project, I strongly recommend you to follow up the whole DMAIC phases”. However, it is difficult for the author to track the whole DMAIC phases during this master’s programme. The complete DMAIC phases last around six months and from the perspective of this thesis, and it is difficult to spare such a long time for the comprehensive data collection. It was also difficult to find research site to conduct the Lean Six Sigma research in Finland due to the language barrier.

9.3. Future research directions

The ethical dimension in LSS project activity is worth discussing in the future. Here “ethical dimension” refer to “the possible consequences of LSS project activity to both individual (GB) and community (company)”. In terms of GB themselves, the LSS training and project experience enable them a better understanding of the business and process and better career development opportunities. It is stipulated in the personnel policy that Green Belt certificate is a prerequisite for getting a supervisor level position. GBS2 was promoted from senior administration officer to HSE supervisor right after his project. As he described, “Because I finished this project successfully, then I was promoted to HSE [health-security-environment] department as HSE supervisor.”
However, for the company, the consequences are double-edged. On the positive side, each LSS project itself has already achieved a certain level of cost saving and/or efficiency improvement. In addition, it is likely that Green Belts will make further contributions to the company by utilizing the LSS tools and concepts in their own work fields, and by influencing others with LSS knowledge and concept as the Lean Six Sigma cultural massagers. On the downside, the fact that the GB certificate is with very high value in the job market poses the company in the risk of investing in vain as the GB could leave soon after certification. This can be worse when the GB from a critical position leaves for its competitor. It is wise for the company to balance these two sides. At least for my interviewees, four out of the eight Green Belt had already resigned from MD. Two of them resigned right after receiving GB certificate while another two stayed a few months more.

9.4. Research reflection: Is Lean Six Sigma old-fashioned?

When chosen Lean Six Sigma as my thesis topic, one of my classmates with more than a decade's work experience in many multi-national corporations joked as, "isn't Lean Six Sigma too old-fashioned?" Indeed, organizations appear to jump from one fashionable practice to another (DiMaggio & Powell, 1983; Abrahamson, 1996). The last decade has witnessed a widespread adoption of Lean Six Sigma across various industries. Along with the overwhelming applauses, concerns and criticizes start to emerge. New fashionable approaches are popping up. It seems talking about Lean Six Sigma alone is old-fashioned today.

Spector (2006) argues that Lean Six Sigma could bring initial success to companies, however, the long and lasting improvement efforts tends to grind to a halt if being used alone. He suggests another business improvement approach, the constraints management to amplify the Lean Six Sigma efforts and successful results. This proposal is overturned by Dirgo (2005) in his book "Look forward beyond Lean and Six Sigma", where he appeals a new approach named Look Forward® to integrate Lean Six Sigma and theory of constraints within a process-driven cross-functional team environment to foster a self-
perpetuating, ever-evolving continuous improvement without the need for intervention in the organization.

These new Lean Six Sigma complementary approaches, namely the constraints management and the Look Forward®, echo with Näslund's claim that at any given time, practitioners and researchers are likely to agree that older management techniques are deficient (Näslund, 2008). Based on a critical comparison of Lean and Six Sigma with the previous dominating concepts JIT (just-in-time) and TQM (total-quality-management), Näslund (2008) finds that the concepts of Lean and Six Sigma are mainly the replacement of, not the additions to the concepts of JIT and TQM. In other words, Lean Six Sigma is essentially repackaged version of the former. It is merely fad rather than real process improvement methods.

It is out of this thesis scope to argue whether Lean Six Sigma or the future versions of Lean Six Sigma are merely fads or real process improvement methods. The author also highly doubts if there exists such a self-perpetuating, ever-evolving continuous improvement method without the need of intervention in real organizations as Dirgo claims. It is more accountable to believe that the self-perpetuating, ever-evolving continuous improvement could be achieved with perpetuating and evolving expansive learning efforts (Toiviainen et al., 2012) in the organization. The fashionable names should be disregarded, while the practical content should be highly emphasized. In terms of Lean Six Sigma practices in MD, it is for sure the company still has a long way to go, as articulated by the Master Black Belt in the following.

**MBB**: MD is a new adopter to LSS. There is still huge difference compared with the world famous LSS practitioners. The main difference is between being passive and being active. In MD, LSS has no direct connection with company strategy. It only provides GB training materials. It connects GB projects with the company production, rather than integrating LSS concepts into company daily operation process. We still have a long way to go.
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