OULUN AMMATTIKORKEAKOULU

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APPLYING LEAN THINKING IN PRODUCT DEVELOPMENT

Deepening Lean Awareness and Knowhow in the Design Team for Better Quality and Throughput

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ABSTRACT

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Lean thinking is a holistic improvement philosophy which has roots in Japanese auto industry. The biggest influencer is Toyota with the operations they have been using successfully since the Second World War. The core parts of Lean are aims for waste mitigation, continuous improvement, and standardized operating mode. Lean thinking is holistic because Lean principles are expanded thorough the whole organization, and long-term target is to achieve a Lean culture in which every individual member of the organization knows the best methods for their work.

The aim of this study was to investigate improvement prospects of product development organization by introducing and practicing Lean principles. Lean thinking and methods related to it have been already in use in production side, but all the product development groups have not been comprehensively taken Lean in use. The main purpose of this thesis was to develop ways of working in a product development group, which is called as an integration team. The second important goal was to introduce Lean thinking also wider audience within the organization by including horizontal teams partially in the study. Also, middle management and quality managers have been involved in the study with interviews, brainstorming sessions, and development discussions.

The first part of the study was the current state analysis, which was examined by the interviews and surveys. The next step was to familiarize the theory behind Lean and establish a plan for implementing Lean thinking into integration team. In the empirical phase of the study the research scope was expanded to cover several product & development groups for collecting wider feedback and expanding Lean trainings for wider audience. For testing Lean theories, series of workshops were carried out for five groups and the leadership team. The feedback gathered from the workshops were used to understand the current state of the organization and plan the Lean implementation. The selected research approach was constructive approach in which the idea was to develop a construction of Lean implementation. The aim was to investigate equivalency between the current ways of working and the theory and make improvement proposals. Theoretical contribution based on the empirical observations were also analyzed.

The result of the study was a construction, which gives an opportunity to implement Lean principles and methods in wider use in product development. The results from interviews, surveys and observations revealed that product development groups including managers are ready to familiarize Lean principles for improving the organization's ways of working. Also, the feedback form practical workshops revealed that Lean tools are working very well especially in problem-solving area. The results of the study are arguing that it is possible to achieve Lean culture in the product development unit under the study if the organization is willing to invest on training and accepting the long-term aspect of Lean implementation. This requires actions especially from management, quality management and group leaders. The designer community was open for improvement actions.

Keywords: Lean thinking, Lean methods, Lean principles, quality, change management

TIIVISTELMÄ

Oulun ammattikorkeakoulu
Lean-johtamisen koulutusohjelma

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Lean-ajattelu on kokonaisvaltainen parannusfilosofia, jonka juuret ovat Japanin autoteollisuuden toimintatavoissa. Näitä toimintatapoja on erityisesti Toyota käyttänyt menestyksekkäästi aina 1950-luvulta lähtien. Leanin ytimessä on turhan tekemisen poistaminen, jatkuva parantaminen ja vakioidut toimintamallit. Leanin kokonaisvaltaisuus tarkoittaa toimintatapojen sisällyttämistä organisaation kaikkiin portaisiin ja pitkän aikavälin tavoitteena onkin saada aikaan lean-kulttuuri, jossa organisaation jokainen työntekijä tietää parhaimmat menetelmät omien tehtäviensä hoitamiseen.

Tässä opinnäytetyössä tutkittiin tuotekehityksen parissa toimivan organisaation kehittymismahdollisuuksia lean-ajattelua ja siihen liittyviä menetelmiä ja periaatteita hyödyntäen. Lean-menetelmät ovat jo organisaatiossa käytössä laajalti, mutta kaikki organisaation osastot ja pienryhmät eivät ole lean-menetelmiä vielä kattavasti hyödyntäneet. Tämän opinnäytetyön ensisijaisena tarkoituksena oli integrointi-suunnittelutiimin toimintatapojen kehittäminen lean-menetelmiä hyödyntäen. Toisena tärkeänä tavoitteena oli lean-ajattelun ja -toimintatapojen esittely laajemmallekin suunnittelijayhteisölle organisaation sisällä. Suunnitteluorganisaatioon liittyvää keskijohtoa ja laatupäälliköitä oli myöskin osallistettu haastatteluiden, aivoriihien ja kehityskeskusteluiden kautta.

Työn ensimmäinen vaihe oli integrointitiimin ja suunnitteluorganisaation nykytilan arviointi, joita kartoitettiin haastattelujen ja kyselyiden avulla. Seuraavassa vaiheessa tutustuttiin leanin käyttöönottoon liittyviin teorioihin ja laadittiin suunnitelma leanin käyttöönotosta integrointitiimissä. Empiriavaiheessa tutkimuksen kohderyhmää laajennettiin kattamaan useampi suunnitteluryhmä kattavimman palautteen saamiseksi. Teorioiden testaamiseksi lanseerattiin sarja työpajoja viidelle eri suunnittelutiimille sekä johtotiimille. Työpajoista saatua palautetta hyödynnettiin sekä nykytilan kartoitukseen että leanin käyttöönottoon liittyvään suunnitteluun. Työn tutkimusote oli konstruktiivinen tutkimus, jossa tavoitteena on luoda konstruktio lean-periaatteiden käyttöönotosta integrointitiimissä. Tutkimuksessa keskityttiin löytämään vastaavuuksia nykykäytännöistä teoriaan ja tekemään parannusehdotuksia teorioiden ja tutkimustulosten perusteella. Tutkimustulosten kontribuutiota teorioiden täydentämiseen myös analysoitiin.

Työn tuloksena saatiin aikaan konstruktio, jonka avulla lean-periaatteet ja -menetelmät on mahdollista ottaa laajempaan käyttöön sekä integrointitiimissä että laajemmaltikin suunnitteluorganisaatiossa. Haastatteluiden, kyselyiden ja havaintojen tulokset osoittivat, että suunnitteluorganisaatio johtajineen on valmis omaksumaan lean-periaatteita toiminnan parantamiseksi. Myös käytännön työpajat osoittivat lean-menetelmien toimivan erityisesti ongelmanratkaisumenetelmien osalta. Tutkimustulosten mukaan tutkimuksen kohteena olevassa tuotekehitysorganisaatiossa on mahdollista saada aikaan toimiva lean-kulttuuri, mikäli organisaatio on valmis investoimaan koulutukseen ja leanin jalkauttamiseen pitkäjänteisesti. Investointi vaatii toimia erityisesti johtoryhmältä, laatupäälliköiltä ja pienryhmien johtajilta. Henkilökunta oli yleisesti vastaanottavainen parannusehdotuksille.

Asiasanat: lean-ajattelu, lean-johtaminen, lean-toiminta, laatujohtaminen, muutosjohtaminen

CONTENTS

ABBREVIATIONS AND TERMINOLOGY

A3	Visual problem-solving method. See Chapter 2.5.4
Agile	Manifesto for Agile Software Development. Better ways of developing software by doing it and helping others do it
Autonomation	The same as Jidoka
CRA	Constructive Research Approach
DSR	Design Science Research
Genchi genbutsu	"Go and see" rule of Lean.
Hoshin Kanri	Understand the vision and align all the goals towards the vision.
HW	Hardware
Integration team	A specific Squad Group which was under the study
Iteration	Time-boxed development cycle which is typically two weeks
Ishikawa diagram	Visual problem-solving method. See Chapter 2.5.3
JIT	Just-In-Time. Taking place at the time when it is needed, and not in advance. Means the importance of the correct timing in the process.
Jidoka	Intelligent automation. Stop and fix the problem immediately when recognized. See more in Chapter 2.4.2
Kaizen	Continuous improvement
Kanban board	Visual tool for manage work at a personal or organizational level
KPI	Key Performance Indicator
Local Product Owner (LPO)	Leads the Squad and is accountable for the competence area backlog and for maximizing the value that the Squad delivers.
NVA	non-value-added
PDCA	Plan-Do-Check-Act. See Chapter 2.4.4

Squad (Agile Scrum team)	A small team of people, consisting of a (Local) Product Owner, a Scrum Master and developers. In the organization under study the Scrum team is called as Squad, which typically consist of 4–12 persons.
Squad Group	A group of Squads
Squad Group Leader (SGL)	People leader and team leader of Squad Group
Tribe	A group of Squad Groups
Tribe Leader	People leader and team leader of Tribe
TPS	Toyota Production System
TWI	Training with Industry
VA	Value-added activity

1 INTRODUCTION

1.1 Background

Lean methodology and principles are based on Lean thinking, which is a framework of transformation changes for organization. Lean thinking aims to provide a new way of organizing and planning human activities to deliver more benefits to organization and value to individuals while eliminating waste. Lean thinking and culture have evolved over the several decades after the Second World War. The roots of Lean thinking come from the Toyota Production System (TPS) with major influences from Taiichi Ohno and Eiji Toyoda (Womack et al. 2007, 48).

Nowadays Lean thinking is used worldwide in various business and industry areas. Traditionally Lean methodology and principles have been described from production point of view and service-based organizations are discussed separately. This is natural since Lean roots are coming from the traditional heavy industry and production which is described more deeply in Chapter 2.1. According to Modig & Åhlström (2013) an interest in Lean have been risen also among the service-based companies and this has been noticeable in private sector but also in public sector. Modig & Åhlström (2013) also mentions that typical Lean implementation for the companies has been realized by taking in use the Lean tools, but not focusing as considerable on teaching and studying Lean thinking behind everything. Deep understanding of Lean philosophy needs considerable effort and that is the main reason why Lean implementation for the companies are many times handled just by adapting the Lean tools without deeper understanding. (Modig & Åhlström 2013, 90–91.) Challenges for Lean implementation in service companies are further discussed in Chapter 2.7.

The aim of this thesis was to study how Lean methodology and principles could help an organization's design groups to improve throughput and quality. The main idea was not to just deploy the Lean tools, but also try to bring Lean philosophy into the awareness of the teams. The thesis was made for a product development organization, which consists of several design groups. Lean methodology and principles have been already deployed by some specific business groups within the organization, but the product development unit under the study had not yet fully deployed all the benefits of the Lean.

This thesis was concentrating to improve one of those sub-groups, which could gain value by adapting Lean principles more deeply in use. Target was to preserve already existing methodologies, which were proven to be good, and improve other areas by leveraging the Lean way and Lean thinking.

1.1 Scope and Research Goals

The sub-group in which Lean thinking was aimed to be taken in wider use is called as an integration team, which consist of 15 design engineers. The main function of this team is to integrate lower level software and hardware components to a unified top-level component, which is then further delivered to internal and external teams for further processing. The integration team is positioned in the middle of the supply chain and it plays an important role in terms of total product lead time.

Product supply chain and the scope of this thesis:

1. Intellectual property teams (**in scope, as applicable**)
2. Subsystem teams (**in scope, as applicable**)
3. Integration team and other similar teams (**main scope**)
4. External & internal post-processing teams (out of scope).

The challenges in integration team execution were originating from several sources. Although the integration team was functional and can execute the work as planned, there was still uncertainty if the process flow and methodologies were the best in class. Employees' willingness for improvement ventures and middle management vision for Lean thinking deployment were also reviewed during this study. However, the main focus was to research the possibilities of implementing Lean thinking in the product development group, since Lean has been proven to be successful in several other companies. Lean implementation should improve organizations delivery time, overall quality, customer satisfaction, and at the same time also improve employee satisfaction.

This thesis sought answers for three research questions:

1. How can management help team for increasing Lean awareness and making Lean possible?
2. What are the best practices for growing the team towards Lean way of working?
3. How to improve integration team's performance and throughput?

1.2 Research Approach

General distinction between the different research approaches is to category them under quantitative and qualitative research. Lowhorn (2007) has published an article about the both research methods as a goal for helping new researches and graduate students for selecting the best method on their study. Quantitative research uses statistical methods for making conclusions over a representative sample of the population and validate the outcomes against to a theory. The data in quantitative study is often coming from surveys, correlations studies and measures of experimental outcomes. In qualitative research the researcher seeks to explain a current situation from the group members perspective and arrive at a theory that explains the observed behavior. The data in qualitative research is collected from a smaller group for example with interviews. (Lowhorn 2007.)

Both research approaches – quantitative and qualitative – contains several sub-categories which are being used various areas like in nature sciences and social sciences. For example, qualitative research contains ethnographic research, grounded theory, illustrative case research, theory testing case research, and action research sub-categories. The main differences are coming from different approaches and contribution on theory and empirical part.

In addition to the research approaches described above, the Design Science Research (DSR) methodology was analyzed as an option for the thesis. Design Science Research is especially aimed to apply existing knowledge to solve various business problems and DSR has become popular especially in information technology. Design Science Research seeks to create innovations that defines the ideas, technical capabilities, practices and products which are designed and implemented efficiently. (Piirainen & Gonzalez 2014.)

As this thesis was not aimed to analyze laboratory experiments, statistics or other numerical data, the quantitative research was not suitable research method. Also, DSR was not seen as a good alternative since the goal was not to design any product or innovate technical capabilities. In the early phase of the study it was planned that the research would lie more on the qualitative side, and small group feedback along with empirical tests would be interesting part of the study. However, some quantitative methods like surveys have been carried out as an additional empirical input for the thesis.

The selected research approach for this thesis was a constructive research approach (CRA). The constructive research approach can be described as a way of reducing the gap between practice and science (Labro & Tuomela 2003). The aim is to produce relevant scientific theories with practical implications. This can be achieved by combining theoretical knowledge into practical problems (Kasanen et al. 1993). The constructive approach is presented in Figure 1.

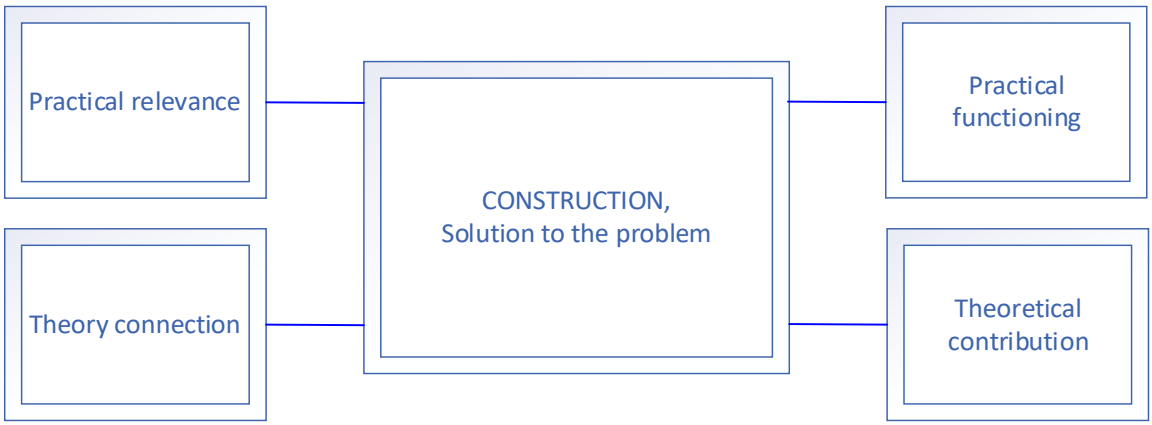

FIGURE 1. The constructive approach (Kasanen et al. 1993)

The constructive research's ultimate objective is to produce findings that can be stated in the form of technical norms (Kasanen et al. 1993, 253). As a result of constructive research's normative form, it is possible to express how one should act in the current situation in order to achieve some desired state. The same can be expressed also in the general technical norm: In order to achive a state A and the starting position is a situation B, then you ought to do X (Niiniluoto 1993, 12; Olkkonen 1993, 56). Olkkonen (1993, 56) presents this logic as: B → X → A

Lukka (1999; 2000, 114) also has suggested that constructive research approach could be treated, in addition to an autonomous approach, as a form of case/field research. He parallels it with ethnographic research, grounded theory, illustrative case research, theory testing case research, and action research. (Lukka 2000, 114.)

1.3 Theoretical Review and Structure

The thesis was structured as follows. Chapter 1 is the introduction chapter which contains the background of the thesis, scope definition, research questions and research approach. Chapter 2 introduces history and then continues with an overview of Lean philosophy. It also presents the theories behind Lean principles with a focus for the principles referred in this study. Chapter 2 then continues with the most essential theories referred this study: continuous improvement, problem-solving, learning organization and the Lean culture.

Chapter 3 presents the empire part of the study and it is divided to three sub-chapters. Chapter 3.1 briefs the main goals for the trials. Chapters 3.2 then continues by describing the empirical research process steps, and the methodologies which have been trialed for the improvements. The empirical results and improvement ideas were collected in Chapter 3.3. Chapter 4 summarizes the results and introduces critical analysis from validity, reliability, and feasibility point of view. It also contains a proposal for the next steps. Finally, Chapter 5 summarizes the content of the thesis and the gained value for the organization and author.

2 THEORY

2.1 Lean History

The roots of Lean are coming from the industry evolution by Japanese automotive manufacturers like Toyota. Lean revolution did not happen like a flash from the sky, but instead of it progressed by improving from the weaknesses which were identified in earlier production methodologies like craft work and mass production. Toyota was the key player for Lean revolution. Toyoda Automatic Loom Works Ltd. (nowadays Toyota Industries Corporation) was established in 1926. In the beginning Toyota was producing looms, which were based on Sakichi Toyoda's inventions on powered and automated looms. In 1935 Toyota introduced the first prototype of a car and mass production started in 1935. During the 1950's Toyota was suffering in their business and productivity was poor. At that time Toyota was in very difficult situation and something dramatic had to be made to avoid bankruptcy. The main influencers for the birth of Lean was Taiichi Ohno and Eiji Toyoda. Toyoda san was the founding member of Toyota motor company and Ohno san was the production manager. (Shimokawa & Fujimoto 2016; Toyota Industries Corporation 2022.)

The early years at Toyota's organization were challenging and problems were seen everywhere. Toyoda and Ohno decided to trial something extraordinary for overcoming the problems. They established "no blaming" culture in their manufacturing facilities by allowing trying and failing as many times as needed. The key object was to learn from the mistakes and try to avoid the mistakes in the next trial. This was revolutionary thinking during the 1950's. They also established improvements in management and communication. Ohno and Toyoda were of course aware of the mass production methods which were in use in Europe and USA, but they believed that the current western methodologies would not work well in Japan. This was also one reason for improving the flow for matching better the Japanese culture. However, Toyota decided to take the best pieces from other methods in use. One piece of this came from Ohno's visits to USA, where Ohno visited several factories and other facilities like supermarkets. It is being said that Ohno invented the famous Kanban board method from the supermarket. (Shimokawa & Fujimoto 2016.)

Important observation in Lean history was to understand the Toyota's way to distinguish valuable work and waste. Another remarkable difference between the previous ways of working was the Lean way for thinking about the employees and their careers. The employees were not anymore just simple executors who kept doing just one specific work. Instead of, the employees evolved multi-purpose talents who were able to do many kinds of tasks in the assembly line. Lean employees were also more committed to management visions since they felt important and valuable members in the community. (Womack et al. 2007, 12–13, 254.)

Toyota was not the only Japanese company that was using new ways for improving the production and overall producibility. American quality pioneer Edward Deming was also active lecturer after the Second World War, and he influenced especially Mazda's production at the same time when Ohno was doing improvements on Toyota's side. Thus, it can be said that Lean way of working is an interesting collection of various improvement ideas from all over the industry. Starting from the 90's Lean thinking started spreading also to other areas than auto industry. Nowadays there exists hundreds of books and articles about Lean methods and Lean thinking. Lean has become the most popular methodology for successful companies. Still none of the companies or teams or communities are automatically aware of Lean. Therefore, continuous study and research for better Lean is still needed. (Womack et al. 2007, 284–297.)

When coming to the first decades of 21st Century, some noticeable happenings from Toyota's history can be found. Toyota had crises in 2008 due to the global recession, vehicle recall campaign 2009 due to the problems with braking and earthquake with tsunami 2011. Toyota had challenges during the crises and they also made some mistakes. The Japan Headquarter for example did not let the local leaders in USA to make corrective actions, even if the local leaders had the best understanding of the local problems. So, they did not follow their own "Genchi genbutsu" i.e. "Go and see" rule, which means that the local problems should be always tried to be solved by the local employees and leaders since they are closest to the problem source. Japan Headquarter should have trusted local leaders and their ability to follow "Go and see" rule. (Liker & Convis 2012, ix.)

All in all, Toyota had challenges, but they still managed to tackle the problems by trusting the force of continuous improvement and finding the root causes for the problems. Toyota's crises showed that the organization is never completely ready for tackling all the possible problems. There is always room for continuous improvement, and this was the key takeout from Lean thinking for the future decades. (Liker & Convis 2012, ix.)

2.2 Lean Philosophy

Lean thinking as defined by Womack et al. (2003) means a way to specify value in such a way where value-creation actions are lined up in a reasonable sequence. These sequences should be conducted without any interruption and perform the actions always more and more effectively. The famous sentence for describing Lean in other words is "*Lean provides a way to do more and more with less and less – less human effort, less equipment, less time, and less space – while coming closer and closer to providing customers with exactly what they want*". (Womack et al. 2003.)

Traditionally it was commonly understood that Lean thinking can be most easily applied to conventional, discrete-product manufacturing. Reason for this was the fact that flow technics were already pioneered in such manufacturing field. However, as Womack et al. (2003) anticipates Lean thinking could be applied to any areas if management is taught to see the Lean benefits. (Womack et al. 2003.)

Lean philosophy benefits can be also described from psychology point of view. Womack et al. (2003) describes about the psychological workflow that can be achieved while the work is experienced the most rewarding. In such a mood employee knows the clear objective, concentration is so intense that not attention is leftover, there are no distractions and interruptions. Employees also needs clear and immediate feedback on the progress towards the objective. There should be also sense of challenge for the perception that one's skills are adequate to be able to cope the task at hand. In these kind of situations people might lose their self-consciousness and sense of time. In these conditions is also common that employees feel the work itself more important than the money. (Womack et al. 2003.)

The biggest influence for Lean thinking is coming from Toyota Production System (TPS). The TPS was not invented from a scratch – instead of it has been taking influences from several other industry and life areas. The biggest influences for TPS are coming from Henry Ford's writings, quality aspects from W. Edwards and TWI (Training with Industry) program from United States Army. Toyota took the best parts of every areas and embedded them to the TPS. (Liker & Convis 2012, 38–39.)

2.3 Lean Principles

The following chapters describes the main parts of Lean principles as presented in Lean Thinking (Womack et al. 2003).

2.3.1 Value and Waste

Value is the critical starting point for Lean thinking. Valuable work consists of value-created actions. Value is defined by the ultimate customer and value is created by the producer (Womack et al. 2003). The opposite definition for value is waste. If something cannot be categorized as value-added action for the customer, it is defined as waste (Poppendieck M & T 2003, 1).

It is also defined that in addition to value-added (VA) activity, and waste as non-value-added (NVA) activity, there can be also necessary non-value-added activity. The necessary non-value-added activity might be required for completing the value-added activity. (Liker 2004.)

The necessary but non-value-added activity can be abbreviated as NNVA (necessary non-value-added activity) or essential non-value-added (ENVA) activity. All types of activities can be defined in three categories as presented in Figure 2 (Eswaramurthi & Mohanram 2013, 2).

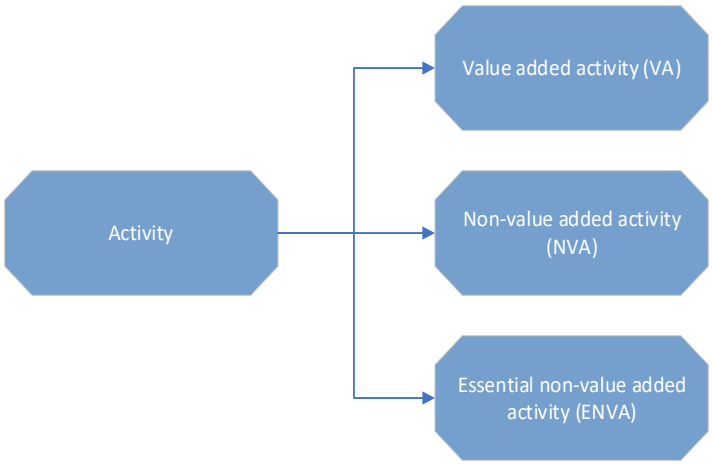

FIGURE 2. Activity defined in three categories (Liker 2004; Eswaramurthi & Mohanram 2013, 2)

Waste can be seen as something that is not immediately needed by the customer. For example, waiting, unnecessary transportation, motion and extra processing are categorized as waste, since they do not bring value for the customer. Different waste types are commonly categorized in seven categories as seen in Table 1. The categorization is based on the thoughts of Shigeo Shingo from Toyota. Even if the roots of Lean are in production and manufacturing, waste definitions can be tailored for product development purposes. Table 1 shows waste categories also for software (SW) development. (Poppendieck M & T 2003, 4.)

The work nature in integration team is close to SW development, but it cannot be exactly compared to SW industry. For example, integration team's coding style is different with many abstraction levels and feedback cycle of the defects is significantly longer than in traditional SW development. Despite of that, integration teams work can be categorized similarly as SW development, but the details of the categories are different.

TABLE 1. The seven wastes of manufacturing and software development (Poppendieck M & T 2003, 4)

The Seven Wastes of Manufacturing	The Seven Wastes of Software Development
Inventory	Partially Done Work
Extra Processing	Extra Processes
Overproduction	Extra Features
Transportation	Task Switching
Waiting	Waiting
Motion	Motion
Defects	Defects

The examples of seven wastes in software development can be found in Appendix 6 as presented by Tom & Mary Poppendieck (2003).

2.3.2 **The Value Stream**

The value stream means a set of specific actions which are processed in order to bring specific product or service thought the critical management tasks in any business (Womack et al. 2003, 19). Womack et al. (2003, 19) have defined the tasks as follows:

1. Problem-solving task. This means a task that is required to run the concept through detailed design or engineering work to product launch.
2. Information management task. This task means the process from order-taking through the detailed scheduling to the delivery.
3. Physical transformation task from processing raw materials to a finished product for the customers.

Once there has been gained understanding of the value and waste, the next step in Lean thinking is to identify the value stream. Value stream mapping helps to identify the different type of activities as presented in Figure 2. (Womack et al. 2003, 20.)

Important aspect for the value, value stream, and waste is to make everything measurable. If something cannot be measured, then it cannot be controlled. If something cannot be analyzed or identified, it cannot be challenged or improved. (Womack et al. 2003, 37.)

According to the research results from auto industry by Womack et al. (2003) they discovered that benchmarking against the others is not the most effective way for the success. Instead of it might be waste of time if the leaders have understood Lean thinking principles. One should focus on eliminating waste and seeking for perfection instead of benchmarking own work for the others. (Womack et al. 2003, 48–49.)

2.3.3 **Flow**

Enabling the flow is the main goal after the valuable work has been identified, waste has been eliminated and the value stream has been mapped. This is really important step in Lean thinking and requires rearrangement beyond traditional thinking. (Womack et al. 2003, 21.)

According to Womack et al. (2003) the traditional thinking of functions and departments might be the bottle neck in an effective value stream. It has also been very common to think that batch work would be the obvious choice for most of the work. Henry Ford and his team were the ones who took assembly line in use for improving the efficiency and making better flow for the production. This was significant leap for the productivity, but it only worked for the mass production. Taiichi Ohno and his team at Toyota improved the flow, making it also working well also for low-volume production. They learned to switch the tools from one product to another one very quickly and still managed the continuous flow without any delays. They used continuous improvement methods and forgot the traditional borders of functions and departments. (Womack et al. 2003, 22–23.)

In order to get the flow working, the next steps have to be taken. First, the value and value stream or value streams must be defined. It is important to focus on the correct order. The second step is to forget the traditional borders like departments, jobs, careers, or functions. It is important to remove all the impediments that would gate the flow. The third step is to think about the current practices, tools, and stoppages of all sorts. All these three steps should be done together for improving the flow. (Womack et al. 2003, 52.)

One important aspect that affects the flow is the team setup. The Lean approach is to use a team that has all the skilled workforce in one team and preferably close to each other's. The team should be full committed to the work and they should be able to define their own value. The team should use standardized methods and process for their work. (Womack et al. 2003, 54.)

Womack et al. (2003) also highlight the importance of cross-skilled workforce in order to maintain good flow. Every team member should know something about others work so that they can substitute if needed. Also, tools should be kept in good condition and 100% available when needed. The job should be standardized and improvement methods like Poka-Yoke and 5S should be taken in use. (Womack et al. 2003, 60–61.)

2.3.4 **Pull**

Lean way of starting the production is initialized by the customer. In simplest this means that no one in upstream should produce a good or service until the internal or external customer in downstream requires it. This means that the customer makes an order and "pulls" the product or service e.g. from the assembly line or another team. Obviously, this can be translated to product development as well – the design or service should be made only if the customer makes the order. (Womack et al. 2003, 67, 84.)

In the SW industry the pull can be understood by as a pull scheduling mechanism, which is widely used especially in Agile Scrum ways of planning and scheduling the work (Poppendieck M & T 2007, 112). Typically, the scrum iteration lasts two weeks, and in the beginning of every iteration the team members have authority to decide how much work they are able to do within the two weeks iteration period. Every team member then "pulls" the tasks from the queue and commit to do the selected tasks (Poppendieck M & T 2007, 112). At the same time the local product owner (LPO) gives own view of the tasks and set the priority order. Once the pulled tasks are done, they are then categorized to done category until some other team as a customer pulls them to the next step in the value stream.

2.3.5 **Perfection**

In order to achieve perfection, the organization and especially organization managers should be able to visualize and follow these four Lean principles:

1. Define the vision and understand the value
2. Value stream identification
3. Make the value stream flow
4. Understand the pull. Value should be pulled by the customer.

The fifth Lean principle is the perfection. The organization management and employees should understand that Lean is continuous improvement and for example waste elimination is never ending task. It is not possible completely remove waste but revisiting the same process again and again might always reveal something new to be improved. (Womack et al. 2003, 90.)

Managers should also understand the importance of correct operating technologies needed to the next steps on the path. In addition to understand the best technologies, managers are needed to set stringent timetable in which improvements for the perfection should be done. (Womack et al. 2003, 94–95.)

Another important aspect for the managers is transparency. The techniques and philosophy for the improvements is inherently open and egalitarian. Transparency for the actions and decisions is a key principle. While asking employees to participate improvement actions and problem-solving, they should be transparent informed about the importance of the transformation. It is likely that the change agents who breaks the old rules and steps in with a new set of Lean rules might face strong resistance. Thus, it is important to highlight that transform to Lean practices takes many years. Those organization who succeed to implement Lean practices can achieve success and benefiting for everyone. This needs right spirit and willingness to invest five years in order to gain full benefits of Lean. (Womack et al. 2003, 97–98.)

Managers should also take care of employees concerns after the Lean actions and improvements. It might be confusing for some employees that why there are continuous improvement actions ongoing. Why something that has just been fixed or improved needs to be improved and fixed very soon again. Employees also might be worried about the rewarding policy. Will they be rewarded if they make improvement actions? What kind of influence the Lean transformation has for their career? All kind of worries and concerns can rise, and even change resistance is possible. It is important that management takes all concerns seriously and is willing to handle each issue carefully. (Womack et al. 2006, 122–123.)

One way to visualize the perfection goal is to use famous Lean house example as presented in Figure 3. Taiichi Ohno have said that purpose of TPS is to bring problems visible in the system. Toyota Lean house keeps standing only if all the pillars are equally controlled and maintained. It is based on the JIT (Just-In-Time) on the left pilar and the Jidoka on the right pilar. JIT means the importance of correct timing in the process. If the flow is continuous there will not be unnecessary waste caused by delays, waiting or extra inventory. (Liker & Convis 2012, 78–82.)

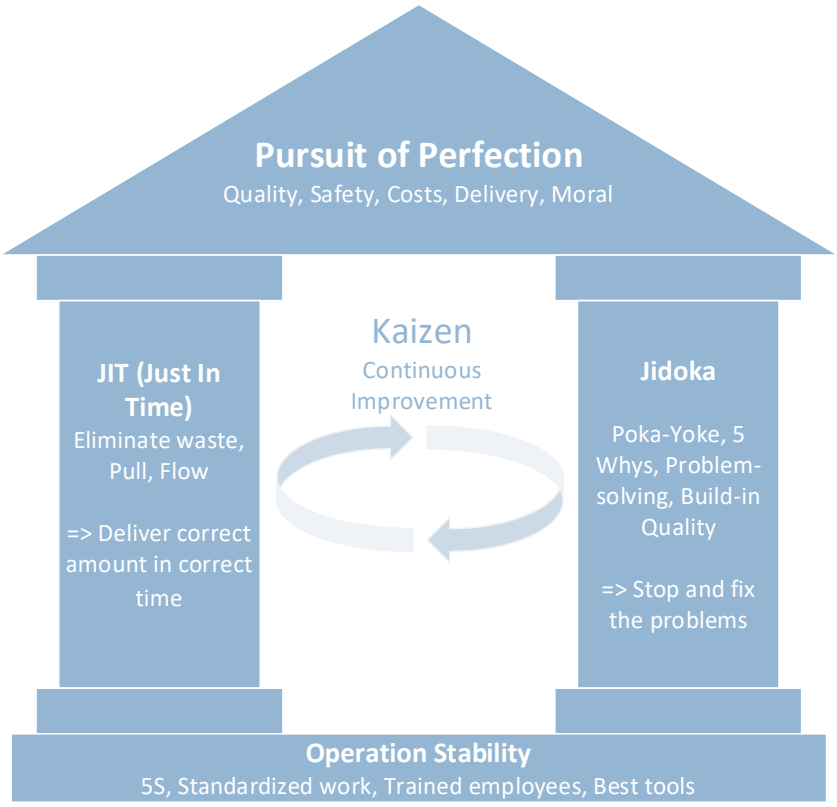

FIGURE 3. The Lean house (modified from Liker & Convis 2012)

Timing is good if the process is adjusted to work “Just-in-Time” and wastes are mitigated in the flow. Jidoka on the right pilar means the importance of fixing the problems immediately when recognized. The basis of the whole house consists of well-educated and trained personnel, good equipment, tools, and standards. If all the elements are in balance, the perfection is achievable. This brings safety, good quality, low expenses, and high moral for the organization. (Liker & Convis 2012, 78–82.)

2.4 Continuous Improvement

The continuous improvement aka “Kaizen” in Japanese is a key goal in Lean thinking. It is especially important for ensuring organizations competitiveness in the future, but also important aspect of the Lean culture itself. The world is never ready, and every employee should understand the importance of continuous improvement. Thus, it is necessary to spread the message of the importance within the teams as Liker & Convis (2012) have proposed as follows.

Toyota’s former chairman Akio Toyoda emphasizes the importance of sharing Lean principles to the younger generation in the organization. Every leader and manager should act as a teacher and pass the Lean knowhow to the following generation in the company. According to Akio, it is also important to share challenging enough tasks for the employees. The given task should not be over challenging, which could lead failing every time, and causing excessive frustration. Instead of, the task should be achievable with the employee’s current skills if the employee works hard. Once this kind of task is completed, it gives significant experience of success and as a consequence also gives more self-confidence for the future tasks. At the same time, the employee should be able to use criticism for their own work and think how they could have been even better and improve for the next tasks. That’s the best way to learn in their career. It is also important to challenge the improvement actions employees provide. Managers and leaders should give accurate, exact, and constructive feedback about the improvement actions. This way the manager can get the respect from the employees. (Liker & Convis 2012, 78–84, vii–xxiii)

The continuous improvement context covers a wide amount of possible improvement methods which can be adapted to achieve continuous improvement goals. This thesis presents only few of them and the selection is based on the methods which are very often mentioned in Lean literature and theory. The following sub-chapters gives a brief overview of the continuous improvement methods which have being taught and practiced during the empirical part of the thesis.

2.4.1 **Poka-Yoke**

Poka-Yoke is a Lean practice that is developed for Toyota in 1961 by Shigeo Shingo. Poka-Yoke is Japanese, and it means “avoid simple mistakes”. The purpose is to avoid mistakes and errors as greatly as possible, and the ultimate goal is to get rid of all of the mistakes. However, in some systems it is not possible to avoid all the mistakes. In those cases, it is essential to notify and alarm about the possible incoming mistake as early as possible. (Dudek-Burlikowska & Szewieczek 2009.)

Poka-Yoke can be categorized into two categories: prevention-based and detection-based. Prevention-based methodology makes the system straightforward and mitigates the possibility for mistakes as far as possible. In the detection-based methodology a mistake is already happened and after that the system can make three steps to avoid further damage. The system controls the process to avoid further damage, it alarms the user and stops the whole process if necessary. (Dudek-Burlikowska & Szewieczek 2009.)

Figure 4 presents a simple example of the prevention-based Poka-Yoke. The connector can be connected only one way into the socket. This prevents a user to make a mistake.

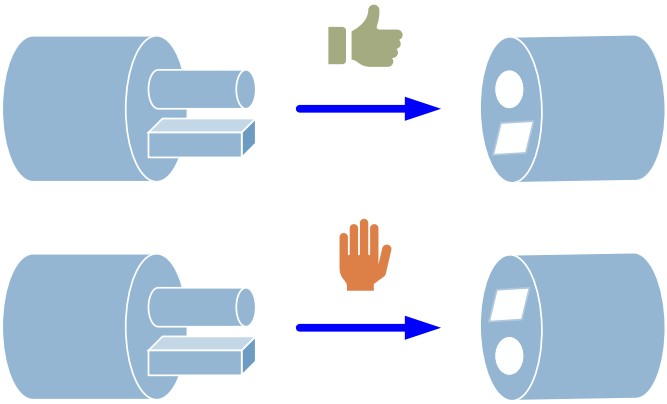

FIGURE 4. Poka-Yoke example

2.4.2 **Autonomation (Jidoka)**

Jidoka is a concept that is developed for Toyota by Sakichi Toyoda after the Second World War. Autonomation (Jidoka) may be described as "intelligent automation" or "automation with a human touch" as described by Taiichi Ohno (1988, 6). At Toyota, this usually means that if an abnormal situation is detected, the machine stops, and the production line is also stopped. The line will not be restarted again before cause is detected and remediated (Poppendieck M & T 2007, 5).

The autonomation word is referred to an autonomic nervous system similarly as human bodies are having when reacting for example too hot water. Similarly, organization, tool or flow should have fast reflex if something unexpected happens and fast reaction is allowed. In these situations, Jidoka could be used for avoiding further damages in the flow. (Poppendieck M & T 2007, 5-6.)

Jidoka steps can be presented in the following way as presented by Rosenthal (2002):

1. Detect the abnormality
2. Stop
3. Fix or correct the immediate condition
4. Investigate the root cause and install a countermeasure.

2.4.3 **5S**

5S is a tool, that is named by the five Japanese words (seiri, seiton, seiso, seiketsu, shitsuke) which can be translated as sorting, systemizing, shining, standardizing, and sustaining. The purpose of 5S is to improve the process by adapting the five improvement actions. The result from 5S is improved productability and avoiding mistakes caused by disorder and confusion. (Gapp, Fisher & Kobayashi 2008, 565–566.)

5S focuses on effectively organized steps, which are aimed for delivering better organized workplace environment and standardized work procedures (Abdulmalek & Rajgopal 2007, 223–226). 5S steps are presented in Figure 5.

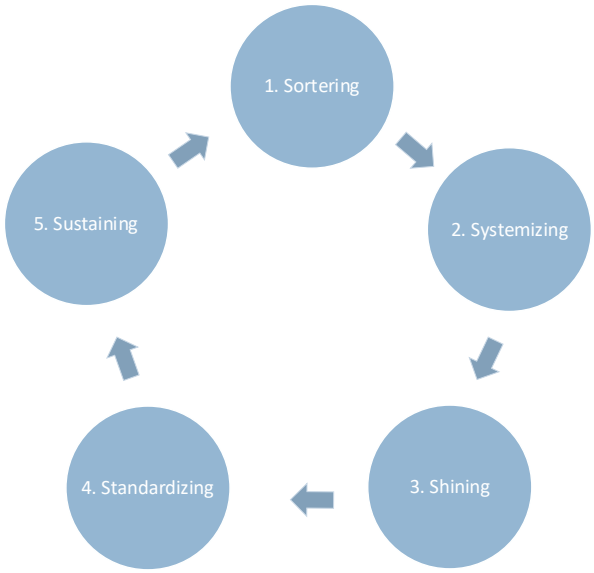

FIGURE 5. 5S process

2.4.4 **PDCA**

PDCA (Plan-Do-Check-Act) is the quality improvement methodology developed by James Womack. The first step is the PLAN phase and it consists of the understanding the current situation with all the facts. Also, development goals should be defined in the PLAN phase. It is important to understand the development target so that the bigger surprises could be avoided in the process. The plan is then made based on the best current understanding of the current situation and setting realistic development actions to reflect the development goals. (Lodgaard et al. 2012.)

The next step (DO) is to execute the planned actions, followed by the (CHECK) phase in which the outcomes of the actions are carefully analyzed against the predefined goals. The final phase is the (ACT) phase in which the all the good and bad behaviors of the process are analyzed and documented. This phase should contain the plan of the improvement action for the next PDCA cycle. It is also important to share the lessons learned for all the group of interests. (Lodgaard et al. 2012.) PDCA steps are presented in Figure 6.

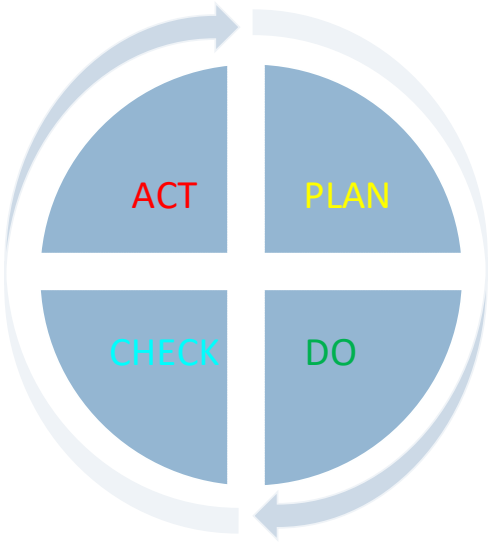

FIGURE 6. PDCA cycle

2.5 Problem-Solving

Mary and Tom Poppendieck have argued that a mark of an excellent organization is not to have problems as little as possible, but lack of systematic problems is a sign of excellent organization. Another clear remark of an excellent organization is to have regular and reliable channel for addressing the problems through the all organization levels in everyday manner. Every team should have enough amount of time for regularly and systematically find and fix the processes that makes daily work difficult. The idea is to establish a cadence for continuous improvement with continuous willingness to discuss about the problems. Many times, the problems cannot be solved by one-shot and several consecutive problem-solving events are often required. (M & T Poppendieck 2007, 168.)

Problem-solving skills are essential for excellent organization and problem-solving process should be embedded in the everyday activity of the existing work teams. In addition to that, there are sometimes a need for going even deeper to the key aspects of the process and organize problem-solving focused Kaizen events or workshops. (M & T Poppendieck 2007, 173.)

Following chapters are presenting the problem-solving tools which were lectured and practiced during the study.

2.5.1 Toyota Business Practice Problem-Solving

Toyota's famous problem-solving method is based on Edvard Deming's PDCA cycle. The method starts from the description between the current state and the goal. After that the anomaly is analyzed in deeper level and the main problems are described. Next step is the root cause analysis in which for example 5 Whys can be used. After recognizing the root causes, then solution goal is defined and after that, the most suitable solution proposals are selected for the corrective actions. Next step is to perform the corrective actions, make sure that the actions are helping for the problem. Final step is to make fixes if needed, standardize the solution, and spread the solution to avoid similar problems in other facilities. The eight steps are presented as follows. (Liker & Convis 2012, 83–84.)

1. Understand the gap between current situation and the desired situation (planning)
2. Split the anomaly in problem statements (planning)
3. Execute root cause analyze for the problem statement. Use for example A3, Ishikawa diagram or 5 Whys to identify the root causes and find the solution proposals (planning)
4. Define the solution goal or the level of solution (planning)
5. Select the best solution proposal (planning)
6. Execute the corrective action (do)
7. Check if the corrective action is fixing the problem (check)
8. Adjust, standardize, and inform others about the working solution (act)

2.5.2 **5 Whys**

In order to find the best solutions for solving the problems, the root causes should be understood. The 5 Whys is a method developed for finding the root causes of the problem. The method is applied simply by asking at least five consecutive questions. The purpose of each question is to go deeper and deeper in the analysis and finally find a root cause or the root causes. It is common that the root causes are in deep of the system and they depend on various aspects. As a consequence of that, the method is not as simple as it sounds and sometimes the solution cannot be found without rethinking the questions or even starting over the whole process. (Murugaiah et al. 2010.)

2.5.3 **Ishikawa Diagram**

An Ishikawa diagram i.e. fishbone diagram is a problem-solving method that provides visual and structuring way to identify the possible root causes beyond the problem. It is especially good method in the situations when the problem solver does not even know where to start or if the environment perception is challenging. The Ishikawa diagram gives visual opportunity to search possible causes by taking in account different viewpoints and making sure that none of the possible causes are discarded without careful thinking. A template of an Ishikawa diagram is presented in Figure 7. (George et al. 2005, 146.)

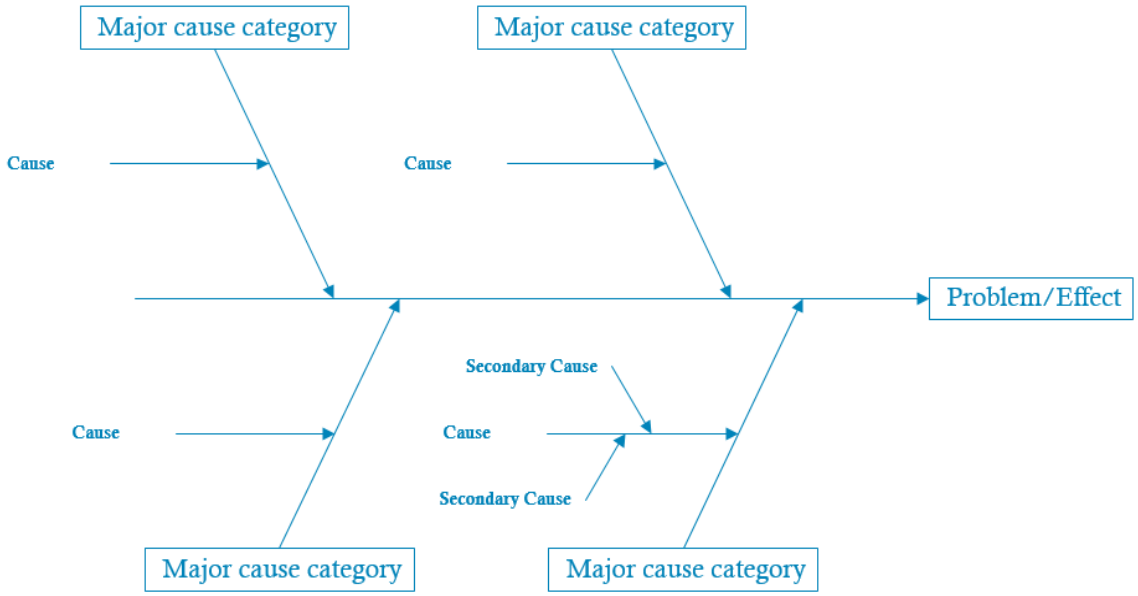

FIGURE 7. Ishikawa (Fishbone) diagram

2.5.4 **A3**

The main idea behind the A3 method is to visualize the problem-solving process. A3 consists of a report that visualizes the summary of the problem, root causes and the corrective actions in a one page. A3 idea can be presented in A3 size paper or in a modern way by visualizing the sheet in display boards. A3 is significantly better visualization method than commonly seen Power Point presentation with bullets. The standard A3 template is presented in Figure 8. (Liker & Convis 2012, 82–85, 180.)

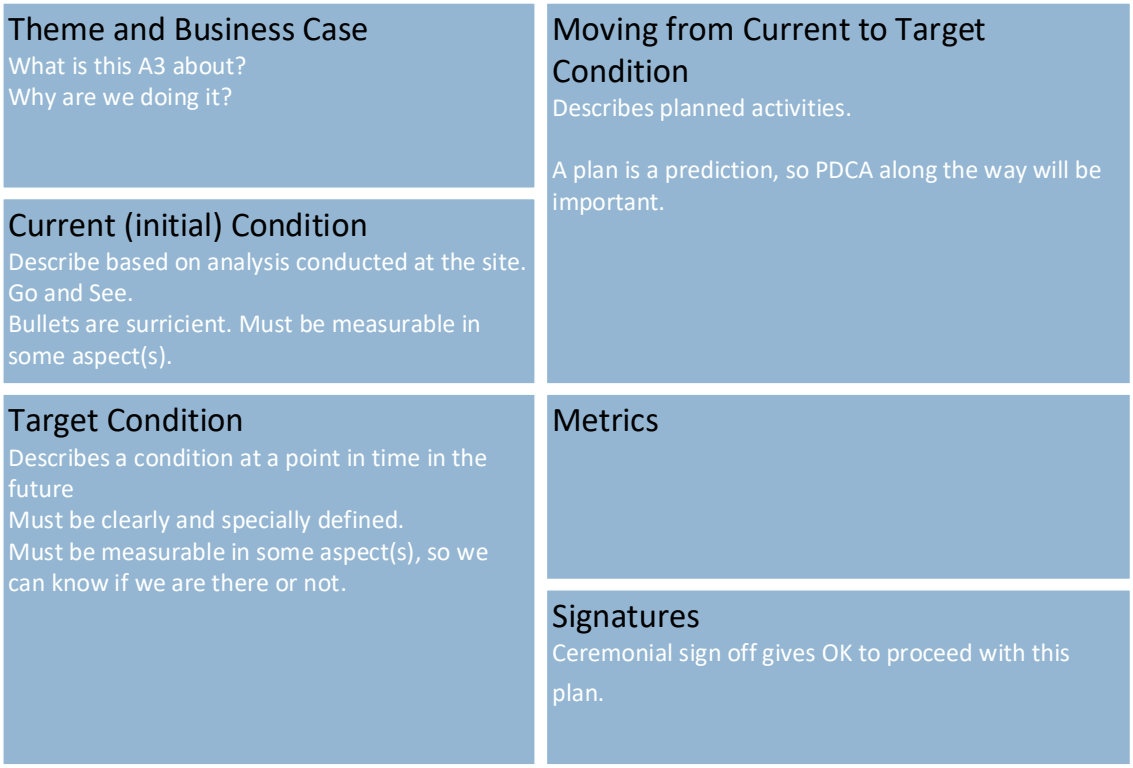

FIGURE 8. A3 example sheet (Rother 2010, 221)

2.5.5 **Other Problem-Solving Tools**

Following sub-chapters briefly describes the principles of the rest of the problem-solving related tools which were presented during the lectures and trainings.

GROW

GROW model was originally developed for a coaching purpose in the 1980s by Graham Alexander, Alan Fine, and Sir John Whitmore. According to Eure Consulting the GROW model can be also used for innovative problem-solving. (Eure Consulting 2022).

GROW stands for: 1. Goal, 2. Current Reality, 3. Options (or Obstacles) and 4. Will (or Way Forward). First step is to decide the goal of the coaching. The next step is the understanding of the current reality. Third step is to explore various options for the coachee. The final step means establishing the will and way forward towards the goal. (Graham 2006, 61–64.)

8D

8D problem-solving approach is based on the US government addressing of nonconforming materials during the Second World War. The approach was then later applied by the Ford Motor Company. (Elangovan et al. 2021, 2.)

8D cycle is widely used improvement methodology and it stands for the following 8 disciplines: 1. Form a team, 2. Contain the symptom, 3. Describe the problem, 4. Find the root cause, 5. Verify the root cause and select the corrective action, 6. Implement permanent corrective action, 7. Prevent recurrence and make the solution, 8. Congratulate and celebrate (Bicheno & Holweg 2016, 54).

DMAIC

Six Sigma methodology is a tool for variability reduction and clarifying tough problems. It can be used as a special tool under the wider umbrella of Lean. Six Sigma is biased towards data and statistic, and it is process oriented. The DMAIC is used in the Six Sigma methodology and it is a variation of PDCA. The D stands for “Define, M as “Measure”, A as “Analyze”, I as “Improve” and C as “Control”. (Bicheno & Holweg 2016, 54–55, 240.)

2.6 Learning Organization

Senge states in the Fifth Discipline (Senge 2006, 4, 22, 300) that every one of us is capable of learning and the learning skill is a part of human nature. He also mentions that the strongest learning experience can be achieved by doing and practicing. The same way as a human learns crawling, walking, eating, and communicating it is possible to learn multiple skills by using the try and fail method. Senge also argues that the lectures are not very effective methods for teaching since quite often students only listen passively during the lectures. Therefore, practice is an essential part of a complete learning experience. (Senge 2006, 4, 22, 300.)

According to Senge, it is challenging to achieve continuous learning organization if employees understanding of learning is limited. If learning is only understood as short-term learning events and random lectures, continuous learning organization cannot be achieved. Learning as a word could be also misunderstood. Learning is not just about emphasizing new information, but it is also about growing the overall skills towards the common goals. Thus, learning should be continuous and lifetime lasting. Learning organizations are not possible if there are no continuous learning and practicing possibilities in every level of organization. (Senge 2006, 132.)

Nowadays complexity in various industry areas is very high. This gives another challenge to learning organization. It is common for managers to think that they would need more and more information in order to make better decisions efficiently. Senge proposes alternate option: we should find ways to distinguish important information from less important information in different use groups and teams to grow shared understanding. Also, information should be able to categorize in broad and detailed patterns. This allows managers to see the forest from the trees and respond more efferently for the complexity problem. (Senge 2006, 125.)

The Leadership team should consider carefully how to reward the employees after the big accomplishments and after achieving personal goals. A traditional way is to use KPI (Key Performance Indicator), but this is not necessary always the best or only way. Toyota's way is not to just follow the KPIs because it may emphasis employees to do everything just for the KPI and not for the overall perfection and kill the natural motivation for the work. If an employee is willing to do the work anyways and especially if it belongs to employee's job grade, the normal duties should not be especially rewarded. Only the most challenging and hard-working outcomes should be rewarded. (Liker & Convis 2012, 10.)

2.7 Lean Culture and Challenges for Taking Lean in Use

Modig and Åhlström (2013, 88–92) defines Lean in three abstract levels (Figure 9). The highest level describes the Lean as values, culture, and philosophy. The middle emphasis the Lean for improvement and quality. The lowest level describes the Lean as different methodologies and practical tools and processes. If the organization's understanding of Lean lies only at the single level, there is a risk than Lean benefits are misunderstood at other levels level and Lean principles will be forsaken in the organization.

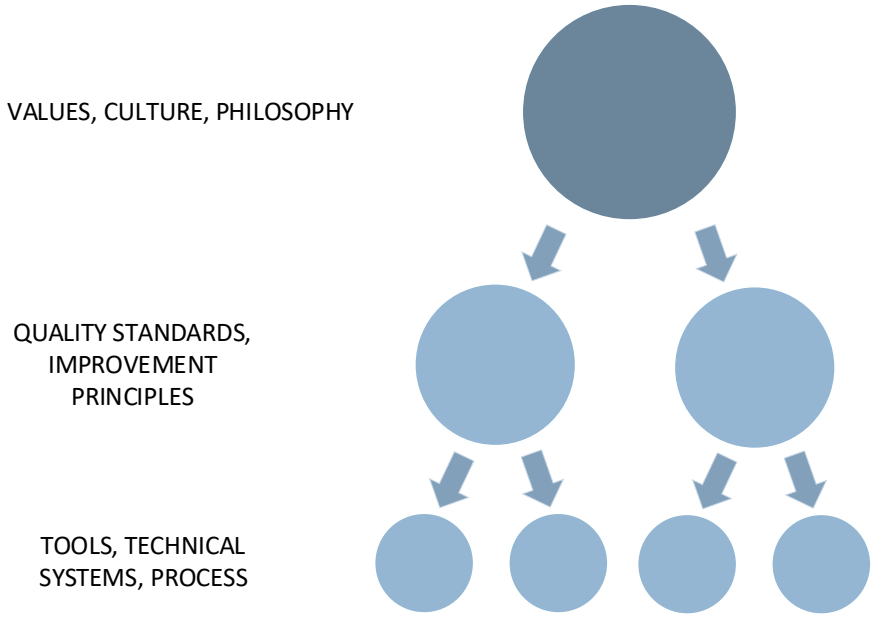

FIGURE 9. Lean abstraction levels (Modig & Åhlström 2013, 88–92)

Cultural change for Lean has been seen especially challenging in service business, since the service is immaterial and thus not similarly measurable as something physical in manufacturing industry. In the category of service business belongs all the organizations which are not industry, farming, mining industry or construction industry. (Hadid, Mansouri & Gallear 2016, 619.)

For example in manufacturing side Lean can be used to improve the standard to mitigate product quality variation, the similar principle for service business could be to increase the knowledge of the customer in order to serve them better and thus mitigate the service quality variation. In service organization it is the customer who defines the value of needs (Seddon 2005, 17–18).

It is relatively easy to organize workshops and lectures about Lean principles. It is also possible to practice and take in use some of the main Lean principles and have success after that. However, it has been showed that cultural change towards Lean thinking is way more difficult to achieve than just taking some of Lean principles in use. This problem has been identified in several organizations, which have been trying to take Lean in use. The cultural change is possible, but it takes long time and needs continuous investment from the management. It is also important to explain the reasons behind transformation and especially the historical background of the Lean. (Liker & Convis 2012, 4.)

According to Womack et al. (2003) it is recommended to start Lean improvements from the activities which are in very poor condition. It is good to select a task or process which is easy to understand, has great visibility and is very important for the organization. Immediate feedback is one of the important techniques in Lean. It is important that the employees can see the improvement changes and the outcomes with their own eyes. This way Lean facilitator can create psychological sense for the improvement actions. It is also important to not establish too complicated and long-lasting planning exercises. Value stream mapping process should not last longer than two weeks. (Womack 2003, 253.)

When implementing Lean, it is important that management understand the long-term aspect of the Lean concept. The process is not completed once value streams are mapped and waste removed. Lean requires long term commitment for continuous improvement. It is also important to highlight to the employees that continuous improvement is indeed repetitive process. It is possible that recently improved topic is re-opened after three months for another improvement. However, after longer period of time the employees starts to understand the new culture and resistance for repetitive improvements is not existing anymore. It has become the new normal. (Womack 2003, 255–260.)

The past decades have shown that there are still improvement possibilities in several organization's whose have namely taken Lean in use. It is very common that only few of the Lean practices or principles have been taken in use, but not the whole concept. This is usually better that nothing, but still there are significantly room for improvement. The basic problem is the lack of understanding about the leadership model of Lean. Lean is not "fast diet" or one-time improvement action or series of actions. It is about long-term development and continuous commitment for life-time improvement. The key object is to have committed and skilled leaders who understand the Lean leadership model. The leaders cannot be externals or sub-contractors. Instead of, Lean leadership team must be compiled of organizations own personnel. (Liker & Convis 2012, 7.)

The leaders should also have capability for communicating the vision, purpose and goals of the improvement actions. The leaders should be committed to support employee engagement for Lean and improvements actions. It is also very recommended that the leaders are capable for coaching the team and also emphasizing the employees for being creative during the improvement processes. (Mann 2005.)

Finding a leader who is capable for the characteristics above might be challenging (Mann 2005). It is possible that in expert organizations a technical specialist can be nominated to the position of people leader without giving the person full support or training. This kind of behavior is hazardous for the people leader itself and for the whole organization. It is possible that in some circumstances the new people leader still feels itself more as a specialist than a people leader. If the leader is not willing to ramp down the specialist tasks and take more responsibility for people leading tasks, it is possible that there is not enough willingness for coaching and implementing Lean thinking for the team. (Ristikangas 2008.)

Once the Lean way of working has been adapted to the daily practices and the major phase of Lean transformation is completed, care should be taken that the Lean practices are followed by everybody. In order to ensure that, few additional steps are required. Management should establish rewarding system to keep score of the improvement actions and reward those employees who do tasks in a right way. It is also important to make rewarding transparent. In addition, there should be systematic process to teach Lean thinking continuously for the current and especially new employees. (Womack 2003, 261.)

When trying to get people thinking and acting in a new way certain amount of challenges are possible. This is due to the fact that mindset change within an organization means cultural change and new culture takes long time to evolve. However, most of the organizations planning for change to Toyota's approach do not need to change completely their culture and only some level of adjustment might be sufficient. (Rother 2010, 232–235.)

Leading Model at Toyota

The five main leading principles at Toyota have documented first time in year 2001 as follows:

1. The willingness to accept challenges. This is linked to the fifth Lean principle "Perfection". Leaders at Toyota are continuously developing themselves by accepting bigger and bigger challenges. This way they became better leaders.
2. Kaizen thinking. This means the responsibility to improve effectiveness all the time.
3. "Genchi Genbutsu" is Japanese and means "get yourself into the place where activities are happening". In order to understand fully the problem or the area of interest, the leader have to visit the place personally. It is also important to meet the employees who are dealing with the problem.
4. Teamwork. Teamwork is essential part for success. This phrase is quite commonly repeated by the managers but establish a really good team and maintaining the team's performance is challenging. The reason is that many times individual performance withing the team is recognized over the team performance. At Toyota, the team purpose is emphasized clearly over individual goals. They also highlight that the individual growth can only happen within a team. This is further tied to the career path, which is closely linked to a team's success.
5. Respect. The core value in Toyota's thinking is respect. Leaders are respecting employees in all possible ways and situations. This means that Toyota is committed to employees' personal growth and career plans. Also, in difficult economic situations, the personnel are not the first cost reduction source. If Toyota sees that there is not anymore suitable work for some group of the personnel, those employees are re-trained to new tasks and career. (Liker & Convis 2012, 32–33.)

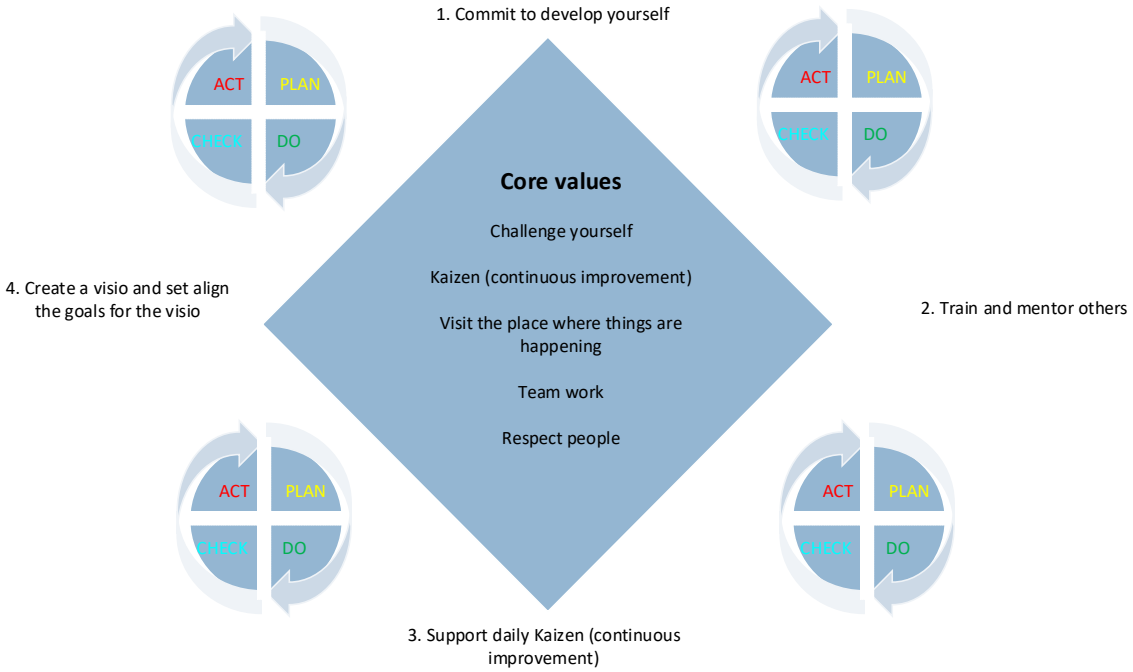

FIGURE 10. Leading model at Toyota (Liker & Convis 2012, 34)

As seen in Figure 10 Toyota's way of leading is based on the five key principles. In addition to the five key principles, four key goals are also defined. They are categorized as follows:

1. Leaders are committed to develop themselves. This means proactive attitude from all the leaders. Managers are very often busy, but this should not be an excuse for not attending the trainings. Managers should thus ensure that next generation leaders are getting all the training needed. Good training methods for self-development are learning from senior members (sensei coaching), learning through work and continuously growing challenges in work. It is important to commit continuous and long-term trainings. Training cycles should be repetitive. (Liker & Convis 2012, 42–76.)
2. Leaders are committed to train and coach other employees. Every manager should be interested in coaching and at least organizing coaching, unless feel themselves to be a good coach. One example of giving training possibilities is to organize training for problem-solving and share information of A3 and PDCA problem-solving methods. (Liker & Convis 2012, 82–85.)

3. Keep daily Kaizen ongoing. As the phases 1 and 2 are focusing more for individual growth, the daily Kaizen aims for institutional improvement. This is not about forcing the kaizen from top to down, but instead of the leaders should ensure that Kaizen possibilities are recombined all the hierarchy levels in the organization. There are two types of Kaizen: maintenance Kaizen and improvement Kaizen. In maintenance Kaizen, the daily problems are made visible and then handled immediately and effectively. The problems are solved by using problem-solving methods. Target is to return the previously working situation or even improve the process if possible. Improvement Kaizen focuses for long-term improvement. This is not just to maintain the standard but try to make tasks better and improve as a whole. The target is perfection. (Liker & Convis 2012, 107–109.)
4. Understand the vision and align all the goals towards the vision. This means setting the common goals towards the commonly agreed long term master goal. For achieving this master goal, resources and the tasks should be planned very carefully in every corner of the organization. This is called “Hoshin Kanri” in Japanese Lean culture. This is the most difficult corner of the diamond. The personnel should understand that meeting the goals is not enough. Instead of the journey how the goals can be achieved is as important as the goal itself. These goals are closely linked for the fifth Lean principle “perfection” (Liker & Convis 2012, 36.)

Organization Model for Learning Organization

Organization structures of companies can vary from flat hierarchy organizations to multiple levels of hierarchy. Flat organizations are common in smaller companies and once the company grows, more hierarchy levels are typically constructed.

Many organization leaders who have tried to implement Lean have been surprised about the several hierarchy levels at Toyota. The reason behind Toyotas hierarchical organization structure is the ability ensure enough sensei’s for the organization. Since every leader should be able to be a coach and mentor for their subordinates, as a consequence significant number of leaders are needed. (Liker & Convis 2012, 92–93.)

At Toyota, there are approximately one leader for every 5 employees. This ensures that the leader's coaching possibilities are meaningful, and all the employees gets enough coaching. In the flat organization in which one leader can have for example 20–40 employees it is clearly that the employees do not get all the help, coaching and mentoring from their leader. (Liker & Convis 2012, 92–93.)

2.8 Summary of the Theories

The theory chapter started with the Lean history, philosophy and the main theories of Lean methods and principles (Chapters 2.1–2.3). It was essential to introduce the basics since the theses practical evaluations are constructed from the Lean basics and continuous improvement. Some of the Lean basics like pull, level production (Heijunka) and Value Stream Mapping were not introduced in in-depth level since the scope was to include the concepts, which were most relevant for the thesis. The waste mitigation, 5S, PDCA, Jidoka and Poka-Yoke were essential part of the workshops and therefore introduced in chapters like Continuous Improvement (2.4), Value and waste (2.3.1), and Appendix 6.

Problem-solving was a main theme for the thesis and workshops, and therefore the meaning, purpose, and the most common tools of the problem-solving were introduced in Problem-Solving chapter 2.5. Chapter 2.6 (Learning Organization) presented important aspects from learning organization and highlights of combining learning with practice. Theory of management investments towards learning organization was also introduced in the Learning organization chapter.

Chapter 2.7 (Lean Culture and Challenges for Taking Lean in Use) contained important observations and proposals for the construction. Applying Lean thinking in product development is not just about teaching the methodology and organizing workshops. Rather it is a cultural change, and therefore theories of cultural change were included.

3 EMPIRICAL RESEARCH

3.1 Empirical Research Goals

The empirical research was the core part of the study. The first target was to collect data for understanding the current situation of integration team's performance and Lean knowhow. The initial construction was then applied with current data and connected to the theories. The second target was to find connections between the practical results of the study and Lean theory. This phase also included brainstorming for seeking answers to the research questions. The initial construction was then updated and improved based on the field-study results and theory.

3.2 Empirical Research Process

Chapter 3.2 walks through the research process in detailed level. Chapter 3.2.1 presents the construction that is linked to the existing theories of Lean. According to the previous theories Lean methodologies and principles should give practical workaround for improving integration team's performance and also give guidelines how to increase Lean awareness in the organization. Chapter 3.2.2 goes through the research methods and data collection techniques used in this thesis. It also presents field tests which were used for testing the theoretical construction in practice. Practical evaluations are presented in Chapter 3.2.3.

3.2.1 **Initial Construction**

The initial construction is illustrated in Figure 11. Connection to the theories and practical relevance are presented in the following sub-chapters. The core part of the construction is based on the selected Lean theories which are fitting the scope of this thesis and organization needs.

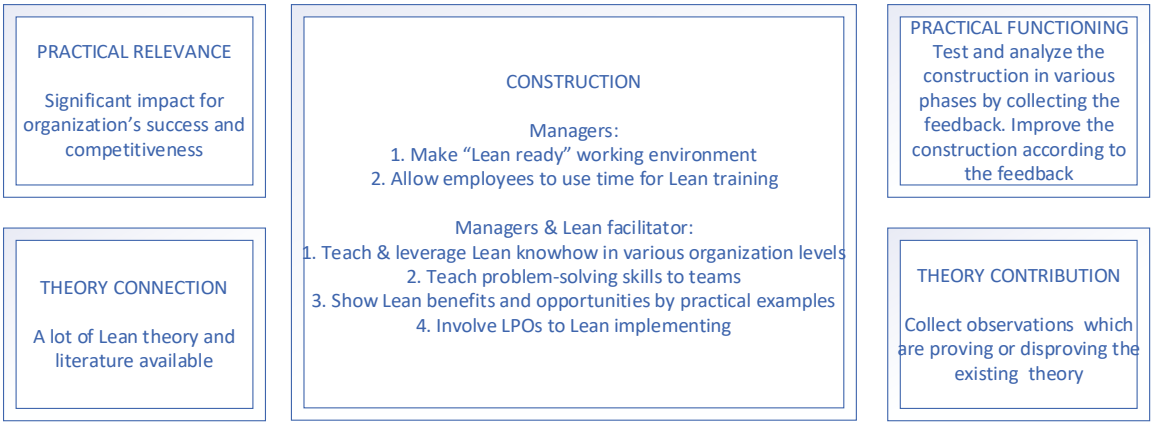

FIGURE 11. Initial construction

Theory Connection

As mentioned in Chapter 2.2 (Lean Philosophy) there is a significant amount of theory supporting the benefits of Lean. Lean is intended to provide a way to do more and more with less and less. This means less human effort, less equipment, less time, and less space while providing the customers exactly what they want (Womack 2003). As a result of that there can be multiple benefits as improved overall quality, enhanced throughput, and performance. One possible consequence is happier employees as they have received strong support from management. Management support should cover coaching, mentoring, and giving opportunity to have many kinds of interesting and challenging tasks (Womack et al. 2003, 12–13, 254). This also means condition in which employees are experienced most rewarding from psychology point of view as explained in Chapter 2.7 (Lean Culture and Challenges for Taking Lean in Use).

The theory also provides suggestions on how to take Lean in use. Chapter 2.7 (Lean Culture and Challenges for Taking Lean in Use) explains the most common challenges in Lean implementation. According to theory the traditional classroom trainings and lectures are not the most effective and more effort should be invested for the Lean culture implementation. The cultural turnaround would be the most important task, but it is also the most challenging part and takes long time.

Even if the Lean implementation recommendation as Mann (2005) emphasizes "*creating a Lean culture requires a leader who is committed for long term improvement*" could be fulfilled by author's and other quality managers effort, there would be still tens of other employees whose mindset turning from traditional culture to Lean culture might take long time. This would be doable, but not within the timeline of this thesis. Therefore, less effective methods like classroom trainings and workshops have been carried out during the timeline of this thesis to teach the Lean basics and principles to the integration team.

Rother (2010) recommends that Lean implementing could be started with experiments. He claims that probably not all approaches fit to all organizations. Each company should work out with the Lean details and find out the best ones in their use. Experiments with Lean do not mean that there should be separate Lean activity for each experiment, but instead of there can be continuous improvement actions, adapting new methods, train people and developing the organization culture simultaneously with the same activities. (Rother 2010, 234.)

As mentioned in Chapter 2.7 (Lean Culture and Challenges for Taking Lean in Use) it is recommended to start Lean improvements from the activities which are in very poor condition. It is good to select a task or process which is easy to understand, has great visibility and is very important for the organization. Thus, it was decided to start Lean improvement activities which are explained in Chapters 3.2.2 (Empirical Research Methods & Data Collection) and 3.2.3 (Practical Evaluations). This covers lectures of Lean thinking and various workshops. Effort has been also put to ensure that employees could see the improvement change and the results with their own eyes and to not establish too complicated and long-lasting planning exercises. Also, the most common and easy to be understood practices like 5S, Poka-Yoke, Jidoka and PDCA were lectured in the very first sessions. Problem-solving was seen as very important part of the Lean implementation and was taken in as an lectures and workshops.

Practical Relevance

If the theories related to Lean benefits are revealed to be even partially applicable to the organization, it can be considered that the time and effort spent on the thesis has been beneficial for the organization as well. The initial understanding was the assumption that there might not be anything dramatically wrong with the current organization, but the ideas for improvement are welcomed by the management.

3.2.2 Empirical Research Methods & Data Collection

As the initial construction in Figure 11 presents, already existing Lean theories should give theoretical framework for improving the integration team's performance and also give guidelines how to increase Lean awareness in the organization. Author was also able to find a great deal of material that describes in detail level how organization should be able to improve as a whole. However, every organization is different and there can be variation in organization's values, cultural background, environment, leadership, and reputation. It has already been mentioned earlier (Chapter 3.1 Empire Research Goals and 2.5.1 Toyota Business Practice Problem-Solving) that it is important to understand the current situation. Also, several Lean theories and practices as PDCA highlights for grasping the understanding of the current situation before improvement actions can be made (Lodgaard et al. 2012). Therefore, various interviews, feedback surveys and discussions were selected for collecting data and put in place to understand the current situation. Research method for building the construction employed data collection feedback, interviews, and own observations for the improvement.

Lean Awareness and Quality Survey

In order to get employees' understanding of the current quality status in the organization, several quality surveys were carried out during the workshops. Survey was conducted in a way that basically everybody in the workshop had to answer before going further in the workshop. That way it was possible to get rather high answering percentage for the surveys.

Since the organization had already given Lean training in previous years, it was decided to investigate how well Lean is known in the current organization. Also, Lean awareness survey was conducted during the workshops in similar way as quality and problem-solving surveys. Survey feedback is presented in Chapter 3.3.1 (Current State Analysis), Figures 12–16.

Problem-Solving Skills Survey

Problem-solving skills are essential in improvement actions. Importance of problem-solving, and the most common problem-solving methods are presented in Chapter 2.5 (Problem-Solving). In order to get understanding of integration team's previous problem-solving experience, the survey was conducted in the beginning of the problem-solving workshop. Survey result is presented in Chapter 3.3.1 (Current State Analysis), Figure 17.

3.2.3 Practical Evaluations

Practical Functioning 1: Deepening Lean Awareness and Know-How Within the Teams

For supporting this thesis and increasing Lean awareness in the integration and horizontal teams, following steps for trainings and events were arranged:

1. The first steps towards high performance team & Lean "2021"
2. The lessons learned workshop and Lean presentation "2021"
3. Lean lectures about the basics of Lean and waste recognition workshops "2021–2022"
4. Lean lectures about the basics of Lean and waste recognition workshop for managers "2022".

Each step is briefly described as follows:

Steps 1: The first steps towards high performance team & Lean.

The first step consisted of presenting the idea of Lean and the long-term development plan to the integration team and management. The idea of Lean lessons learned workshop and waste removal workshop was also introduced. After the presentation, Lean topics, and the idea of Lessons Learned workshop was individually discussed with every integration team member in the development discussions. Manager feedback was collected with interviews. The feedback and results are presented in Chapter 3.3.1 (Current State Analysis) in Tables 2–3 and Appendix 1.

Steps 2–3: The lessons learned workshop and Lean presentation. Lean lectures about the basics of Lean and waste recognition workshops.

The practical Lean steps were presented to five development teams in the Quality Circle workshops. The organization arranges Quality Circle workshops two times a year. The topic varies every year and for the years 2021–2022 Lean and waste was selected as a main topic. In order to increase Lean & quality knowhow among the development teams, Lean thinking and waste recognition workshop was introduced to the teams. The workshop included theoretical part in which following topics were discussed: Lean highest goals, Lean thinking, Lean principles, Lean practices and methodologies like 5S, Poka-Yoke, Kaizen, value & waste and Jidoka. The practical part of the workshop consisted of waste recognition exercise for the team. Integration team's workshop was slightly different in terms of the goal since the main goal was to collect lessons learned topics from the previous project. The feedback from all the workshops were collected and used for improving the problematic areas. The results are presented in Chapter 3.3 (Empirical Research Results).

Step 4: Lean lectures about the basics of Lean and waste recognition workshop for managers.

This workshop was basically identical with team workshops. The only difference was that presentation included more info about the importance of setting clear vision and strategy for the future. The importance of decision transparency was also highlighted in the given presentation.

Practical Functioning 2: Deepening Problems-Solving Skills Within the Teams

As mentioned by Liker & Convis (2012), the importance of well-educated and trained personnel is essential part of Lean. Excellent problem-solving skills are one of the most important skills of the well-educated and trained personnel and therefore problem-solving skills training was selected as a main theme for practical functioning 2. The purpose was to familiarize problem-solving methods to the teams. They also had change to practice the problem-solving methods with pre-defined problems. This exercise was done in a co-operation with LPOs, quality manager and Squad Group Leaders. The steps are presented as follows.

Step 1: The teams were informed about the incoming problem-solving workshop. The purpose and the importance were clearly informed to every member in the team.

Step 2: LPOs were involved closely to the problem-solving leading. They were asked to organize a meeting with their Squad and collect a list of problems that could be solved in the problem-solving workshop. Important aspect was to collect problems which can be solved in the scope of the Squad. Another aspect was to find problems which are real life problems and solving them would bring value for the team.

Step 3: The problem-solving workshop which consisted of two main parts: The theory and the practice. The first theory lecture was a recap of the Quality Circles Lean & waste mitigation topics. Another theory lecture consisted of presenting the most common problem-solving methods.

The practical part consisted of practicing first together the 5 Whys and Ishikawa methods. Rest of the workshop consisted of problem-solving in the Squads, which were leaded by the LPOs. Squad members were free to choose the problem-solving methods for the problems. The results are presented in Chapter 3.3 (Empirical Research Results).

Practical Functioning 3: Interviews and Feedback of Lean Thinking

Managers' & quality manager interviews: The main purpose of manager & quality manager interviews was to investigate how managers see the current Lean & quality situation in the organization. Since managers have usually wide perspective over the team borders, questions were focused to reflect that area. Since the quality managers have a broad view and know-how of various improvement ventures from the past years, understanding the purpose of this thesis was also of key point of interest. The main question was to find out: Did they feel that Lean waste trainings and problem-solving workshops have brought value to the organization?

LPO interviews: LPO's are the key players when the detail level planning of the Squad is needed. Therefore, it was important to get feedback from them since they also involved closely to the lesson learned and problem-solving workshops. The main question was to find out: Did they feel that Lean waste trainings and problem-solving workshops have brought value to the organization?

Squad member interviews: Since the purpose of the Lean implementation was to familiarize each Squad member to Lean topics and improve their problem-solving skills, the feedback from them is essential. The main question was to find out: Did they feel that Lean waste trainings and problem-solving workshops have brought value to the organization?

3.3 Empirical Research Results

3.3.1 Current State Analysis

The current state analysis of the organization's Lean understanding was carried out by having discussions with managers and quality leaders. Several personnel surveys were also collected as an initial step for the workshops. The surveys feedback was collected not only from integration team, but also from other design Squads to have broader understanding. The feedback was collected before any workshops or Lean lectures were organized. Interview results are summarized in Appendix 1. Survey feedback is collected in Tables 2–3.

Surveys Before the Workshops

Feedback in tables below was collected from integration team before the workshops, trainings, or lectures.

TABLE 2. Survey 1 of integration team's willingness for getting new ideas from direct manager

What do you think if your direct manager brings new ideas for daily work? (Lean, scrum, life-balance, self-development)	%	Qty
Good behavior. I am interested to hear and discuss	53,8	7
Maybe this could bring some value	30,8	4
Ok, if there is not anything more important ongoing	7,7	1
I am not so interested	7,7	1
Total	100	13

TABLE 3. Survey 2 of integration team's willingness for getting new ideas from direct manager

What do you think if your direct manager explains how the organization strategy and vision links to daily work?	%	Qty
Good behavior. I am interested to hear and discuss	38,5	5
Maybe this could bring some value	30,8	4
Ok, if there is not anything more important ongoing	30,8	4
I am not so interested	0,0	0
Total	100	13

The feedback from quality and line management was supportive and the thesis subject was favorable for all the leaders (Appendix 1). Also, integration team members were open to receive new ideas from direct manager to improve ways of working (Table 2). Integration team also appreciates if direct management can explain the organization vision and strategy, but this was not seen extremely important if something more important is ongoing (Table 3).

The feedback in Figures 12–16 was collected in the beginning of the team workshops. The figures are presenting the survey feedback from the integration team and four other horizontal teams which are working in the same organization and doing almost similar kind of product development. Response rates for these surveys were close to 100% since the survey was organized in the beginning of the workshops and everybody had to answer in order to continue the event.

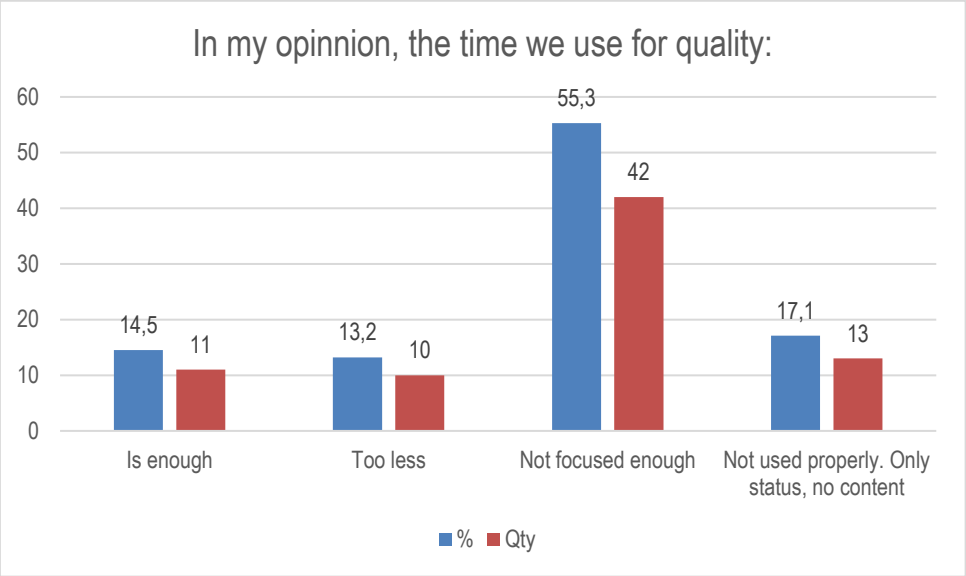

FIGURE 12. Survey results on how the organization sees the existing quality status

More than half of the quality survey responders (55%) were feeling that the time we use for quality is not focused enough. The other half of the answers were divided almost equally to other categories. It is still noticeable that only 14.5% were thinking that we use enough time for quality (Figure 12).

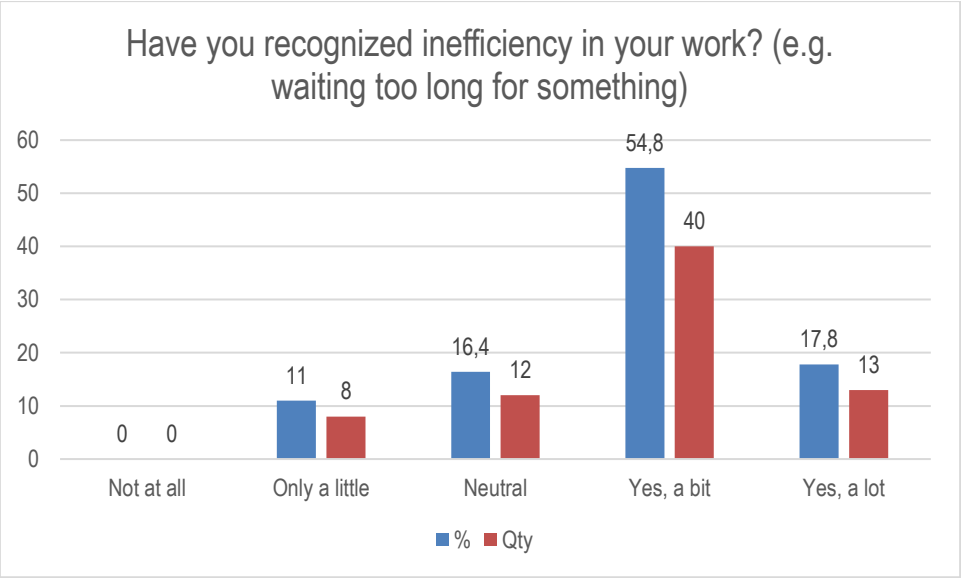

FIGURE 13. Survey results of the existing waste in the organization (inefficiency)

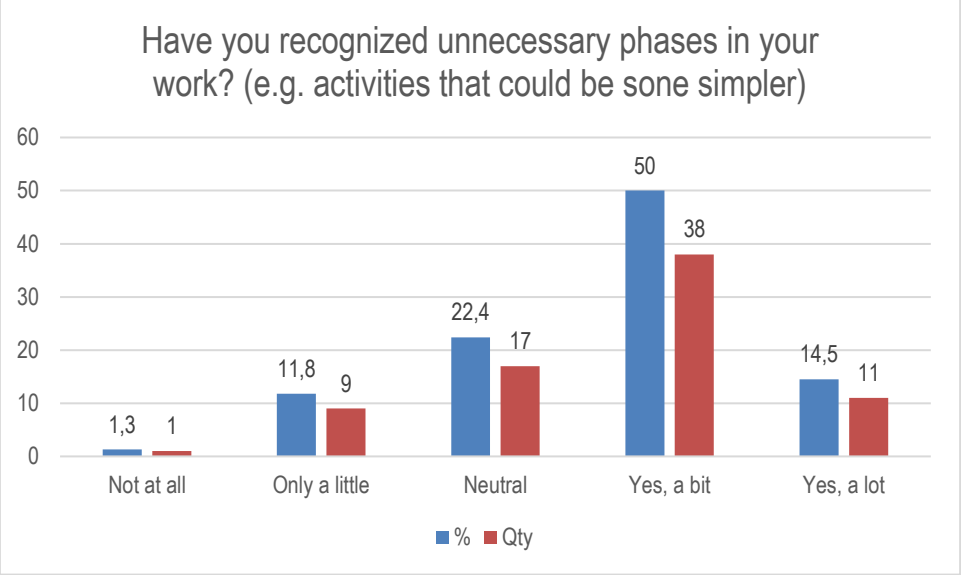

FIGURE 14. Survey results of the existing waste in the organization (unnecessary phases)

The survey feedback of inefficiency and unnecessary phases the employees feel in their work are presented in Figures 13 and 14. More than 70% of the survey responders were experiencing inefficiency either a bit or even a lot in their work. The responses for unnecessary phases were a bit more neutral, but still significant amount of the responders had a feeling that there is significant number of unnecessary phases in their work.

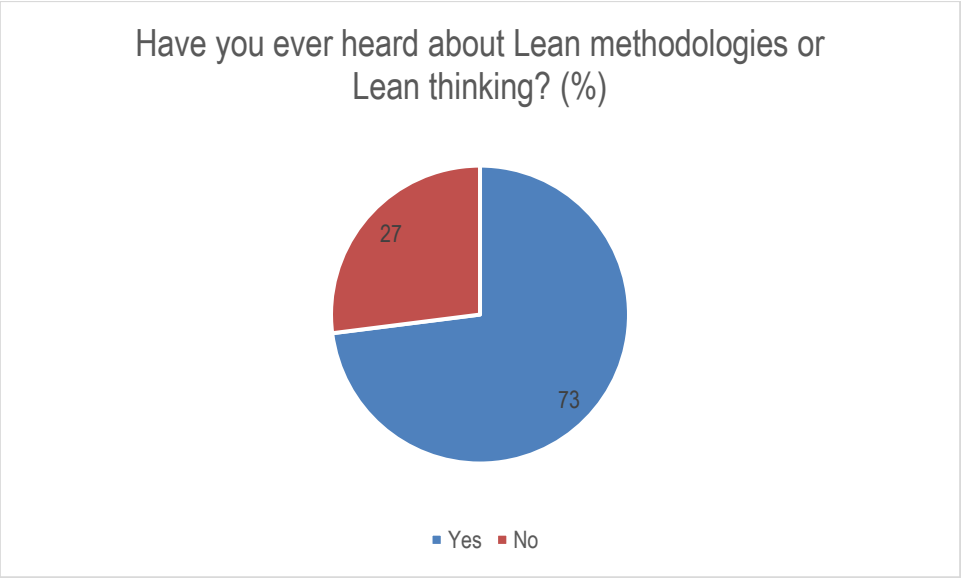

FIGURE 15. 1st survey of the existing Lean knowhow in the organization. Number of responders: 74

FIGURE 16. 2nd survey of the existing Lean knowhow in the organization. Number of responders: 74

The survey responders' answers for Lean awareness and possible Lean trainings they had got before the Lean thesis project are presented in Figures 15 and 16. 73% of the responders had heard about Lean and 37.8% had got some training for it.

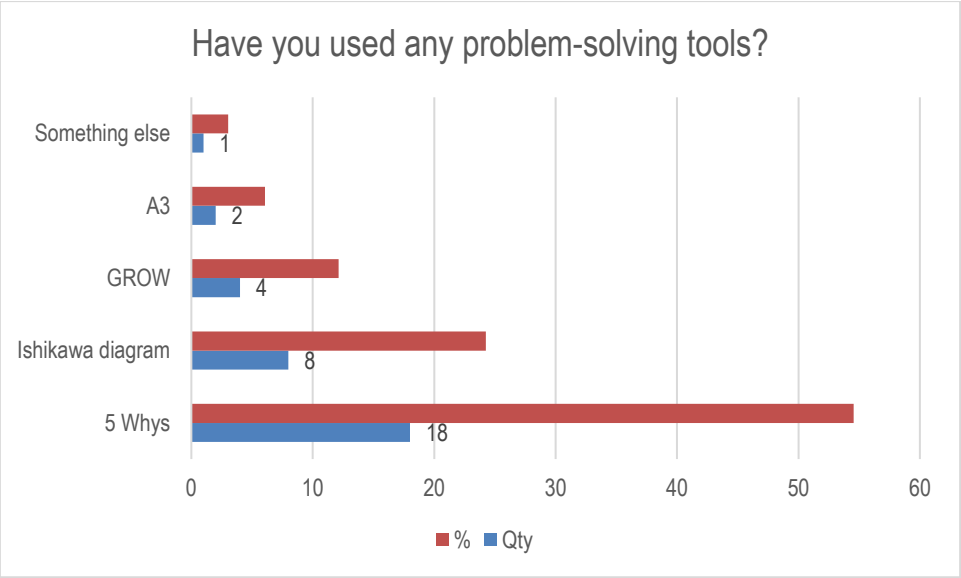

FIGURE 17. Survey results of the problem-solving tool use. Number of responders: 33

The integration team's earlier experience of the problem-solving tools is presented in Figure 17. 5 Whys was the most commonly used problem-solving tool before the problem-solving workshop.

3.3.2 Feedback of Lean Thinking and Knowhow After the Workshops

Online Survey After the Lean Trainings and Workshops

Online survey after the workshops and lectures was not sufficient for any reliable conclusions since the answering rate was only 21%. However, the answers which were recorded were either neutral or positive. Survey responders concluded with 9/41 answers that trainings for Lean/quality and problem-solving are somewhat important, important, or very important. The same group also answered that the most wanted trainings for the future could be related on learning organization, self-development, and hidden potential. Nobody voted for pure lectures or pure workshops, but when the lectures and the hands-on of the workshops were combined, the interest for such a training increased.

The feedback for remote and on-site workshops were also recorded. The employees that answered (9/41) voted remote and on-site workshops almost equally good. Most of the persons preferred on-site face-to-face workshop since it is giving more immediate feedback from colleagues and presence is important for deep conversation. On the other hand, remote workshop was experienced to work well, but not as effectively as on-site workshop. Few persons mentioned that remote workshop had positive impact for understanding and contributing Lean & quality topics.

Personnel Interviews After the Lean Trainings and Workshops

Feedback of the Lean trainings, workshops and Lean usability for our organization was collected with personnel interviews. The questions are presented in Appendix 7. The general feedback after the Lean presentations and workshops was positive (Appendix 2). Employees did feel that the Lean concept makes sense and brings value for the daily work. The most positive feedback was given for the problem-solving process and methods which were presented and practiced during the problem-solving workshops. Employees also acknowledge the lectures given for value stream and making clearer how to distinguish waste and valuable work. PDCA and Jidoka was also mentioned in the feedback as a positive concept. Many persons mentioned that they have been using Lean methods already in their daily work, but they did not know Japanese based Lean words for them.

During the empirical process it was found that there is variation how employees are owning the different theoretical frameworks (Appendix 3). For example, 5S was advertised in several presentations and workshops, but still the employees are not buying it as good as the theory estimates. However, the other Lean methods like Poka-Yoke and waste removal were understood and accepted without bigger criticism. Only one person could not see greatly benefit in Lean, but on the other hand the person admitted that Lean is not interesting, and the person refused the familiarization. It was also found that problem-solving workshops were success and it was decided to continue problem-solving workshops also after the thesis project. The most favorable problem-solving methods were 5 Whys and Ishikawa. A3 was also practiced and experienced useful in the cases where wider perspective was need.

5S was voted for the most unfavorable method in product development (Appendix 4). Interviewed persons did understand the 5S concept, but they did not find exact fit of 5S to the product development work they do. However, half of the interviewed persons could not tell any Lean methods that could not work so probably some persons are using 5S in their daily work successfully. Some persons also mentioned that they have not yet had possibility to try out all the Lean concepts, so they could not answer all the questions properly.

Interviewed persons were generally interested in continuing Lean practicing in the future and they also request more trainings of it (Appendix 5). In-depth problem-solving workshop was hoped the most favourable training in the future. Focus could be in the most challenging problems instead of the simple ones which were handled in the previous workshops. Employees would also like to go beyond the current processes the organization currently have. They were asking if Lean could help the organization to reveal the situations like: “in which phase should we have found the problem?” and,” which process should we improve to tackle some particular problem?”. Managerial feedback stated that we should have close co-operation between the managers and plan the next improvement workshops and trainings together for getting the best out of them.

3.3.3 **Empirical Results and Improvement Opportunities**

Empirical Results

The outcome of the empirical research process was significant amount of new research data, which was collected by various interviews, workshops and making own observations. The measurement period was over a one year and it contained also remote work due to the worldwide COVID-19 pandemic. This was an interesting addition to the study, and it produced new research data considering the success of online workshops and collaboration.

The results from the current state analysis revealed that there is a clear need for an improvement actions within the organization. The feedback from quality and line management was supportive, integration team members were open to receive new ideas, and the surveys from wider group revealed that the current quality processes are not focused enough. The feedback for wider group also highlights that employees feel inefficiency and unnecessary phases in their work. Lean awareness survey resulted the fact that Lean knowhow could be significantly higher in the organization.

The employees' feedback after the workshops was the most important feedback in the thesis. Since the employees under study have experienced at least two workshops covering the Lean general topics and problem-solving it is expected that they have some opinion about the Lean. Some of the employees joined only the workshops and executed the "minimum effort" for Lean, but some persons had taken more time for experiencing Lean and from those persons the feedback was also more profound. The employees' feedback shows clearly that most of the employees do believe in the Lean concept and they are willing to either use it in daily actions or at least practice some of the methods on a one-off basis. However, some of the employees were not fully convinced of Lean concept and they challenged the measurability and some tools of the concept.

Improvement Opportunities

This chapter summarizes the observations from the empirical interview results and survey results. Observations are then referred to the theories and improvement proposals for the future are presented. This chapter also answers the research questions which all handled separately as follows.

The research questions:

1. How can management help team for increasing Lean awareness and making Lean possible?
2. What are the best practices for growing the team towards Lean way of working?
3. How to improve integration team's performance and throughput?

The first research question "How can management help team for increasing Lean awareness and making Lean possible?" is handled from various perspectives. The following sub-chapters "Research question 1.1–1.3" are all presenting solution propositions for the first research question. The rest of the questions are handled accordingly.

Research Question 1.1: Prospect from management

According to Lean theory the management has very big impact in successful Lean thinking implementation. Womack et al. (2003) describes about the psychological workflow that can be achieved while the work is experienced the most rewarding (Chapter 2.2 Lean Philosophy). In order to achieve good psychological workflow, the management should be able to define clear objectives and vision to the employees (Mann 2005). Survey feedback from the integration team also supports this argument as presented in Table 3. The teams are ready for receiving new ideas for daily work and they also expect management to share the vision and how it links to their daily work.

Womack et al. (2003) also expresses that employees needs clear and immediate feedback on the progress towards the objective. There should be also sense of challenge for the perception that one's skills are adequate to be able to cope the task at hand (Womack et al. 2003). This requires also careful planning from the LPO who is planning the tasks for the Squad. Another important aspect for the managers is transparency (Chapter 2.3.5 Perfection). Whatever decision management does, it should be respectively and transparently shared to employees. Transparency for the actions and decisions is a key principle

The organization management and quality management should consider actions for answering the team's feedback in Figure 12. If 72.4% of the responders are thinking that the quality is not focused enough or not used properly, the actions are needed for a change to better. As seen in Figure 13, the teams are seeing waste in the current organization and they also see unnecessary phases in their work. However, 27% of the responders have not heard of Lean methodology and 62% of the responders haven't got any training for Lean. This feedback also confirms that management could do more for allowing training possibilities for the teams.

The immediate actions after the surveys were to organize Lean/waste and problem-solving workshops, but that may not be enough. Continuous quality efforts are needed covering every level of the organization. Not only the code and end-products should be high-quality, but also planning, decision-making, architectural design, technical leading and project management should be under continuous quality improvement. It is management's task to ensure that quality topics are always on the top priority. Lean thinking provides tools and methodologies to improve quality in all areas.

Research Question 1.2: Long term perspective

For successful Lean implementation, it should be important from the management to highlight that Lean implementation is not one-shot happening, instead of it is rather a cultural change and cultural change takes long time to evolve. This could be highlighted for visualizing the three abstract levels as presented in Figure 9. It should be also emphasized for managers that if the organization's understanding for Lean lies only at the single level, there is a risk than Lean benefits are misunderstood at other levels and Lean principles might be forsaken in the organization. Thus, management should make sure that Lean thinking is adopted in every level of the organization. It is also managements task to bring understanding of the long-term perspective of Lean and quality improvements.

Research Question 1.3: Lean leadership skills needed

As mentioned in the Chapter 2.7 (Lean Culture and Challenges for Taking Lean in Use) the key point for lean implementation is to have committed and skilled leaders who understand the Lean leadership model. The Lean leadership team must be compiled of organization's own personnel. The current organization already has several Lean Six Sigma experts, but they are not always visible in the daily work. Organization should make sure that there are enough skillful Lean specialists, Lean Six Sigma experts and quality specialists who belong to the core team of Lean implementation. This group would understand all the Lean abstract levels as presented in Figure 9. Ristikangas (2008) reminds about the importance of giving enough training for the persons who are nominated in leading Lean activities. Project managers and LPOs should be also trained for Lean thinking. They would not need to be Lean experts, but they need to know the main principles in order to work in Lean way, and also spread Lean thinking among the project teams

Chapter 2.7 (Lean Culture and Challenges for Taking Lean in Use) also discuss about the strong recommendation for teaching the coaching skills for the leaders. Every manager should be interested in coaching, and at least organizing training and coaching if they are not natural trainees by themselves.

Managers should be committed to employee's personal growth and career plans as already pointed out in Chapter 2.7 (Lean Culture and Challenges for Taking Lean in Use). Managers and leaders should also give accurate, exact, and constructive feedback about the improvement actions they make. It is important that the employees can see the improvement change and the results with their own eyes. This way Lean facilitator can create psychological sense for the improvement actions.

Research Question 1.4: Training possibilities

According to Liker & Convis (2012 78–82) the perfection is achievable if organization has well-educated and trained personnel, good equipment, tools, and standards. Management should enable continuous learning in the organization. This can be achieved by giving enough training possibilities for the whole organization and reserve enough time for the trainings. As pointed out in the Chapter 2.4 (Continuous Improvement) every leader and manager should act as a teacher and pass the Lean knowhow to the following generation in the company. It is also important to not establish too complicated and long-lasting planning exercises.

Research Question 1.5: Working environment

Poppendieck (2003) proposes that the organization should do everything to make design team communication as easy as possible. One way is to provide open offices and allow people sitting close to each other's. This makes commuting easier and allows agile way of working. This also removes movement waste and increases feeling of togetherness within the team. Liker & Convis (2012, 82–85) highlights the importance of teamwork since it is essential part for success. Good working environment with functional and decent furnishing, innovation rooms and generally inspiriting and decent workspaces makes Lean possible from workspace perspective.

Research Question 1.6: Organization hierarchy

Organization structures without any managers and flat hierarchy have been popular in 2010–2020's in some organizations. Toyota's approach is different. The Lean concept includes the idea of passing the Lean knowhow from the current experts to the younger generation. As a consequence of that, there are significant number of leaders. At Toyota, there are approximate one leader for every 5 employees. This ensures that the leader's coaching and mentoring possibilities are meaningful, and all the employees gets enough coaching. (Liker & Convis 2012, 92–93.)

This approach is common also in Agile Scrum team setup consisting of Squads with 5–10 persons and the bigger entities (Squad Groups) of consisting several Squads. This setup should be maintained in the current organization and ensure that the size of the Squads or Squad Groups will not grow too big to be able to manage by a single LPO or Squad Group Leader.

Research Question 1.7: Rewarding

In Lean thinking it is also important to reward and recognize the employees who make innovative problem-solving and act in a Lean way. The employees should be emphasized that higher quality itself is an important goal, but improvement actions can also lead to quality awards and successful career opportunities. Acting in a Lean way should have positive impact for their career. (Womack 2003, 122.)

However, Liker & Convis (2012, 10) recommends that leadership team should consider carefully how to reward the employees. Only the most challenging and hard-working outcomes should be rewarded and avoid killing the natural motivation for the work. If the employees are willing to do the tasks anyways and they're also getting well paid compensation of it, there should not be continuous extra rewarding in place for normal duties (Liker & Convis 2012, 10). In Chapter 2.7 (Lean Culture and Challenges for Taking Lean in Use) was also proposed that management should establish rewarding system to keep score of the improvement actions and reward those employees who do things in right way. It is also important to make rewarding transparent.

The organization's rewarding system is already in a good shape, but perhaps small quality awards could be also shared for minor quality improvements. The organization has a tool for this, but in the project haste rewarding is sometimes forgotten. Thus, management and technical leaders should ensure they have enough time in the project schedule reserved for rewarding.

Research Question 2

This chapter discusses the second research question "What are the best practices for growing the team towards Lean way of working?"

If Lean thinking implementation is decided to take in use by the management, the first step is to consist a leadership team who will be in the charge of the implementation. This requires long term planning from the management since full Lean implementation is cultural change which takes long time to evolve. (Chapter 2.7 Lean Culture and Challenges for Taking Lean in Use).

If an organization wants to start with smaller scale Lean implementation, there is a risk that Lean will not be adopted fully, and all the benefits of Lean are not achieved. In such case it is recommended to start Lean implementation with carefully planned experiments. Each company should work out with the Lean details and find out the best ones in their use. Experiments with Lean do not mean that there should be separate Lean activity for each experiment, but instead of there can be continuous improvement actions, adapting new methods, train people and develop the organization culture simultaneously with the similar activities. One way to start is to select an activity like a task or process which is easy to understand, has great visibility and is very important for the organization. This paragraph was based on the theories presented in Chapter 2.7 (Lean Culture and Challenges for Taking Lean in Use).

Many of the proven Lean practices are covered in the theory Chapter 2.3 (Lean Principles). In order to get Lean flow working, the team should define the value and value stream or value streams. The second step is to forget the traditional borders like departments, jobs, careers, or functions. It is important to remove all the impediments that would gate the flow and use standardized process. The third step is to think about the current practices, tools, and stoppages of all sorts. All these three steps should be done together and taken into account for improving the flow (Womack 2003, 52, 54).

As presented in Chapter 2.6 (Learning Organization) the strongest learning experience can be achieved by practicing. Therefore, practice is an essential part of complete learning experience and also important practice for leading the team towards Lean. Employees should have continuous learning opportunities for practice the problem-solving and other Lean methods and tools.

Problem-solving skills are essential for excellent organization and problems-solving process should be embedded in the everyday activity of the existing teams. In addition to that, management, project leaders and technical leaders should give possibility for organizing problem-solving focused Kaizen events or workshops. Teams should also study the concept of PDCA (Plan-Do-Check-Act) and use it in everyday actions. This paragraph's proposals were based on the Chapter 2.5 (Problem-Solving).

It is also important to take in account employee's opinions of the best Lean practices and topics when planning Lean implementation. Team feedback in Table 8 summarizes the employees wishes for the following events: an Ishikawa and A3, in-depth analysis or workshop about "in which phase the problem should have been found", difficult real-life problems to be solved together, in-depth problem-solving workshop or similar hands-on workshop couple of times in every year and trainings on effective use of Kanban board. It was also mentioned that Tribe level trainings are needed. Close manager co-operation is necessary to organize the best trainings.

Research Question 3

This chapter discusses the third research question "How to improve integration team's performance and throughput?"

Integration team's performance and throughput could be significantly improved if the management helps team for increasing Lean awareness as proposed for the first research question. Also, if the best practices mentioned for the second research question would be taken in a use, the organization could grow towards the excellence. While the first and the second questions are focusing for improving the Lean ways mainly from higher perspective, the third research question targets for seeking practical methods that could be implemented in process level at integration team, Squad or in personal level. The same proposals can be applied to other teams or Squad Groups under the study.

Employees' feedback of the current way of working showed room for improvements as Figure 13 and Figure14 presents. Employees feel inefficiency and unnecessary phases in their work, and this is definitely an area in which Lean methods could bring help. Squads and Squad Groups should put effort for analysing their value streams in detail level. They should rise a red flag if they have been asked to do a task with unfinished specification since this might affect "partially done work" waste. They should make sure that the documents are kept short and focus is for high quality. This effort also servers the improvement idea that Seddon (2005, 17–18) has proposed: increase the knowledge of the customer in order to serve them better and thus mitigate the service quality variation. In service organization it is the customer who defines the value of needs. The integration team should understand the surrounding teams and their role as a customer in order to achieve best possible value stream towards them.

If the team members see extra processes, they should report the extra process waste immediately to process and quality owners. The team should be also on the alert if a project management request the team to start implementing features which may not necessarily exist in the final product. This kind of behaviour might lead to "extra features waste" which is reducing the efficiency and motivation of the team. However, in some cases it makes sense to make extra tasks if the purpose is to train or experiment something for learning purposes. The main point is to think about the value.

LPOs should be clever when assigning the tasks to the employees. Every time when a designer must switch from one task to another, significant amount of time and energy is wasted for setting the mindset towards the new tasks causing "task switching" waste. This should be taken in account if multiple tasks are planned for the employees. Waiting has been identified to be the most common waste in several organizations. If any employee ends up waiting something too long, the employee should report this to the managers and project owners and the process must be improved.

Very recommended improvement proposal is to take continues improvement mindset in use among the whole team. Everybody should try to improve the process continuously and take the advanced methods like Poka-Yoke, Jidoka, 5 Whys and PDCA in daily routines.

3.3.4 **Updated Construction Based on the Research Results**

About half of the empirical research was performed remotely due to the COVID-19. This gave exceptional opportunity to study and learn about the success of remote workshops. This was especially the case for the early 2021 surveys and workshops. The latter problem-solving workshops were organized traditional way at the office. Based on the experience of hosting similar kind of workshops both remotely and on-site, author was able to find pros and cons from both approaches.

It was found out that remote workshops are working fine if the employees are already familiar for each other's. But even in remote workshops people should enable video connections to make the participance more presence. On-site workshops are recommended if there are new members in the team or if the team members have not seen each other's for a long time.

During the problem-solving workshops author also got further confirmation about the importance of on-site events. Even though some of the workshops and the lectures were given remotely, the on-site event was seen beneficial and on-site workshops should be organized regularly. Project members and managers should be able to meet face-to-face especially when dealing and solving challenging problems. This observation and feedback are well aligned with Liker & Convis (2012, 32) claim about the importance of visiting the place where actions are happening.

Another observation during the empirical research was related on people behavior in the front of new information. When employees had given an opportunity to try different problem-solving methods freely the outcome was fruitful. It was also noted that the same problem-solving method was not good for all the persons even if the problem was the same. The reason behind this kind of behavior might come from different mental models and way how different persons are handling the problems. Some persons are visual minded, and the Ishikawa works very well for them in all situations. Whether, some like other methods more and visualization do not bring great benefit for them.

As a result of different mental minds, each person's personal character should be taken in account more carefully in the future. Any person should not be forced to use some specific method – no matter how good the method feels by the manager. Instead of, every employee should put more effort for self-development and use that as an input for searching the best Lean or problem-solving methods which suits best exactly for them.

Management could also put effort on this and give employees opportunity to participate self-development courses. It was also found that employees are interested in improving themselves and giving their best for the work if they are given opportunity to participate the improvement processes planning.

An updated construction with three additional observations is illustrated in Figure 18. The observations are “Trust the employees’ desire towards perfection”, “Take in account individualism in planning” and " Remote and hybrid working modes are feasible also in Lean".

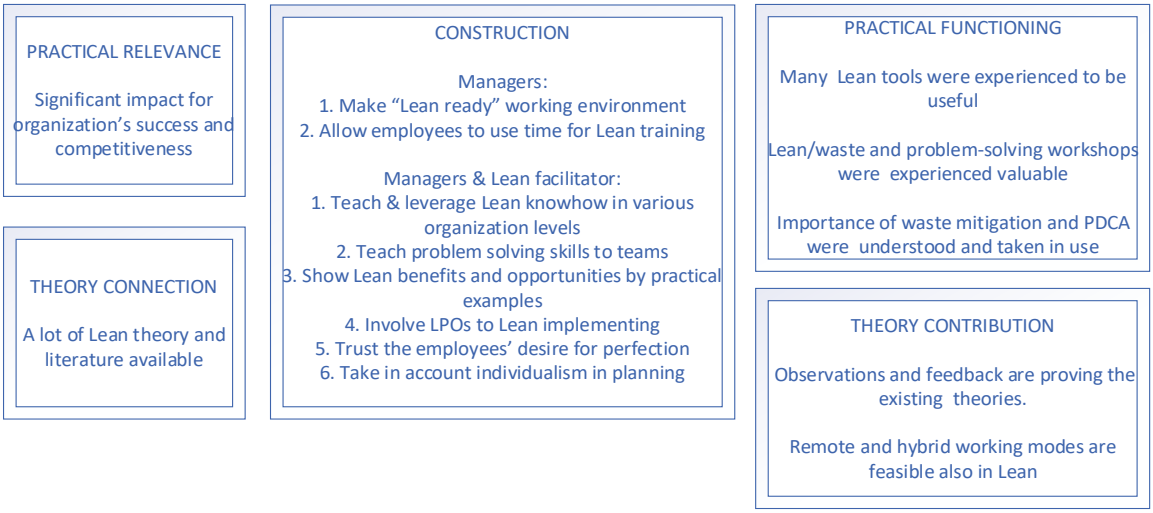

FIGURE 18. Updated construction

4 RESEARCH RESULTS

4.1 Summary of the Results

The research result was creation of a constructive approach, which gives an opportunity to implement Lean principles and methods in wider use in product development. The construction is presented in Figure 18. In the early phase of Lean the implementation requires significant effort from management. It requires a leader who is honestly interested in Lean thinking and ready to teach the basics and benefits of Lean. In the second step it is important to involve quality management, change leaders, education leaders and LPOs, since the message is stronger if a group of people are Lean together. The results are clearly showing that most of the employees are eager to improve the processes and methodologies. They are also very willing to learn and practice new ways of working. This is underlining Senge's (2006, 4, 22, 300) argument that learning skill and willingness is a part of human nature and the best learning experience can be achieved by doing and practicing.

The study also found answers for the research questions, which were seeking solution proposals from three different angles: what can management do for empowering Lean thinking, what are the best practices for Lean implementation, and what are the best everyday Lean tools in the integration team.

4.2 Analysis of Improvement Results

4.2.1 Critical Analysis

The organization under study have had various improvement ventures during the past six years, which have been mainly organized by external specialist and consults companies. Some of the provided methods have been good and they have been taken in use. Some of methods have faded away because the concepts were not extensively adopted, or the employees did not feel to get so excessively benefit out of them.

Even if management and employees are recognizing the sense of Lean, there is a risk that long-term implementation of Lean would not happen, and Lean implementation remains unfinished. The reasons for possible incompleteness might come from too tight project schedules, which leads to the situation in which employees do not have time to study Lean. Higher management can also order to implement some other methodology than Lean thinking. It is also possible that Lean as a word would be replaced by some other "trendy word" and management starts implementing this methodology instead of traditional Lean thinking.

It is noticeable that many of the proposed improvement ideas are already in use in the organization under study. Since the organization have already had several improvement ventures during the past, the best methods might have been already taken in use. The organization already offers leadership trainings, Lean and Six Sigma courses, and large portfolio of tool level trainings for the employees. The importance of rewarding is already understood in the organization and various awards and daily rewarding mechanics are available. The biggest value of this study might be the observation that other employees than managers aka design engineers have not got training for problem-solving methods and overall Lean knowhow was also deficient. Also, the design engineers understanding of waste and value-adding work might not be as high level as experienced technical leads or managers have. Even if the above-mentioned outcomes were the biggest achievements of the thesis, it is still worth of mentioning that the study was seen beneficial for the organization and the author.

4.2.2 **Limitations, Validity and Reliability**

Considering the external validity of the research, it is worth to be understood that the results are not generally applicable outside of the valid organization. Every organization has unique employees' background and organization history which inevitably affect to the results. The second limitation comes from the interview data results, which might have been polarized during the interviews. It is possible that some responders have answered favorably for Lean since the interviewer was their manager. To tackle this problem half of the interviewees were not authors subordinates. The interview itself was unformal and did not follow strictly the predefined Lean questionary (Appendix 7). It was also noticed that some interviewees had not studied the Lean concept nearly at all, but they still answered the questions by some means. This problem was seen only in very few cases. These all above-mentioned limitations affected negatively to the validity.

The survey results internal validity was estimated to be reliable in general level, since the distribution was good, and the questions were carefully set. However, even the survey results were significantly different in different teams. This is underlining the fact that every team is different and consists of different persons from different backgrounds. General reliability of the results is estimated to be good, since every workshop and interview resulted similar positive feedback of the Lean tools. However, deeper level discussions revealed more dispersion in the results. For example, in some day employee might have answered that “5 Why” is the best problem-solving tool, but in another day the answer might have been an Ishikawa.

4.3 Next Steps

The next step is to implement Lean thinking at least in integration team and make sure that Lean principles are followed and understood. Author also recommends Lean implementation to other Squad Groups, Squad level and Tribe level. The organization under study is fruitful playground in terms of any improvement ideas. There is a great deal of interactions between different organizations and teams. It would be interesting for example to analyse the existing value streams, and organizing value stream mapping workshops. Organization also has various problems which could be tried to solve in in-depth problems-solving workshops. This is also a wish from the employees.

Interesting research topic for the future could be to study measurement criteria and Key Performance Indicators (KPI) for the improvement actions. How to measure the benefit and added value when using some Lean or Agile methodologies? The organization should ensure that the root-cause of the problem is firstly identified and then analyzed carefully. The next step is to plan a corrective action and make sure that the effect of the action is measurable with wisely set KPI. Based on the measurements, the action is then judged as positive or negative. In case of positive effect, the organization should take the action in use, make it as a new standard, spread the news about new innovation, and finally celebrate and reward the new way of working. In case of negative effect, nobody should be blamed, and a new round of improvement planning is needed. It should be also ensured that improvement process will not stop since the continuous improvement is an essential part of Lean culture.

5 CONCLUSION

This thesis was made to investigate improvement prospects of a product development organization towards Lean thinking. The main purposes were to develop ways of working in a product development group and to introduce Lean thinking also to wider audience by including horizontal teams partially in the study. The thesis was made for a product development organization, which consists of several organizations and business groups. The target was not to just adapt the Lean tools, but also try to bring Lean philosophy into the awareness of the product development groups under the study. The thesis included structures for an introduction, brief Lean history, Lean theory, empire with the results, research results with critical analysis and the conclusion.

Introduction chapter introduced the research goals, research approach and the structure of the study. The first two research questions were seeking answers for improving the managerial level leading towards Lean thinking. The idea was to find out how Lean ready atmosphere could be created and what are the best practices for growing the teams towards Lean thinking. The third question was seeking practical process level improvements for improving the team level performance.

The theory chapter contained the most common theories for Lean thinking including the principles and methodologies. Lean history was also presented since part of the audience of this study were not necessarily aware of Lean benefits. Proven successful history also gave a more favorable approach for sharing new info in the organization. Theory chapter also introduced practical theories for autonomation, waste mitigation and problems-solving.

The empirical chapter started by describing the research goals and presenting the initial construction which was developed based on the Lean theories and the research questions. The next chapter of the empirical chapter contained the description of the research steps and the research process, which were both described in detail level in order to explain the reasoning behind phases.

After that, the empirical part presented the survey and interview results. Finally, the results of the empirical results were presented containing the improvement proposals for the future and answers for the research questions. The last chapter summarized the results of the study and the results are also reviewed against validity, reliability, and feasibility.

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APPENDICES

TABLE 4. Lean opportunities in our organization. Manager and leader interviews APPENDIX 1

Topic 1	What opportunities do you see for leveraging Lean thinking in our organization?
Manager	I think you have will have a good change for coaching your team into Lean. If it appears to be successful, we could expand it also to other organizations
Manager	I support your idea for leveraging Lean thinking in integration team.
Manager	We have already had Lean trainings in 2017–2018 but it's possible that people have forgot many things. We have also hired lots of new people who don't necessarily have any Lean experience. I support your idea for Lean implementation.
Manager	Lean lessons workshops are excellent idea and also recap of Lean and waste lectures. Could you also host similar sessions for other teams as a part of our annual Quality Circle program?
Leader	I'm willing to help and support you in your journey.
Leader	Lessons learned workshop is at least good idea.

TABLE 5. Interviews of Lean opportunities in our organization, part 1 APPENDIX 2/1

Topic 1	What is your general feedback of Lean?
Leader	I've taken some Lean practices in use personally and also in my group. I'm thinking waste nowadays more often and trying to mitigate it. My team really liked the 5 Whys problem-solving method.
Leader	The concept makes sense and brings value, but it might be difficult to measure the benefit. We should put effort and continue regularly waste mitigation, PDCA and lessons learned events.
Engineer	I don't need Lean lectures or training. I also think that there isn't need for Lean in our organization since we already know all these things. Instead of, you should train our customer organization, since they are lost in their execution.
Engineer	I've been pleased about the Lean lectures and trainings so far. It's good that we are practicing continuous improvement. Especially workshops have been very useful. I didn't have earlier experience of Lean, so I felt this needed.
Manager	I've got very positive feedback from the team members after the Lean trainings and workshops. I also want encouraging people to think about waste and make actions to get rid of it. I'm also using 5 why and Ishikawa problem-solving methods regularly.
Manager	It was interesting to hear about the Lean history and connections to other methodologies. Lean makes sense and the especially the idea of simplify things and make things "Leaner". I've been practicing several ideas of Lean earlier in my career, but without knowing that I'm doing in "Lean way".
Engineer	I liked both workshops and felt them useful. I didn't have earlier experience of Lean. I think the methodologies and principles make sense. I've been thinking about waste and value stream in our workflows. They have been improved during the year. I felt 5 Whys method especially useful.
Engineer	I see that the integration team can benefit of Lean thinking implementation. However, I think that Lean best fits for production. I've experience from root-cause analysis from the previous organization.
Engineer	I think 5 Whys have showed to be efficient tool for solving the problems. We could put more effort for waste mitigation. We've been practicing Kaizen methods unconsciously. we're already using Poka-Yoke methods in the flow scripting. Also, Jidoka have been practiced already long time. Now we know that it's called as Jidoka in Lean.

Leader	Very effective and comprehensive methodology, but following points may make bad effects on the conclusion: 1. when we don't have enough time, 2. under strong pressure, 3. when the conclusion comes first (like recurrence prevention)
Manager	Generally good feedback from the team members

TABLE 6. Interviews of Lean opportunities in our organization, part 2 APPENDIX 3

Topic 1	Which have been the best working concepts in Lean?
Leader	Waste mitigation actions and value stream understanding. Continuous improvement & Kaizen. Team liked PDCA and 5 Why methods. 5S has been alreaydy in use before the workshops.
Leader	PDCA and general Lean concept
Engineer	Unable to name any specific. I haven't familiarized myself with Lean since I already know the best methods on my own.
Engineer	The general Lean concept. 5 Whys, Ishikawa problem-solving methods. We're already using Jidoka. I think A3 could be good in some cases.
Manager	5 Whys & Ishikawa for root cause analysis. Waste mitigation actions also used in several areas.
Manager	Not so much experience yet, but definitely will try the methods in the future
Engineer	5 Whys in problem-solving. We've been using Poka-Yoke and make actions for waste removal.
Engineer	Root cause analysis with 5 Why and Ishikawa
Engineer	5 Whys, Poka-yoke and Jidoka have been used in unconsciously
Leader	We are following 5S, PDCA and Kaizen in daily work like feature builds and backlog management. Fortunately, we haven't got yet in bugs our unit. When we have any bug, we are going to have 5 Whys and Ishikawa method to reserve the time and effort. Jidoka is always in use.
Manager	I've heard them using several problem-solving methods

TABLE 7. Interviews of Lean opportunities in our organization, part 3 APPENDIX 4

Topic 1	Which have been the worst working concepts in Lean?
Leader	I can't tell since we haven't yet tried all the methods.
Leader	We couldn't link 5S easily to office work. I'm not fancy of all Agile concepts. It's difficult to measure which methods are good and which are bad.
Engineer	I don't generally understand the need for Lean trainings. However, I haven't tried any of these since I'm using my own methods.
Engineer	5S and Poka-Yoke. It's difficult to adapt these to our R&D area.
Manager, Manager, Engineer, leader	I can't tell any
Engineer	I can't tell since we haven't yet tried all the methods.
Engineer	5S

TABLE 8. Interviews of Lean opportunities in our organization, part 4 APPENDIX 5/1

Topic 1	What kind of trainings you'd like the organization to organize in the future?
Leader	I'd like to have a change to try out Ishikawa and A3. Recap session of all the methods and principles would be good.
Leader	Would be good to continue trainings of the Lean topics. Could we have some in-depth analysis or workshop about "in which phase the problem should have been found". Would Lean have had some "remedy" for avoiding the problem in the first place.
Engineer	I don't like the idea that organization tries to train everybody to follow some specific methodology. Instead of general trainings we should have workshop for solving the most difficult problems
Engineer	Problem-solving workshop or similar hands-on workshop could be arranged couple of times in every year. How about Lean exhibition at the Tribe level with relaxed evening event. Self-study videos are not the most effective.
Manager	Continuous improvement trainings. Trainings on effective use of Kanban board.
Manager	Tribe level trainings are needed. I've seen that there is some resistance among the teams since new things and ideas are sometimes felt frightening. Close manager co-operation is necessary to organize the best trainings. Let's start improvements step-by-step. It's important to have something concrete and trainings which really have value.
Engineer	Value stream mapping. Another problem-solving workshop would be also good. We could take some difficult real-life problem and try to solve it together. It's important to learn the theory, but theory combined with practical workshop would be the best.
Engineer	Problem-solving and root-cause workshops.
Engineer	Training of the best ways for scheduling and time management. Theory of psychological behavior and people types.
Leader	Somehow, we want to survive with small and appropriate resources to avoid the mistakes: Poka-yoke, Jidoka, Waste removal. I would like to see bug reports and its recurrence prevention measures in whole organization. Also, DFMEA: how much the existing code is evaluated (simulation? end-product? Market?). Change point: What is the effect by that change point (small malfunction? Critical case?)

Manager	Another quick session with the same focus (Lean/waste), to have more experience. Maybe shorter introduction? How the Lean (or other principles/subjects) should be seen in our everyday work in practice, now it felt still a little bit abstract and more like a management thing. Maybe also some practical tips on how to improve, for example from other teams etc. More practical/everyday work topics

Partially done work is something that is started, but not finished properly. There might have been a need to do the work and even specification might have been available, but if the work outcome is not integrated or otherwise taken in use, then the activity has been waste of time. Writing a code for something that is not eventually going to be used is waste of time and resources. Also, if the code is not verified properly, the corporation takes significant financial risk for the final product. (Poppendieck M & T 2003.)

Extra Processes

Many software development phases might need paperwork or documenting. It is worth of asking whether all these paperwork phases really add value. There might be value if there are customers for the documents, but no documents should be created just because the process defines so. If the paperwork adds value for the customer, the documents should be kept short and focus on high quality. (Poppendieck M & T 2003.)

Extra Features

Designer might be keen to add extra features to the code just for fun and curiosity. This is dangerous since every bit and piece should be also verified and maintained in the future. It is also possible that extra features cause unpredictable behavior and makes code more complicated than anticipated. If the extra code is not needed now, it should not be added to the system. (Poppendieck M & T 2003.)

Multitasking can be sometimes necessary for some of the employees but assigning people specifically to multiple projects is a source of waste. Every time when designer have to which a task from one to another, significant amount of time and energy is wasted for setting the mindset towards the new tasks. Also belonging to multiple teams is inefficient since it usually causes more interrupts and thus more waste. It might be attractive to start multiple projects at the same time and share resources between the both projects, but this has been showed to be ineffective way. Better way would be to have dedicated designers for each project and let them also finish the job. (Poppendieck M & T 2003.)

Waiting

Waiting is one of the biggest waste sources is SW industry. Waiting is difficult to be entirely avoided, but every process and handovers should be planned so that waiting times are minimized. Delays can be seen when starting the project and selecting the staff. Delays in reviews and approval phases are also very common. Delays are especially harmful if competitors are already ahead in the market and customers are waiting delivery to be happened so that they can realize the value on their side. All kind of delay and waiting is waste and should be avoided. (Poppendieck M & T 2003.)

Motion

Motion waste in SW industry appears in the situations when designers need to find information, but the information could not be found or reached easily. In this situation designer have to use extra motion to find the information. The Agile way for mitigating this is to make design team communication as easy as possible and use for example open offices. In these kind of single rooms people are sitting close to each other's and asking help from colleague is easier. (Poppendieck M & T 2003.)

Another example of motion waste is moving artifacts from one team to another. This can be improperly handovered documents or other data. For example, if the requirements handover from one team to another is not handled wisely, great amount of motion waste is generated. Care should be taken that every document serves the receiver as good as possible and contains all the information that the next person in the line needs. (Poppendieck M & T 2003.)

Defects

High quality for the customer should be the key object on everything that happens during the project cycle. High quality is the best way to avoid defects and expensive corrective actions which might be needed to fix the defects.

In the SW industry critical defects are not big source of waste if they are found quickly. But if some minor defects are staying hidden for long period of time, they can be considerable bigger waste. To reduce defect waste in SW industry, code should be integrated often and tested immediately and release to production as soon as possible. (Poppendieck M & T 2003.)

Questionary of Lean APPENDIX 7

I would like to get your feedback of Lean. During the years 2021–2022 we have had various workshops and presentations of Lean and quality. My next step is to collect the feedback and use that data in my master's thesis. Your feedback would be very appreciated.

I'm going to ask following questions:

1. What is your overall feedback about Lean thinking and methodology?

2. Manager / LPO: Have you got feedback of the following methods from your team? If yes, which of the methods have worked the best? Engineer: What is your feedback of the following methods?

Lean/waste presentations & workshop

- 5S
- Poka-Yoke
- Jidoka
- Waste removal
- Value stream mapping
- Kaizen & continuous improvement
- PDCA

Problem-solving methods and workshop

- "PDCA"
- 5 Whys
- Ishikawa
- A3

3. Area some of the previously mentioned methods unusable or unsuitable for yourself or your team? Is the purpose of the previously mentioned methods unclear for yourself or your team?

4. Which of the previously mentioned methods you'd be willing to leverage in your team or take wider use by yourself?

5. What kind of Lean and quality event you'd like to participate in our organization? Would you be also willing to share your own best practices?

Thank you!

Harri