How to improve a Craftsmanship?

A case study on applying Lean Six Sigma in a Small to Medium enterprise with highly specialized production processes

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A case study on applying Lean Six Sigma in a Small to Medium enterprise with highly specialized production processes.

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Abstract

To keep up with the pace of the markets, companies have to continuously look for improvements in their processes. And while this is true for both large and Small-to-Medium enterprises (SME), it is often significantly harder for the latter to find and implement the proper method for improving their businesses. Especially so when this SME is dependent on very specialised employees in their production processes. This study focusses on applying and evaluating a framework that allows these Specialized Production SMEs (or SP-SMEs) to implement a well-known business process improvement method called Lean Six Sigma (LSS). The aim is to find an answer to the question what are the lessons learned when a SP-SMEs adopts LSS to improve their business processes? This study starts by performing a Systematic Literature Review to identify success and failure factors for LSS implementation and to find a feasible framework to implement LSS. It then continues to evaluate this framework in an orthopaedic shoe manufacturing company, to evaluate its applicability in the SP-SME context.

The SLR identified a feasible framework from Abbes et al. (2018) that was fit for this context, it proposes a PDCA inside DMAIC framework. Moreover, it found 12 important success factors for LSS implementation. The results of the case study show that this framework is indeed largely applicable with only minor revisions, namely adding Process mapping and '5 why' as tools and dropping the SMED. Moreover, the pareto tool should be restricted to the measurement and analysis phase whilst Kaizen should be integrated throughout the project rather than in a single phase. A slightly revised framework is proposed in the end that includes these recommendations. This framework can allow SP-SMEs to improve their business processes to get ahead of their competition. Other than that, 4 of the 12 aforementioned success factors proved most relevant for the SP-SME context. They are: LSS and data strategy, Tool selection and prioritisation, Employee involvement and resistance management, and Top management support. Future research could look into making this framework applicable to a wider range of SME contexts and/or challenges.

Keywords: Lean Six Sigma, Small-to-Medium Enterprises, Craftsmanship, Business process improvement

Executive Summary

A business that does not improve will fall behind on its competitors, it is therefore crucial for businesses of all sizes and operating in all kinds of markets to continuously look for improvements. This thesis describes a case study on the implementation of Lean Six Sigma (LSS) in Small-to- Medium Enterprises (SMEs). Specifically, it focusses on companies that have production processes that require highly skilled employees, this group of companies is further referred to as Specialised Production SMEs (SP-SMEs). The general aim is to provide insight for both researchers and practitioners on what challenges these companies are likely to face and how they can be overcome. A framework was fine-tuned and evaluated that can aid these companies in improving their business processes. It was evaluated at an orthopaedic shoe manufacturing company. More specifically on their last manufacturing process, since this is a very time- and resource-consuming part of the production process, and it is very error prone. The last is a wooden foot-like structure that is used for the production of the actual shoe. The general research question for this study is:

What are the lessons learned when a SP-SMEs adopts LSS to improve their business processes?

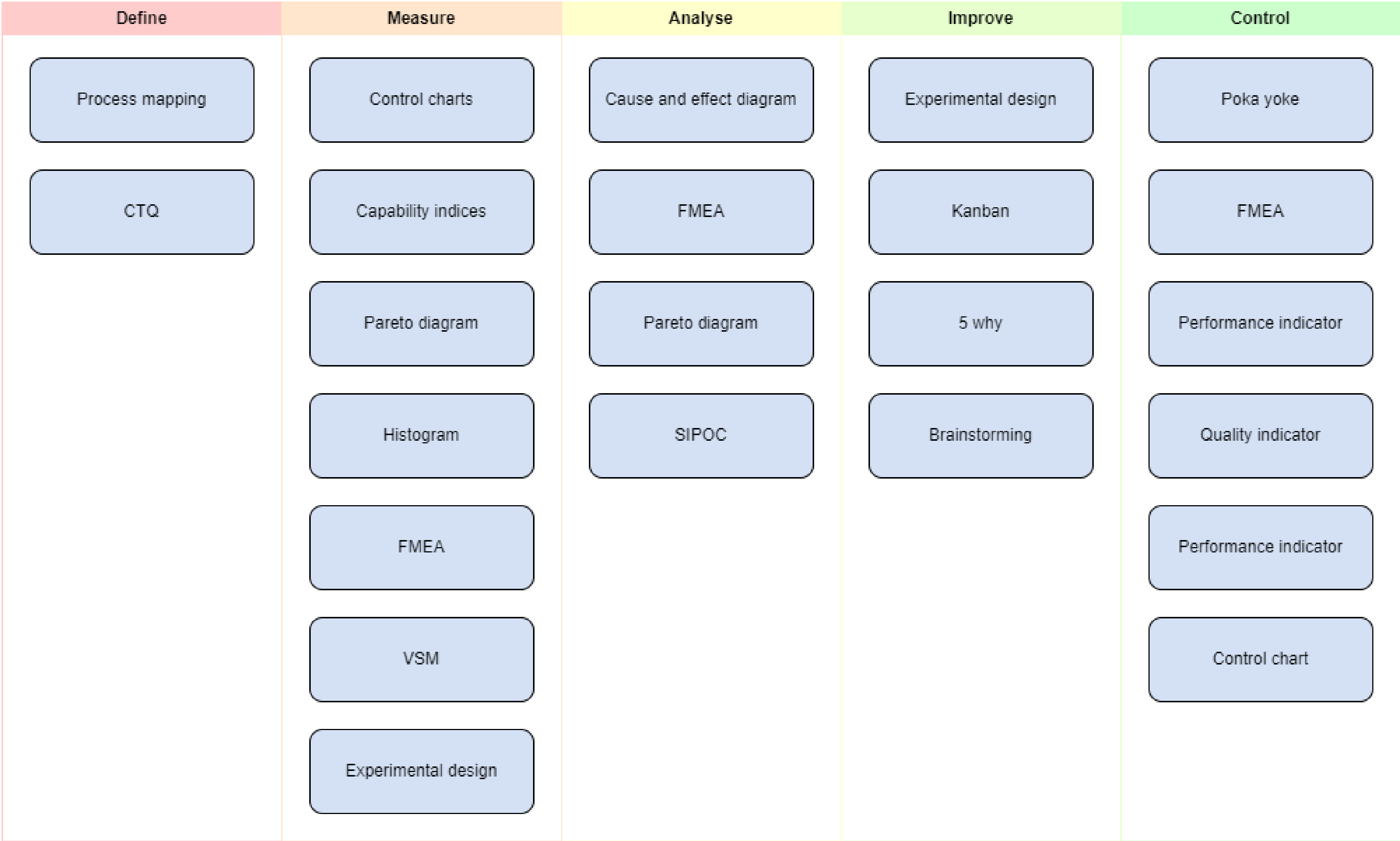
First, this study looks into the frameworks, and success and failure factors that are previously described in the literature. A framework called PDCA-applied-to-DMAIC (further to be referred to as PDCA-in-DMAIC), was found fit for the SP-SME context. PDCA stands for Plan, Do, Check, and Act, this is a common cycle used in Business process improvement methods all around. The DMAIC cycle stands for Define, Measure, Analyse, Improve, and Control, this cycle is the go-to cycle for applying LSS. The combination of these cycles should thus provide a powerful framework. A more elaborate explanation of these steps is provided in section 4.1. A set of 12 success factors was identified, these are: Alignment of LSS with the Organisational Strategy, Ensure Top Management Support, LSS Project Selection and Prioritisation, Clear Goals and Expectations of the LSS Project, Effective Training and Design of Curriculum for different LSS Roles, Development of Reward and Recognition System, LSS Leadership & Culture, LSS and Data Strategy, Proper Tool Selection and Knowledge on Tool Usage, Linking LSS to Customer and Employee Needs, Employee Involvement and Resistance Management, and Ensure Infrastructure and Resources for Project. Both the framework and success factors were evaluated in the following stages of this study.

During the implementation of the framework in the case company, a couple of root-causes for the production errors were defined by the implementation team. The first one was improper planning, and the other one was poor data transfer. The following phases continued to develop three viable solutions for these root-causes, these were new appointment types, changing the forms used for gathering data, and implementing a 3D scanner. Eventually two of these solutions were successfully implemented, only the improved form usage was not. This was due the fact that collaborating with the supplier was exceedingly difficult and delayed the implementation. The other two solutions decreased the number of mistakes by approximately 10% based on the sigma calculation from the analyse and improvement phases. Moreover, the number of wrong appointments decreased by 17% over a 2-month average and lead time was reduced by 2-4 weeks. The case company is advised roll-out the usage of the 3D scanner further since it reduces the number of mistakes. The appointment types have already been rolled out over the entire organisation.

The implementation showed that with some slight changes the framework was very useful to implement LSS in an SP-SME context, the final framework is depicted in ES Figure 1. Moreover, the most important success factors for this case turned out to be:

- Accurately mapping out the LSS and data strategy. This became evident since LSS has an inherently high data requirement. This can be harder for SMEs.
- Tool selection and prioritisation since wrong tools waste time and can distract or provide inaccurate insights.
- Employee involvement and resistance management, because specialists in particular can be resistant towards new processes.
- Top management support because the project can have overly broad and influential impact on the company. Explicit managerial support can improve the process.

In conclusion, implementing LSS is a particularly useful alternative for SP-SME companies to improve their processes. They can increase their efficiency and stay competitive. In order to do this, they can use the PDCA-in-DMAIC framework that is depicted in ES Figure 1. The tools used for this framework are explained in section 4.3, the tools that are added in this study are explained in section 6.1.2, they are process mapping and the 5 why method. It is important to keep the previously mentioned success factors in mind to ensure the project is completed with success. Moreover, it is crucial to realise that LSS should not be limited to a single project. It should be adopted by the entire organisation to ensure continuous improvement now, and in the future. This framework will help them to get started and enables them to roll it out over their entire organisation over time.



ES Figure 1: The final recommended framework for the SP-SME context

Table of contents

List of Figures

List of Tables

List of Abbreviations

Abbreviation	Definition
ABI	American Biographical Institute
AM	Additive manufacturing
ANOVA	Analysis Of Variance
BPI	Business Process Improvement
BPM	Business Process Management
BPR	Business Process Redesign
CAD	Computer Aided Design
CEO	Chief Executive Officer
CTQ	Critical To Quality
DMAIC	Define, Measure, Analyse, Improve, & Control
DPMO	Defects Per Million Opportunities
ES	Executive Summary
FMEA	Failure Mode Effect Analysis
HF	Hanssen Footcare
HOR	House Of Risk
HR	Human Resources
IT	Information Technology
KPI	Key Performance Indicator
LCL	Lower Confidence Limit
LSL	Lower Specification Limit
LSS	Lean Six Sigma
MT	Management Team
OSA	Orthopaedic Shoe A
OSB	Orthopaedic Shoe B
OSC	Orthopaedic Shoe C
OST	Orthopaedic Shoe Technician
PAUC	Project selection, Undertake, Analysis & Control
PCI	Performance Capability Index
PDCA	Plan, Do, Check & Act
PLC	Project Life Cycles
RPN	Risk Priority Number
SIPOC	Supplier, Input, Process, Outcome & Customer
SLR	Systematic Literature Review
SME	Small-to-Medium Enterprise
SMED	Single Minute Exchange of Dies
SP	Specialised Production
SS	Six Sigma
TQM	Total Quality Management
TUE	Technical University Eindhoven
UCL	Upper Confidence Limit
USL	Upper Specification Limit
VLOS	Voorlopige Orthopedische Schoen (Temporary Orthopaedic Shoe)
VOC	Voice Of Customer
VSM	Value Stream Management

1. Introduction

In order to keep up with the fast pace of development of the world, companies have to continuously improve their business. The topic of Business Process Improvement (BPI) has therefore gotten a lot of attention from both businesses and researchers since it touches nearly every aspect of an organisation, from day-to-day operations to their long-term strategic planning (Schäfermeyer & Rosenkranz, 2012). At its core, the goal of BPI is to make an organization's processes more efficient and effective, which can lead to cost savings, improved customer satisfaction, and a more agile and responsive organization overall. Implementing BPI can be a complex and challenging task, but with the right approach and tools, it can lead to significant benefits for any organization (Davenport et al., 2004). A wide range of studies has been conducted over the previous years that aimed to describe and/or formulate the best approaches and tools for this purpose. Step by step, this literature helped businesses and other researchers to further improve BPI as a whole.

1.1 Business Process Improvement

For centuries companies have been developing and improving their business processes, this helps these companies to keep up with the pace of the markets, adapt to changing market environments, decrease costs, get ahead of competitors, and more (Harrington, 1991). The number of methods has grown exponentially over the years and has a wide range of goals and applications. Examples of Business Process Improvement (BPI) methods are, Lean, Business Process redesign, Business Process Reengineering (BPR), Total Quality Management (TQM), Core process redesign, Business restructuring, Continuous improvement process, Six Sigma, and many others (Zellner, 2011). In addition, there have been many studies that refined these methods to make them better. Entire branches have specialised on implementing these methods and coaching companies to successfully adopt them into their daily business. It has increased the productivity and profitability of many companies and therefore helped to create better and more efficient organisations (Romanowski et al., 2013). The field of business process improvement is focused on analysing and enhancing the ways in which businesses operate to increase efficiency, reduce costs, and improve overall performance. One of the most popular methods is called Lean Six Sigma (LSS) and as the name suggests it is a combination of Lean and Six Sigma, wherein the latter is derived from the Total Quality management school of thought. It is a proven powerful combination that has many success stories. Which is one of the reasons (more will be discussed later on) why this thesis focusses on this method in particular. This thesis explores the various methods and strategies used in LSS, as well as the benefits and potential challenges of implementing such changes in an organization. An elaborate review on the various methods is provided in the Lean Six Sigma Rationale section (3.1) in Chapter 3.

1.2 Business Process Improvement in Small to Medium Enterprises

First, it is important to realise that implementing LSS can quickly become a complicated endeavour, a company leader responsible for this task once said:

"…it's more of a matrixed organization, in that as the [Lean Six Sigma leader] for the health system, there are individuals on my team within [the Lean department]. There are five Black Belts and Master Black Belts. At the entities, there are various levels of Lean adoption and infrastructure. So, the [specific hospital] has a staff of three with one director who has a dotted line to me. And [the leader] has two direct reports. And then there is an individual who is at [another hospital] who does not have any direct reports. And one at [a third location] with a dotted line that doesn't have any direct reports. The [two main hospitals] are supported through the Central [office] staff." Brown (2021)

Being able to create a Lean department, freeing up resources to train multiple employees in LSS thinking and coaching, using external resources are some of the success factors mentioned in Brown's (2021) study. These aspects require a significant investment in both time and resources for the company. When considering implementation risk and success factors, it is often reported that organisational readiness, project priority, effective communication and inclusion, managerial dedication and support, resource facilitation, and/or proper BPI knowledge are critical for a successful project (Mishra, 2018; Brown, 2021; Panayiotou et al., 2021; Albliwi et al., 2014). Moreover, a lack of these factors can lead to increased resistance towards the project and possibly cause it to fail, estimations are that 37% of BPI projects eventually fail (Weber, 2015 as cited in Brown, 2021), although some sources reported a significantly higher number. It is probable that this percentage is even higher for Small-to-Medium enterprises (SMEs), since they have less resources and knowledge to successfully evaluate, design, and maintain their new business processes (Imanipouri et al., 2012). Moreover, the majority of the papers overlook these SME specific problems since they focus on large enterprises (Prakash et al., 2021). In the SME context, employee inclusion and training becomes increasingly important since they have to cooperate even more to meet the resource requirements for a successful project (Panayiotou et al., 2021). Therefore, it becomes even more crucial to have the middle and lower managers on board. Since if they resist change, the project becomes extremely hard to complete. This is more so the case when these lower and middle managers are (working with) highly specialized employees (Hayes, 2014).

1.3 Problem Description

All the aforementioned factors, namely limited knowledge and resources on SME BPI methods such as LSS, the specific challenges for SMEs to perform BPI/LSS projects, and the increasing challenge of resistance when collaborating with specialists make it a relevant topic. Combined with the knowledge that SMEs represent about 90% of businesses and 50% of employment worldwide (World Bank, n.d.), it is societally relevant to enable them to improve their businesses. This unique set of challenges is often seen in craft, healthcare, and/or technically sophisticated manufacturing SMEs and often hinder their advances in improving their businesses. This specific SME context will further be referred to as specialised production driven SMEs, or SP-SMEs for short. A thorough analysis of these challenges and providing a possible solution can benefit these companies, their employees, and the broader society.

1.4 Research Gap

As previously mentioned, and as discussed in Chapter 3, there is an extensive amount of literature on the implementation of LSS and its success/failure factors (Mishra, 2018; Brown, 2021; Panayiotou et al., 2021; Albliwi et al., 2014). In the recent years, there has been in significant growth of literature on implementing LSS in SMEs. However, there is little known about the effects of specialised production processes and how they play a role in implementing LSS. The intuitive nature of the crafts of their employees can hinder the analysis and standardisation of the processes since it can be harder to explain to reasons for change to get their support (Lawrence, 1969). It is therefore important to include them in the design and execution of the new processes in order to reduce resistance, whilst keeping a check on the wide range of interests of the stakeholders (Hayes, 2014). These challenges accumulate in the pre-defined SP-SME context. This thesis therefore considers this aspect of the LSS implementation project and defines what challenges and opportunities the SP-SMEs can offer for a successful implementation.

1.5 Research goals and questions

In order to add to the existing literature on LSS and BPI in general, this thesis aims to describe the unique set of challenges and a solution for implementing LSS in a SP-SME. This description will be formulated based on the findings of a case study on the implementation of LSS in a SP-SME. The goal of this case study is thus to describe the challenges that arise during the implementation and their solutions in order to add to the knowledge about this topic or in other words; what are the lessons learned.

1.5.1 Research Questions

For the purpose of meeting the previously described goals, namely studying the unique set of challenges and opportunities related to implementing LSS in a SP-SME context, this study contains two parts. The first part is a literature review on the current state of the knowledge in this domain. The second part is a case study where the knowledge is used to implement LSS in the predefined context. For this study as a whole, a broad research question was defined:

What are the lessons learned when a SP-SMEs adopts LSS to improve their business processes?

In order to answer this question in a satisfying manner, it is split up into two parts, a set of review questions and a set of case study questions. The first part is purely based on the theoretical knowledge coming from the literature. This set of questions, hence to be referred to as review questions, will be answered by the Systematic Literature Review (SLR) in Chapter 3. They focus solely on identifying a feasible framework for the case study and the success and/or failure factors described in other studies. The review question for finding a framework is as follows:

1. *What are feasible Frameworks for LSS implementation in a SP-SME context in the current literature?*

In order to answer this question more effectively, it is divided into two sub-questions that focus on both the steps used in these frameworks and their (dis)advantages. They are formulated as follows:

1.1 What steps are described in the frameworks from the literature?

1.2 What are the distinct (dis)advantages of these frameworks?

In addition to this set of questions, another main review question was formulated that focussed on the crucial success and/or failure factors of implementing Lean and/or Six Sigma. The reasoning for including both Lean and/or Six Sigma in this question is that lessons learned in either of these methods are likely to apply in their combination, since the tools and steps used in LSS come from either Lean or Six Sigma. This question is:

2. *What are the most relevant success and failure factors described in the current literature for Lean and/or Six Sigma implementation projects?*

The second set of questions is focussed on extracting the lessons learned from the case study. They focus on evaluating the framework and the extent to which certain success factors are relevant in this context. Considering the framework, the following case study questions are formulated:

3. *How well does the framework perform in implementing LSS in a SP-SME context?*
4. *What aspects of the framework are better or worse equipped to deal with the specific challenges coming from the SP-SME context?*

The answer to the first case study question is quantitative in nature and focusses purely on the realised improvements in the company. The second question, however, evaluates the framework in order to aid future research in improving the framework. Furthermore, a final case study question is formulated that aims to assess what success factors are most important in the context of this case study. This question also concerns the failure factors but later in this study failure factors are reformulated into success factors. Therefore, it is formulated as:

5. *Which of the previously defined Success Factors are most important when implementing LSS in a SP-SME?*

Over the following chapters, the aforementioned research questions are studied, and an answer is formulated. The set of review questions, namely 1 (with 1.1 and 1.2) and 2 was studied by means of a SLR. The SLR procedure is described in section 0, whereas its findings are described in the chapter 3. The set of case study questions, being 3, 4, and 5 were studied with a case study. The description of this case study can be found in section 2.2, The findings from this case study are described in chapter 6. This chapter combines all insights from the case study. Chapter 7 continues to provide a concrete answer to the general research question. An overview of which question is answered in which section is provided in Table 1.

1.5.2 Scientific Contribution

As mentioned in previous sections, the aim is to evaluate a framework for implementing Lean Six Sigma in a SP-SME context. This framework is evaluated in an orthopaedic shoe manufacturing company, where a lot of tailor-made products are produced by specialists on a daily basis. This allows the theoretical bases of this framework to be evaluated in an extended range of practices.

Table 1: Overview of Research questions and the sections they are answered in.

Research question	Part of	Chapter	Section
Main research question	Entire study	7	7
Research question 1 (with 1.1 & 1.2)	Systematic Literature Review	3	3.2.2
Research question 2	Systematic Literature Review	3	3.2.3
Research question 3	Case study	6	6.2.1
Research question 4	Case study	6	6.2.2
Research question 5	Case study	6	6.2.3

In addition, the success and failure factors found in previous studies and different contexts are assessed against the unique set of challenges incorporated in this study. This thesis offers more insight into how these factors come to surface and what mechanisms are most effective in combating/including them. Thus, this thesis functions as an extension of the literature on success and failure factors in implementing LSS, and it broadens the scope of the framework used for the implementation by implementing it in the SP-SME context.

1.6 Report Outline

The following chapter (3) of this report contains the methodology for both the SLR and case study. Chapter 3 describes the findings of the Systematic Literature Review (SLR) conducted in advance of the case study. Since the protocol and methodology have already been described, this chapter mainly focusses on the insights coming from the SLR. These findings provide the framework for implementing LSS and the crucial success factors. Chapter 4 gives a more in-depth overview of the chosen framework (section 4.1), the proposed use (section 4.2), and its tools (section 4.3). Chapter 5 provides an overview of the actual LSS implementation based on the DMAIC steps of LSS (sections 5.2, 5.3, 5.4, 5.5, and 5.6) and the interviews done post implementation (5.7). The findings of the case study are summarised in the following chapter 6. Chapter 7 formulates an answer to the research question and concludes this study.

2. Methodology

This chapter provides a detailed overview of the methodology for this study. As previously mentioned, the SLR was conducted in advance of the actual case study. Therefore, the SLR is discussed first. Figure 1 gives a visual overview of said methodology.

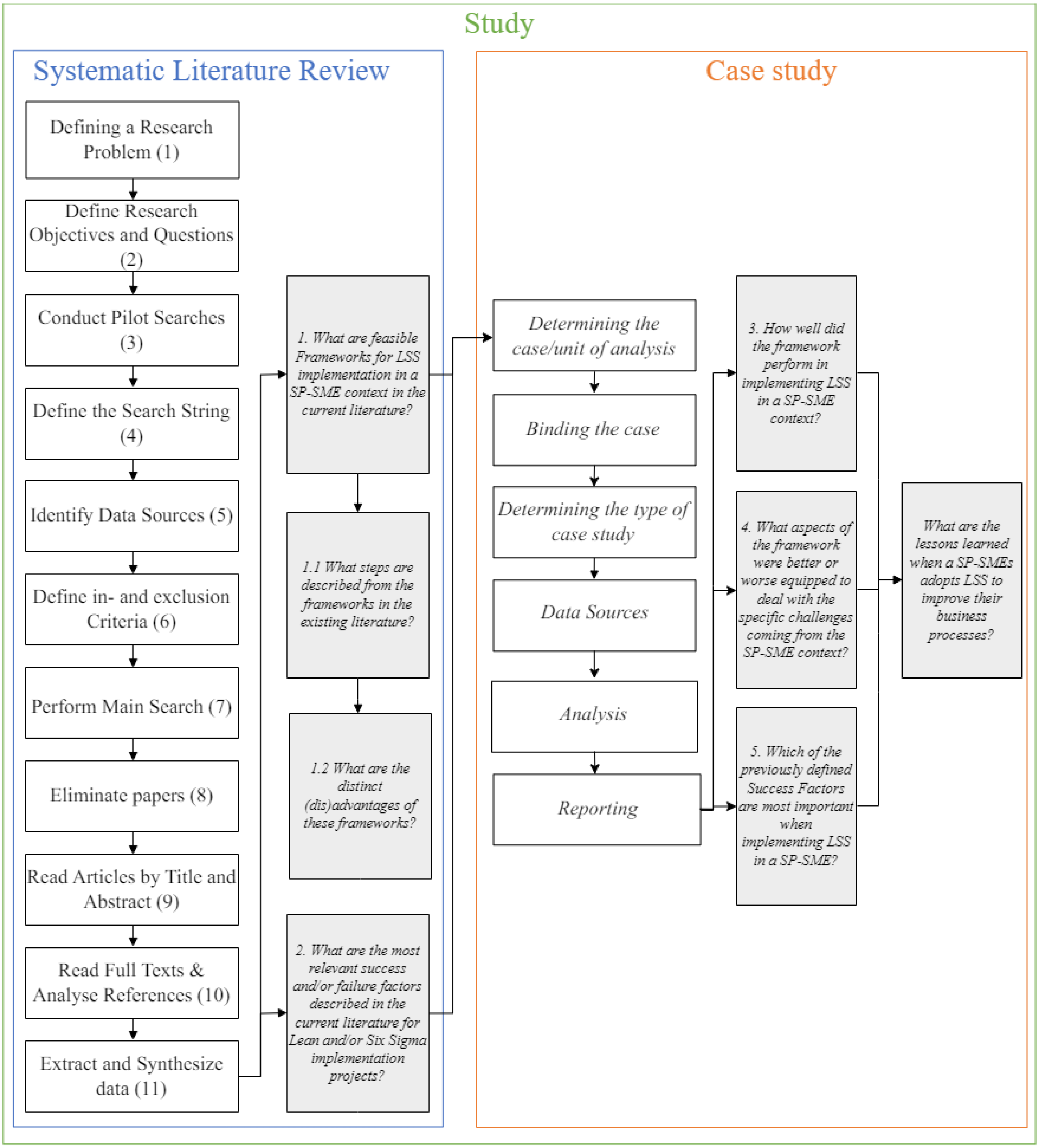


Figure 1: Visual overview of the methodology for this study.

2.1 Systematic Literature Review

The SLR focussed on finding a feasible framework for the case study later on, as to identify critical success and/or failure factors in LSS implementation. The SLR was conducted based on the guidelines described by Kitchenham and Charles (2007). Accordingly, the following steps are identified; Defining a Research Problem (1), Define Research Objectives and Questions (2), Conduct Pilot Searches (3), Define the Search String (4), Identify Data Sources (5), Define in- and exclusion Criteria (6), Perform Main Search (7), Eliminate papers (8), Read Articles by Title, Abstract, and Keywords (9), Read Full Texts & Analyse References (10), and Extract and Synthesize data (11). These steps are followed when describing the protocol in the following sections. They are integrated into the general guidelines from Kitchenham and Charles (2007) on reporting a SLR. Their suggestions on reporting are built up as follows; describe the Requirement (Step 1), the Methodology, the Review Questions (Step 2), the Review Protocol (Step 3 to 10), the Results (step 11), the Conclusion, and finally the Discussion. The Requirement and methodology are described in this section. The review question is already defined in section 1.5.1. The protocol is discussed in their respective order in the following section (2.1.1) and chapter 3 discusses the actual search the results.

2.1.1 Review Protocol

In order to ensure reproducibility of the SLR in future studies, it is important to define the protocol for reviewing on forehand. Moreover, this protocol contains the search terms and resources used for the SLR. The resources are defined as the libraries, journal, and conference proceedings that are included in the search. For this SLR, a string was created based on four aspects of the general research question, these are Lean Six Sigma (LSS), Small to Medium Enterprises (SMEs), Implementation, and Craftsmanship (also described as specialised production). A couple of pilot searches were conducted in order to find the most relevant terms and synonyms for this SLR (step 3). These are based upon searches in the Proquest database since this was the most effective database, the next paragraph goes more into depth into the choice of databases. First, it is important to define the final search string coming from the proposed search terms (step 4). Note that the string only contained a combination of Lean and Six Sigma rather than both separate terms, this was to avoid results focussed on either one of these methodologies. Even with this combination of terms, the results showed a substantial proportion of papers focussed on only one aspect. In the correct notation, the following search string was formulated:

('small enterprise' OR 'medium enterprise*' OR 'small to medium enterprise*' OR 'small compan*' OR 'medium compan*' OR 'small business*' OR 'medium business*') AND ('lean six sigma' OR LSS) AND (Adopt* OR implement* OR apply OR application OR utilisation OR usage) AND (Specialist* OR expert* OR craftsman*)*

An overview of the used resources for this SLR is shown in Table 2. Since they did not provide additional sources, both SpringerLink and JSTOR were not included for further analysis. Because the Proquest database is mainly based on the Business Premium collection (ABI/INFORM, JP Morgan and such), Google Scholar was also used for gathering additional literature. In order to narrow down the number of hits, certain selection criteria were defined.

These selection criteria were evaluated with several pilot searches in order to assess their feasibility (step 6). After a couple of iterations, the main search was conducted in Proquest and Google Scholar (step 7). First, Full-text availability was used as a criterion, this option was not available for Google Scholar. Moreover, only scholarly journals and theses & dissertations were included for further analysis, since other sources were deemed to be irrelevant in a lot of cases (or beyond the aim of this SLR). Furthermore, in order to ensure the most recent insights, only papers from the last 5 years were included for further analysis (step 8). Exceptions to this criterion were made for additional sources that were found by either front- or back referring strategies, meaning sources found while reading papers or citations.

However, since Google Scholar did not provide the same filter alternatives as Proquest, a manual analysis was done on these results. This was after the selection of papers from the Proquest database was finished and was done by manually going over the first 50 pages of results of the Google Scholar results. The results were compared and analysed on the same criteria as the Proquest results. It was found that the Google Scholar results seemed to correlate highly with the Proquest results in the first pages of the search, only for review articles it provided a substantial number of extra results. Therefore, it was mainly used for this purpose. This part of selection had fewer specific criteria in order to define the applicability of the papers to this SLR. The selection took place based on the Title and abstracts of the papers (step 9). Criteria in this process were papers aimed at irrelevant sectors (such as retail, administration, mining, governmental, insurance, loans, and others), comparative studies of LSS against other methods, studies done on irrelevant markets (developing nations), and studies not focussed on implementation. On the others hand, there were also some inclusion criteria for papers not directly relevant but taken into consideration in the case of lacking literature. These were: related methods (such as Kaizen, Poka Yoka, etc. or broader groups of methods such as TQM) and papers about Lean (since they often still used Six Sigma). These in- and exclusion criteria were predetermined and developed during the pilot searches performed in advance of the actual search. In some cases, exemptions were made on the premise that the article in question provided a strong or well-founded framework for implementing LSS.

Table 2: Overview of the Resources used in the SLR.

Data source	Documentation
Digital library	Name: Proquest Search date: 4th October 2022 Search strategy: String Search criteria: Journal papers, Thesis, and dissertations Years covered: 2017 -2022
Academic search engine	Name: Google Scholar Search date: 21st October 2022 Search strategy: String Years covered: 2017 -2022
Digital library	Name: SpringerLink Search date: 6th October 2022 Search strategy: String Search criteria: Journal papers, Thesis, and dissertations Years covered: 2017 -2022
Digital library	Name: JSTOR Search date: 6th October 2022 Search strategy: String Search criteria: Journal papers, Thesis, and dissertations Years covered: 2017 -2022

Based on this selection, a more in-depth analysis of the papers was done by skimming through the most important aspects of the papers which was followed up by reading the paper if it contained relevant findings (step 10). First the implementation and review papers purely focussed on LSS in SMEs were analysed, later on in the process more papers were included if this was required for gathering more insights into a certain topic, method, sector, or market. If a paper had a relevant framework for implementing LSS it was set aside for later analysis.

The answers to the review questions were formulated based on the papers that were left after all these steps. From the case studies the frameworks were listed, and the distinctive (dis)advantages were noted in order to aid the choice in framework later on (step 11). In addition, the different success/failure factors were noted, and the most common and applicable ones are reported in response to the formulated questions.

2.2 Case study Design

There is already a lot of knowledge and useable literature on the topic of LSS implementation in SMEs. However, there still is a perceived need for knowledge based on first-hand experiences throughout the implementation process in specific scenarios, such as the SME context defined in this study. Therefore, a case study was in place. This section describes the Methodology used in the case study. The research questions for the entire study are formulated in section 1.5.1, as is the scientific contribution (section 1.5.2). This case study follows the recommendations for conducting a qualitative case study from Baxter and Jack (2015). Their recommendations are based on a wide range of literature on this topic and includes several types of case studies in order to ensure the most applicable method is followed. It therefore provides a good basis for this study. The steps are now discussed with their application in this study.

Determining the case/unit of analysis

The first step in the case study was defining what the actual case was. For this study, it was a LSS implementation project within an orthopaedic shoe manufacturing company. The project was limited to a small, but significant, part of the company's manufacturing process. A broader scope would have likely exponentially increased the strain on both the researcher and the case company and thus made it unachievable in the given time limit. It possibly would have decreased the effectiveness of the project itself as well since there was no prior experience with LSS in this company, making a limited trial more viable than an all-round LSS project. The participants of the case study were current employees from different departments of the case company. They formed a team that performed the implementation, in other words they were the focus group of this study. Please note that they will generally be referred to as team members rather than participants for the remainder of this study. The specifics on selecting these team members are discussed in chapter 5.

Binding the case

After defining what the case will be, it was also important to define what the case will not be. The previous section already provides some insight in this domain by defining the limits of the production process that was improved. Other limitations were the branches that were included in this project, this was limited to the main branch of the company. However, the main branch produces lasts that are used in five other branches, these were included as well since disentangling these processes would have been inefficient in itself.

Determining the type of case study

There are several types of case studies possible, these are based on the question whether one is describing, exploring, or comparing a case. Yin (2016), and Johnson and Stake (1996) have differing distinctions between types of case studies. First, the descriptive, exploratory, or explanatory distinction is made. Moreover, there is also a difference between single, holistic, or multi-case study. Another distinction is intrinsic, instrumental, or collective. Due to the interventionist's nature of this study, the instrumental case study was deemed best applicable. This method is focused on generating insight in an issue or to refine a theory, wherein the latter was relevant in this study. The case often plays a secondary role in this type of case study, it facilitates the understanding of a broader concept or theory. In addition, a sole case was analysed, making this study an instrumental single case study.

Data Sources of the case study

Case studies are often qualitative in nature, but it remains important to define how data is gathered. In this study, there were two main data requirements. Primarily, the LSS implementation itself required a vast amount of data in order to measure, analyse, and control the business processes of interest. The data sources from the company were mainly their orders, agenda, measurer portal, and measurements of the lasts in distinct phases. This data was retrieved from the company's databases, or from their supplier's. The last data had to be collected by retrieving it from the digital lasts, the physical lasts were digitised for this purpose. The company uses a Computer Aided Design (CAD) program that can take the measurements from these digital lasts. This first data requirement was thus for the purpose of describing the tools that were used and as a response to the case study questions. Only a limited amount of this data is presented in this thesis, as only the processed numbers are reported for the tools and in response to the first case study question (research question 3).

The other data requirement was for gathering information on the implementation process, in other words the case study. For this purpose, feedback from employees on the process was gathered about their experiences with the framework and how the implementation was perceived. This was done after the implementation project by means of semi-structured interviews. The main structure for these interviews was based on the case study questions, so:

1. *How did you feel the framework performed in implementing LSS? (RQ3)*
2. *What were the (dis)advantages of this framework in your opinion? (RQ4)*
3. *Which success factors did you feel were most important for this case? (RQ5)*

Based on the role of the interviewee in the company and their answers, differing sub questions were asked. The interviews took approximately 30 minutes to complete and were planned for each team member that participated in the case study. The respective profiles of these team members are described in section 5.2. This information allowed this study to respond to the second case study question (research question 4). Based on the 12 previously defined success factors from the SLR, the final case study question was answered as well (research question 5). According to Yin (2016) and Morgan (2016), a case study should have multiple sources of information. This principle was incorporated by gathering information throughout the implementation project, namely during each 'check' step in the separate phases. The researcher asked feedback from the team members about the current phase (e.g., the define phase from DMAIC). These observations focussed on extracting the challenging aspects and successes of the framework during the implementation. This was expected to greatly improve the reliability and validity of the observations.

Analysis

After data was gathered it had to be analysed properly. Due to the vast amount of qualitative data gathered in this study, only the most crucial aspects are reported. The feedback from the implementation team is reported as part of the phase in which it was observed. During a later analysis on the findings of the entire implementation project, all feedback was considered. During this analysis, the findings from the researcher were included together with the interviews conducted on the team member after the project. All these insights and feedback combined allowed this study to properly formulate a response to the case study questions, and to respect the multiple information sources requirement for case studies. The observations were grouped together in multiple groups of challenges or advantages that came to light during the observations. The analysis of these observations additionally aimed to discover what success factors were more prevalent than others, since this was one of the research questions as well. The company data used for the implementation was already processed throughout the measuring and analysing phases in this case study. Due to the vast number of different tools and data requirements for these tools, the different analyses are not described in this section. They can be found in both the tool descriptions in chapter 4 and the descriptions of the how they were used for this case in chapter 5.

Reporting

Finally, the entire case study was reported together with the actual business case and literature study. The lay-out of this report is discussed in the Report Outline section. A clear differentiation was made in the results and findings in and about the case. So, the results for the company, and for science are discussed separately, albeit that they are mutually relevant. This is best captured in the difference between research question 3, and 4 and 5, were the last two are more observational based rather than data driven. In addition, the case study research questions (answered in section 6.2) were answered separately from the review questions (answered in section 3.2.2 and 3.2.3), but since the case study was dependent on the insights coming from the SLR they are related.

3. Theoretical background

In order to assure that the findings of this thesis are based upon the most recent insight stemming from the literature, a Systematic Literature Review (SLR) was performed. The findings of the SLR are described from section 3.2 onwards. First, the rationale for choosing LSS as a BPI method is provided as it is a crucial choice made during the design of this study and, in extension, this SLR. It influenced almost every part that followed and thus requires a proper theoretical foundation.

3.1 Lean Six Sigma Rationale

As previously mentioned, a broad range of BPI methods has been developed over the years. These methods often have the same goal, namely improving business processes. However, many methods focus on different means to achieve this goal. These can range from; process time, cycle time, throughput (time), quality, costs, resources, or a combination of these factors. Furthermore, some methods are more radical in nature than others, an example hereof is Business Process Reengineering (BPR), which aims to fully re-design the processes to a nearly optimal solution. (Zuhaira & Ahmed, 2020). Picking the right methodology is thus crucial in order to ensure a successful BPI project. Due to the nature of provided context, quality is the most important aspect of this framework. Since, when improving the process, the quality should remain at a remarkably high standard. In addition, since the study focusses on SMEs, resource usage is an important aspect. So, balancing the highest quality against the minimum resource strain is crucial. Therefore, a group of methods called Total Quality Management is best applicable, this school of thought comes from the 1970's and 1980's and is widely popular. It has a wide range of sub-methods such as Lean management, Six sigma, Agile, BPR, Just-in-time, Kaizen, Hoshin, Poka-Yoka, and so on (Gershon, 2010). The problem with all these methods is, however, that they generally share the same basis and deviate on small additional niches. For example, BPR specifically focusses on radical improvements, while Agile looks more into waste reduction in processes. Just-in Time, in comparison, is based on the premise of streamlining processes so that stock can be decreased. But one method in particular focusses on error free business performance whilst incorporating the great variability that comes from different business actors, this method is called Six Sigma (Gershon, 2010). When considering business processes wherein specialists are active, variability is likely to be high (Smith & McKelvey, 1986). In elaboration on the Six Sigma method, some companies include the lean concept. This basic method was developed by Toyota and focusses on a systematic approach that reduces activities that do not add value to the eventual product. It is a more incremental mindset that works best if applied throughout the entire organisation (Gati-Wechsler & Torres, 2008). This makes it work great in a context where specialists would like to have a say in their working environment and processes. Thus, Lean Six Sigma (LSS) was chosen as BPI method in this study.

3.2 The Systematic literate review results

As concluded in the previous section, the LSS methodology is most appropriate for the context of this study. However, this conclusion provides little insight into how the actual implementation will take form and what factors are crucial during this implementation. Neither did it go into depth on the current state of knowledge on LSS. The SLR was therefore performed to get an in-depth overview of these aspects. The review questions are already described, with their rationale, in the Research Questions section in Chapter 1 (1.5.1). They are therefore just repeated here. The review questions are:

1. *What are feasible Frameworks for LSS implementation in a SP-SME context in the current literature?*

   1.1 What steps are described in the frameworks from the literature?

   1.2 What are the distinct (dis)advantages of these frameworks?

2. *What are the most relevant success and/or failure factors described in the current literature for Lean and/or Six Sigma implementation project.?*

3.2.1 Search results

The string yielded more than 700.000 results in the Proquest database, and far less for other databases provided by the Technical University Eindhoven (TUE) such as SpringerLink and JSTOR (+/- 500 and +/- 70 respectively), the results that were found in these databases were also available in the Proquest database. In addition, Google Scholar provided 17.000 extra hits. As previously mentioned, Full-text availability was used as a criterion, this narrowed it down to approximately 63.500 results for Proquest, but this option was not available for Google Scholar. Furthermore, only scholarly journals and theses & dissertations were included for further analysis, since other sources were deemed to be irrelevant in a lot of cases (or beyond the aim of this SLR). This narrowed the results down to almost 5000 results. Then, only papers from the last 5 years were included. This criterion narrowed the results down to 1856 result in the Proquest database and 13.100 on Google Scholar. The approximate number of 2500 papers were selected based on Title and Abstract. This left 353 papers, which were further analysed. In order to foster this analysis, they were divided into several categories while downloading these papers. These categories and the number of papers belonging to the respective categories are shown in Table 3.

Table 3: Papers categories and corresponding numbers

Categories	Number of papers
Implementation	59
Reviews	110
Success and/or Failure factors	10
Lean or Six Sigma	87
Related methods	57
Other	30

It has to be mentioned that these categories are not clearly distinctive since a lot of reviews also focussed on success/failure factors or implementation strategies and because some related methods such as Poka yoke and Just-in-Time (JiT) are used as a part of LSS. The categories are merely used for structuring the reviewing process by having several chunks of papers on a certain topic that are reviewed rather than all papers in random order. They were divided based on their title and moved to another category if it turned out the be more fitting for that category whilst reading the actual paper. The entire selection process is depicted in Figure 2 and as depicted in this figure there were 53 relevant papers for the success/failure factors and 16 papers describing frameworks left in the end.

3.2.2 Frameworks for Lean Six Sigma implementation (Research Question 1)

The first review question (research question 1) focussed on identifying a feasible framework for the purpose of this study. Of the almost 60 implementation papers, 16 papers had clear descriptions of their framework and the steps and tools they used. This was one of the main requirements for selecting frameworks since a lack of transparency on how the framework was used in practise, would make it hard to replicate the usage and thus to evaluate this framework.

These papers were evaluated more in-depth to find the most fitting framework for the context of this study. Table 4 gives a brief overview of these frameworks and their (dis)advantages. The evaluation based on the perceived distinct advantages of a particular framework, the amount it incorporated change management practices, and how data-heavy the requirements for this framework were. These aspects of the frameworks are discussed with a conclusion on which framework performed best on these aspects. This is done based on the steps described in these frameworks (research question 1.1) and an explanation of the advantages (research question 1.2).

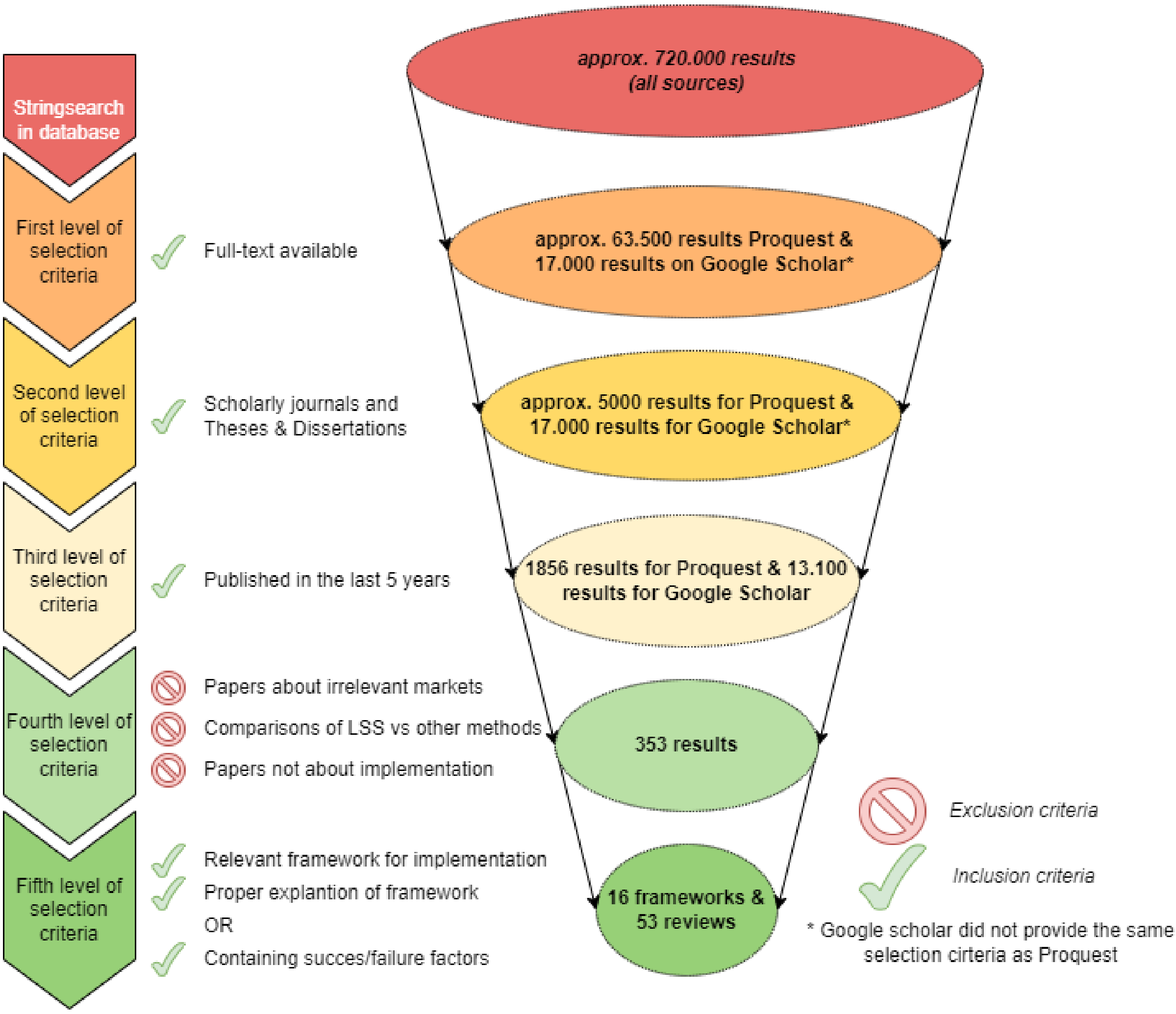


Figure 2: Visual representation for the Literature selection process.

Most of these frameworks were purely based on the basic DMAIC roadmap for LSS implementation. There were four exceptions, namely the papers from Arnheiter & Venkateswaran (2017), Abbes et al. (2018), Machfud & Atika (2019), and Wang et al (2019). The latter in this list was interesting because it focusses on how the new practises are best sustained in the organisation, or the so-called self-sustainability of the framework.

Table 4: Overview of the Frameworks analysed for further usage with their (dis)advantages.

Article	Phase steps	Target sector	Advantages	Disadvantage
A DMAIC Framework to Improve Quality and Sustainability in Additive Manufacturing—A Case study. (Delgadillo et al., 2022)	DMAIC	AM producing SME	Well-defined and proven roadmap which is explained clearly with use of the tools. Good integration of KPIs in the process. Multiple goals for improvement included.	Lacks insights on implementation and change management.
A bare-Bones approach to Lean Sigma for Low-Resource Environments (Arnheiter & Venkateswaran, 2017)	PAUC	Low resource environments	Analysis of most critical aspects of a LSS implementation project, theoretical foundation of this process	Ill-defined and not validated.
A conceptual Lean Six Sigma framework for quality excellence in higher education institutions (Sunder & Anthony, 2018)	DMAIC	Higher education	Also includes steps before implementation, focus on change management.	Lacks insight in implementations steps and tool usage.
Waste reduction of polypropylene bag manufacturing process using Six Sigma DMAIC approach: A case study (Sajjad et al., 2021)	DMAIC	Plastic bag manufacturing	Strong statistical based implementation framework with a good explanation of the tools and their usage.	Pretty standard framework and the statistical part requires sufficient data mining and analysing capacities, this makes it hard to apply without the proper resources. Due to productive nature, it lacks strategies for coping with resistance.
Adopting Six Sigma DMAIC for environmental considerations in process industry environment (Prashar, 2020)	DMAIC	Pharmaceutical manufacturing	Adds to DMAIC framework by redefining the phases as a dual loop. Provides clear overview of tools usage and their relation to grander scheme. Follows a dual goals approach while improving.	Lacks insights in change management other than ensuring management support.
Application of Six Sigma in Clothing SMEs: A case study (Abbes et al., 2018)	PDCA in DMAIC	Clothing manufacturing	Adds to DMAIC by implementing PDCA steps in each cycle fostering implementation. Elaborate overview of tools used.	Lacks insights on implementation and change management.
Application of six sigma method to minimize risk of rejection product: A case in cheese industry of company X (Machfud & Atika, 2019)	DMAIC & FMEA-HOR	Cheese industry	Well-defined inclusion of Sigma calculation, inclusion of FMEA-HOR in framework and thus more apparent. Good explanation of used methods and change management	Resource intensive method
A Lean Six Sigma framework to enhance the competitiveness in selected automotive component manufacturing organisations (Rathilali & Singh, 2018)	DMAIC	Automotive component manufacturing	Elaborated DMAIC framework with attention to employee involvement.	More review based instead of implementation.
Lean Six Sigma competitiveness for micro, small and medium enterprises	DMAIC	Printing industry	Good explanation of steps and tools, also focusses resources required for employee	Incomparable context

(MSME): action research in the Indian context (Bhat et al., 2020)			training. Includes exceptionally low resources as well.	
AN INTEGRATED LEAN SIX SIGMA APPROACH TO MODELING AND SIMULATION: A CASE STUDY FROM CLOTHING SME (Nedra et al., 2022)	DMAIC	Clothing manufacturing	Good visual presentation of framework and the tools that are used are well-defined and worked out.	Lacking focus on change management
Green implementation of Lean Six Sigma projects in the manufacturing sector (Shokri & Li, 2021)	DMAIC	Manufacturing	Framework with strong mathematical foundation	Poor elaboration on implementation outside of the mathematical part.
Development of a roadmap for Lean Six Sigma implementation and sustainability in a Scottish packing company (Vallejo et al., 2020)	DMAIC	Packing company	Good comparison of multiple frameworks and combination of these into one. Integrated Unfreeze, change, and Freeze steps.	Poor elaboration in case study and validation
Contextual effects on the LSS implementation in networked service environments (Wang et al., 2019)	PDCA	Service	Test of DMAIC vs PDCA framework which showed PDCA is better in sustaining the practices.	Poor elaboration on tool usage
Lean Six Sigma in Rural Hospitals: The case of the Ortho Clinic (Leon, 2020)	DMAIC	Ortho Clinics	Special focus on collaborating with specialists and good elaboration tools en steps.	Limited focus on other issues outside of time
Lean Six Sigma Approach to Improve the Production Process in the Mould Industry: A Case study. (Pereira et al., 2019)	DMAIC	Moulding industry	Wide range of tools used in framework, and clear description of the place and time of these tools.	Lacking focus on change management
A conceptual examination of Lean, Six Sigma and Lean Six Sigma models for managing waste in manufacturing SMEs. (Sodhi et al., 2019)	DMAIC	Manufacturing SMEs	Roadmap is based on numerous factors from other roadmaps that were successful. They also provided a clear and concise overview of the tools use and the phase in which it is used.	Tool usage not described in detail, which makes the suggestions vague at times. There is also no validation of their tool.

They found that between the DMAIC and PDCA frameworks, PDCA has a higher self-sustainability. It would therefore have a clear advantage in comparison to the other frameworks. However, since they merely focus on this feat and less so on how the framework works, it is not preferred. The same goes for the framework suggested Arnheiter & Venkateswaran (2017), they pose an interesting take on LSS by proposing a bare boned approach. They stripped the LSS implementation to a bare minimum in order to account for low resource environments. Their findings are not applicable in the context of this study since it diminishes the effectiveness of LSS, but the idea of prioritising critical aspects of LSS while dropping redundancies is important to keep in mind during the case study.

The remaining two papers were interesting for a couple of reasons; first they contained a basic scheme of DMAIC which they improved by adding steps to it. In line with the twelve other frameworks that were considered, they adhere to the basic tendency of using DMAIC when implementing LSS. This is a proven strategy that has a successful history. The main differences within the 12 DMAIC frameworks was in their choice of tools. Some were more focussed on the statistical or mathematical bases of their framework, examples hereof are Sajjad et al. (2021) and Shokri & Li (2021). Some frameworks are focussed on employee- and change management, such as Sunder & Anthony (2018), Rathilali & Singh (2018), and Leon (2020). Moreover, these frameworks also specialised in differing sectors ranging from manufacturing to healthcare and networking service to education. It is therefore clear that the DMAIC is a usable and flexible framework for implementing LSS. Finally, following the suggestions of Wang et al (2019), PDCA was included as well in order to build in a higher level of self-sustainability of the framework, this left the framework suggested by Abbes et al (2018) which has a PDCA applied to DMAIC framework. A visual representation hereof is shown in Figure 3.

3.2.3 Success Factors for Lean Six Sigma implementation (Research Question 2)

Another main review question formulated for this SLR focussed on the success and failure factors in LSS implementation. There are approximately 50 papers in the selection that mention success and/or failure factors, but it can be assumed that many more will cover this topic to some extent. These factors are overlapping, and it therefore makes little sense to discuss them one by one. Rather, the most common success/failure factors are listed and discussed in this section. They are based on more overlapping themes that existed amongst the different formulations of success factors. For example, upper management can be formulated as senior management, management team and other synonyms. But the difference can also be broader, so ensure sufficient resources, dedicate enough resources early on, avoid pulling resources, provide the necessary infrastructure, and so on, was summarised as ensure infrastructure and resources for the project. The most informative papers, with their corresponding authors, for this purpose are shown in Appendix A. The factors were formulated as success factor rather than failure factors, so it is to be read as 'do' instead of 'do not,' this is to avoid any confusion.

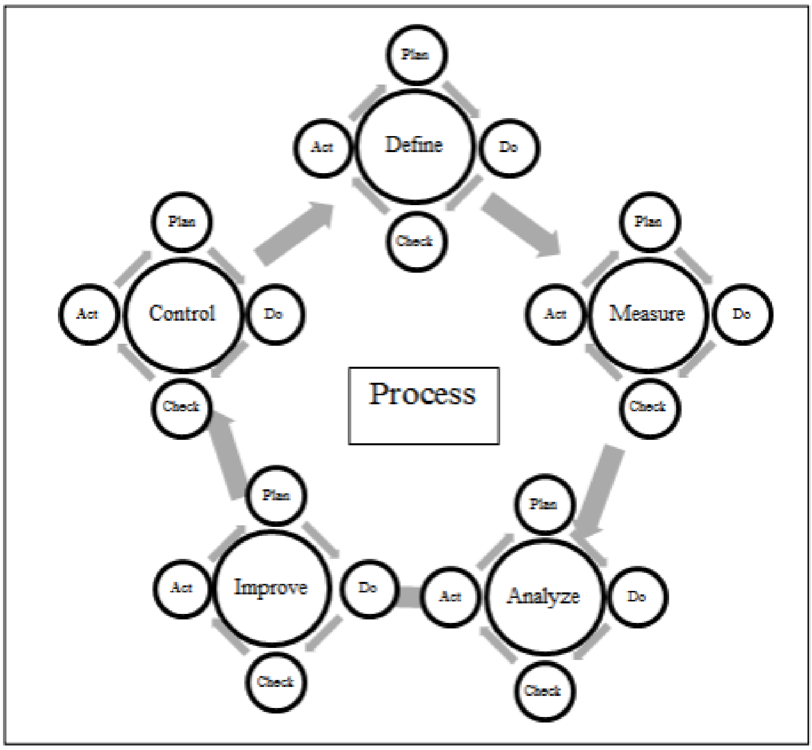


Figure 3: The visual representation of the Framework from Abbes et al. (2018)

Alignment of LSS with the Organisational Strategy

Many studies have found proof that the alignment of the broader organisational strategy and the LSS project goals is crucial for ensuring long-term success of the project. The success of a particular project or individual is often measured in how well it corresponds with the goals of the upper management layer or organisational strategy, thus making it important for the LSS project's legitimacy to be in line with these goals. If there is a poor alignment between these goals, the LSS is discontinued more easily or too few resources are made available for proper completion of the project.

Ensure Top Management Support

In order to prevent discontinuation of the project, ensure long-term commitment, have the proper resources made available, include, and inform other employees, and many other aspects;

it is important to ensure top management support. If they are not on board the project is extremely unlikely to be successful in short-to-medium- as in the long-term.

LSS Project Selection and Prioritisation

The portfolio of LSS initiatives in a particular company has to be carefully evaluated and managed in order to prevent a scattershot approach of LSS/Process improvement projects. Particularly in larger companies where multiple departments are working on multiple projects at the same time. For smaller companies it is important because the more apparent strain on resources these projects require. It is therefore evident that one or two projects with skilled employees and LSS experts in relevant domains are worth far more than ten half-witted LSS initiatives throughout the organisation.

Clear Goals and Expectations of the LSS Project

Often LSS projects fails due to overshooting goals and targets making the project large and practically unachievable or by setting the bar too low in order for it to be significant. This can be prevented by agreeing on a clear set of targets and expectations for the LSS project so that it can be achieved and implemented in a reasonable time limit. This also includes the range of activities included in the project, so starting with a specific part of the production process and only including a wider range after achieving the set targets, can be advantageous to keep project support over the longer term.

Effective Training and Design of Curriculum for different LSS Roles

Training the affected employees of the LSS initiative helps with both fostering implementation of the project as with ensuring longer term durability of the project. This training is often based on the Belt system related to LSS, but understanding of the tools, insights, and new processes can already make a significant difference in the project's success.

Development of Reward and Recognition System

The project groups and/or employees involved in the LSS initiative can be encouraged by reward and recognition programs related to achieving or even overachieving the set targets. This also helps in gathering more bottom-up information about improvements or inefficiencies in the organisation.

LSS Leadership & Culture

The leadership required for LSS stretches far beyond the project manager and the upper management related to the LSS initiative. It is about the entire structuring of the project within the organisation. It is important to foresee an infrastructure that allows input from lower levels in the organisation to be heard by the managers in the process, but that also allows wishes, goals, and communiques from higher levels in the organisations to reach all people in the process. Only then will the LSS initiative be able to identify root-cause of problems and effectively tackle inefficiencies or problems in this process. In addition, it is important to provide frequent communications towards the company's employees about the ongoing projects and their impacts on certain domains.

LSS and Data Strategy

Six sigma is a statistically driven process which requires accurate and relevant data of the process. It is therefore evident that data has to be gathered and analysed in a proper manner. This is often a painstakingly complicated process and thus requires a data strategy to be put in place and be integrated in the LSS initiative. It is also important to look beyond the data, what does it measure and is it telling the entire story. Misuse of data is a common threat to the success of an LSS project and should be well-considered throughout the project.

Proper Tool Selection and Knowledge on Tool Usage

Often project fail by simply using too many tools in the LSS initiative. It is therefore important to have a team of trained LSS professionals assess the needs and requirements of the project and select the right tools accordingly. Using the wrong (number) of tools can be detrimental to the project's support and thus its success. Moreover, knowing how to use these tools and what they reveal of the process is another important aspect in this domain. Wrong interpretations can hinder the effectiveness of the tool.

Linking LSS to Customer and Employee Needs

In order to assure the right changes are made, it is important to consider all the parties affected by the project. There tends the be a discrepancy between the company's expectation of customer needs and the actual customer needs, the same goes for management and its employees. Talking with these parties, critically assessing their needs, and validating the assumptions and proposals of the project can thus be of significant importance.

Employee Involvement and Resistance Management

To some extend is this point already included in the aforementioned success factors. However, it is specifically stated as a success factor since it cannot be stressed enough. People are inherently resistant to change and can sometimes require extensive and exhaustive meetings about the need for change. Including employees from day one of the project until the end, instead of surprising them with entirely reviewed business processes, can decrease their resistance towards these new activities. This is particularly important in order to ensure long-term success of the LSS initiative.

Ensure Infrastructure and Resources for Project

Last but certainly not least, ensure that the right number of resources are assigned towards the project. This means that the right experts, employees, other parties are assigned to the project. But also, the funds made available for training and gathering external knowledge is required. It should also allow for communication networks to be build or dedicated and regular meeting to be attended in order to keep the momentum of the project.

3.3 Conclusion of the SLR

One of the main aims of this SLR was to identify frameworks that focussed on implementing LSS in SMEs with a SP-SME alike context. Eventually sixteen frameworks were found that could be used for this purpose, an in-depth analysis of these frameworks then proved one framework to combine the best aspects from these frameworks. This was the PDCA applied to DMAIC framework proposed by Abbes et al. (2018). It combined the proven framework of DMAIC with the self-sustainability ingrained in the PDCA framework. It was also deemed the most understandable framework with a well-defined focus on employee involvement. The second aim was to identify the most important success/failure factors for LSS implementation yielded a list of twelve success factors (some inversed failure factors) that captured the biggest challenges of success. These were: Alignment of LSS with the Organisational Strategy, Ensure Top Management Support, LSS Project Selection and Prioritisation, Clear Goals and Expectations of the LSS Project, Effective Training and Design of Curriculum for different LSS Roles, Development of Reward and Recognition System, LSS Leadership & Culture, LSS and Data Strategy, Proper Tool Selection and Knowledge on Tool Usage, Linking LSS to Customer and Employee Needs, Employee Involvement and Resistance Management, and Ensure Infrastructure and Resources for Project.

As previously mentioned, the remainder of this thesis describes a case study on implementing LSS in a SP-SME. Based on the results of this SLR, it can be stated that it will be a case study on applying the PDCA applied to DMAIC framework to a SP-SME. The identified success factors are included as critical aspects that have to be respected during this implementation. The only remaining question is what tools are used in particular during the LSS implementation, since this can deviate to some extend from the proposed framework. This question, however, is part of the iterative process in building an implementation plan for this framework. The tools used in Abbes et al. (2018) will be described in the following chapter (4), and the rationale for possible deviations from the choices made in Abbes et al. (2018).

3.4 Discussion on the SLR

One unanswered question before this SLR was whether a feasible framework even existed in the literature that could be used for the context of this study. The short answer to this question is yes. The framework proposed by Abbes et al (2018) was deemed to be meeting the challenges coming from low resources of SMEs and higher friction coming from specialists. With the aim of finding the best possible framework (aspects) for implementing LSS in a SP-SME, choices were made in line with this aim about certain inclusion and exclusion criteria. These are listed and will be validated by experts in this domain, which is important since there is only one author of this SLR. Due to the academic nature of this study, these choices and the protocol are reviewed by two supervisors from the TUE who have both have conducted several SLRs in the past. Based on these reviews, the protocol will (if required) be improved until its methodology is sound. Another notable shortcoming is the fact that not all Business research databases were used for this SLR, but the ones on offer by the TUE. This was countered by searching Google Scholar for extra literature, but since not all 13.100 results from Google Scholar could be assessed, it has to be noted.

4. The Proposed Framework of Abbes et al.

As mentioned in chapter 3, the framework from Abbes et al (2018) is selected for use in the LSS implementation in this case study. An explanation of the steps and results from this implementation is discussed in Chapter 5. This chapter goes into depth about the framework's underlying theory, the proposed use, and the tools included in this framework.

4.1 Theoretical Foundation of Abbes et al.

The framework is based on two basic improvement cycles in the literature on SS and the broader TQM. The grand framework is the well-known DMAIC (Define-Measure-Analyse-Implement-Control) cycle, which offers a useful template for implementing SS in a lot of organisations with differing sizes and operating markets. It was initially developed in the 1980's by Bill Smith who worked for Motorola at the time, but later on championed by General Electric's CEO Jack Welch in 1995 (Alexander et al., 2019). In comparison to the original model, Abbes et al. (2018) decided that each step of the DMAIC framework is conducted based on the PDCA (Plan-Do-Check-Act) cycle stemming from the broader TQM school of thought, this structure is depicted in Figure 3. The PDCA cycle is developed in the 1950's in Japan by dr. W. Edwards Deming (Langley, 2014). The rationalisation for combining both cycles is based on the premise that PDCA will add the rigour of Project Life Cycles (PLC) to the implementation strength of the SS cycle. As stated in Abbes et al (2018), with the established framework of PDCA applied to each DMAIC step there is a better capability to learn continuously and create knowledge in the process. The different steps of both frameworks are now discussed with their rationale and required actions.

4.1.1 The DMAIC cycle

Define

As the name might suggests, this step is purely focussed on defining the problem. During this step, the problem is formulated in a clear sentence combined with a description of the customers (can be both in- and external) that are affected by the problem. This also includes defining the scope of the problem in order to ensure that the improvement project is feasible. In line with the project feasibility, it is also important to create a business case for the project. Building a proper business case is crucial to ensure top-management support and thus increase the chances of project success. Last but not least, the planning for this project is defined together with the critical stages of this project. Together these actions help to create a solid overview of the problem and the path towards solving it, which is crucial to foster project success.

Measure

As soon as the define phase is finished, the measure phase starts. In this phase, relevant data about the problem will be gathered, it therefore functions as a validation of the actual problem definition. This phase enables the validation of the problem and whether the scope is properly defined to solve the problem. To achieve this, one should define what data is needed to measure the problem and the effectiveness of the solution (in other words, what KPI do you need to improve), how this data will be gathered, and how the validity of this data is ensured. After the correct data is gathered, the validity of this data is ensured, and the problem scope is validated the analyse phase can be started.

Analyse

After the data is gathered it should be analysed, it is therefore important in this phase to find explanations for the previously defined problem. Often multiple causes can be formulated for the problem. It then becomes important the prioritise these causes and their solvability. Further analysis can be required to find the root-cause(s) of these causes. Even though this can be quite time consuming, it is a crucial step during the analysis phase. Moreover, the analyse phase often has two distinct angles, a data-driven angle, and a process-driven angle. Whereas the process-driven angle goes into depth on what processes add value and how, when, and where certain mistakes happen, the data-driven side focusses on discovering or supporting the assumptions from the process-driven side.

Implement

Since it has become clear how the problem occurs, the focus will shift towards finding solutions to these problems. These solutions are prioritised on two scales, namely their expected impact and their required effort. The solutions with the highest impact and lowest effort will be evaluated first. The solutions will be assessed in small pilots, which will validate their feasibility. If the pilot is found successful, the solution will be implemented further. The implementation can cause friction in the organisation, this phase, as for the following phase, therefore have an additional focus on change management.

Control

When the right set of solutions is defined and implemented, it is important to ensure their durability. In theory, this phase is part of the project, in practise however, this phase never ends. Towards the end of the project, certain safeguards are defined that ensure the sustainability of the solutions. These safeguards are, for example, data dashboards that allow the monitor the KPIs defined in the earlier phases or improved training to teach the new working processes. When monitoring the new solution, properly defining what happens when the thresholds are crossed will help to react to fallbacks into previous behaviours. Thus, whilst the defining of these safeguards is part of the actual project, the monitoring of the changes will go far beyond the project.

4.1.2 The PDCA cycle

Plan

Before actually starting the project, it is important the map out what de task at hand is, how the proper resources will be allocated, and of course how success can be defined. All the aspects are captured in the plan-step. This often makes this step a rather iterative process of finding and allocating the right resources and combining these with the defined targets for the task.

Do

This is arguably the biggest step of the four. As the name suggests, it comes down to just start the project and make it work. In this step, it is advised to start with small iterations and test that can achieve the goals, but it also includes making the actual improvements or finishing the products.

Check

After finishing the doing part of the cycle, it is particularly important to check your work. In the first place, this means that the deliverable must be checked to see of it meets all the pre-set requirements. In the second place, it is important to identify whether other problematic parts have become known that require a solution. Finally, a retrospective of the work performed is in place. This entails a thorough analysis on what went wrong or right during the process and how this can be used in the future.

Act

The gist of this step is that the final solution will be adopted. Here the result of the previous iterations and lessons learned will be implemented in the grand scheme of things. It can also be the choice re-do or re-design the project if it severely lacked in meeting the targets.

4.2 Proposed use of the framework from Abbes et al.

In Abbes et al. (2018), the framework was developed for application in a Tunisian clothing manufacturing SME. This firm struggled with some of the same problems that are described in the introduction of this study, namely: problems in quality, lack of resources (both financial and labour), lack of time for projects, resistance to change, and a lack of (L)SS knowledge. This also led them to the conclusion that hiring external consultants or using complex tools and techniques is out of the question. They aimed to develop a simple framework that is easy to understand and adapt. The bases for this framework were developed by performing an extensive literature review and the tools they incorporated came from a survey. This survey was conducted in Tunisia amongst 85 SME clothing companies. They assessed their knowledge of SS tools and conducted interviews with a couple of CEOs from these companies. Based on these results, they formulated a list of tools for the framework, these will be discussed in the following section.

They then used the framework in one of these companies to validate it. They formulated the problem as finding the sources for measurement defects of the cutting unit. They found that speed and tension are the main sources for these defects and started testing how these two factors can be optimised to avoid defects in the future. They managed to find an optimal setting that improved the sigma from 0.7 to 2 and the Cp from 0.2 to 1.47.

4.3 Included tools in Abbes et al.

Abbes et al. (2018) used a certain selection of tools in their framework, this section will list and describe these tools.

Critical To Quality (CTQ)

The CTQ is often displayed in a CTQ tree. This tree translates the customers' wishes to concrete improvement targets for the company. In Abbes et al (2018) they formulated a diagram that went from customers' needs to customer requirements, to means of measuring requirements, and finally to targets and specifications. This tool is used in the design phase of

SS and provides the user with means to translate customer needs, or Voice Of Customer (VOC) to concrete goals and actions for the company.

Pareto

The pareto diagram is basically based on a histogram that depicts the biggest categories of mistakes with their frequencies. Another y-axis is then added to show the cumulative percentages of these mistakes, additionally a line is drawn that depicts the cumulative percentages. This tool allows its users to get a clear overview of what type of mistakes are most prevalent and should be solved first.

Control charts

A control chart is a line graph-based visualization that focusses on one indicator in particular. The values of this indicator are plotted over time which shows the variation of this indicator. Two types of variation are defined for these tools, in-control variation is variation within three standard deviations of the mean. Out-of-control variation is all variation outside of three standard deviations, these cut-off values are called Upper Confidence Limit (UCL) and Lower Confidence Limit (LCL).

Sigma

The Sigma, or Z-Sigma, is a quality measure often used during SS implementation. It is based on the number of standard deviations between the target and the average. For this value, it is preferred to be as high as possible, since a low value means there are a lot of defects in the process. It is calculated with the following formula:

$$Z = \frac{SL - \hat{x}}{\sigma}$$

Where:

$$SL = Specification\ limit$$

$$\sigma = Standard\ deviation$$

$$\hat{x} = Mean$$

The Z-score is mostly based on the Defects Per Million Opportunities (DPMO), which is a standardized measure for production errors. The following formula is used to calculate it:

$$DPMO = 1.000.000 \times \frac{D}{N} \times O$$

Where:

$$D = Number\ of\ defects$$

$$N = Number\ of\ produced\ units$$

$$O = Number\ of\ defects\ per\ type$$

The Z-Sigma can thus be used in measuring the current process in the measure phase, but it also allows the user to measure the effectiveness of certain improvements during the implementation phase, as to monitor the implemented improvements in the control phase.

Process Capability Index (Cpk)

The Cpk is another statistical tool that allows the user the asses the ability of a given process, machine, or employee to produce output within the customer's specification limits. It helps to measure how close the current process is, on average, to a given target. Again, a higher value is better. It is calculated with the following formula:

$$Cpk = \min\left(\frac{USL - \hat{x}}{3\sigma}, \frac{\hat{x} - LSL}{3\sigma}\right)$$

Where:

$$USL = Upper\ specification\ limit$$

$$\sigma = Standard\ deviation$$

$$\hat{x} = Mean$$

$$LSL = Lower\ specification\ limit$$

In addition, the Cpk can be translated into a process yield for a particular process. This value also allows the user to measure and/or monitor the current process as well as the improvements made during the implementation phase. It is therefore often visualised.

Histograms

A simple but useful data visualisation tool that can be useful in comparing distinct categories or groups of data.

Failure Mode Effect Analysis (FMEA)

The FMEA is a tool used for mapping all known types of errors that can occur during the different process steps. It maps the occurrence, severity, and detection possibility of these mistakes together with their effects and viable solutions. The occurrence, severity and Detection are scored on a scale from 1 to 10 and are multiplied with one another to get a general priority value called Risk Priority Number (RPN). With this table the user can effectively map all errors that might occur during the process and prioritize them.

Value Stream Mapping (VSM)

The VSM maps the flow of goods and/or information throughout the process in order to analyse where waste occurs. It is often strengthened by including cycle times, waiting time, and (non) value added time. This allows the user and stakeholders to get a good overview of the activities that waste a lot of time and bring down the lead time of a certain product/service. This tool is often, and in this study, used two times, one during the measure phase to map the current process. The second time is during the improve phase to map the ideal process. This way a clear oversight of the improvement/solution directions is provided which can then be used to find the most applicable solutions.

Cause- and Effect Diagram (Fishbone)

A fishbone diagram is often useful to illustrate where certain types of errors originate. It is formulated over five domains: method, material, machine, man, and environment. These domains are connected to the greater problem and for each domain the problems that contribute towards this greater problem are listed. This provides the user with an intuitive overview of the factors contributing to the problems and their origin domains. Figure 4 gives an example of the Fishbone diagram developed by Abbes et al. (2018). There are several methods for creating a fishbone diagram. The usual method is called 5M and maps based on the previously mentioned five domains, and as is depicted in Figure 4. Another possibility is to take the process steps defined for the SIPOC that is often made for LSS and use these as bones. The latter is more appropriate when the usual five domains are not that applicable to the process in question.

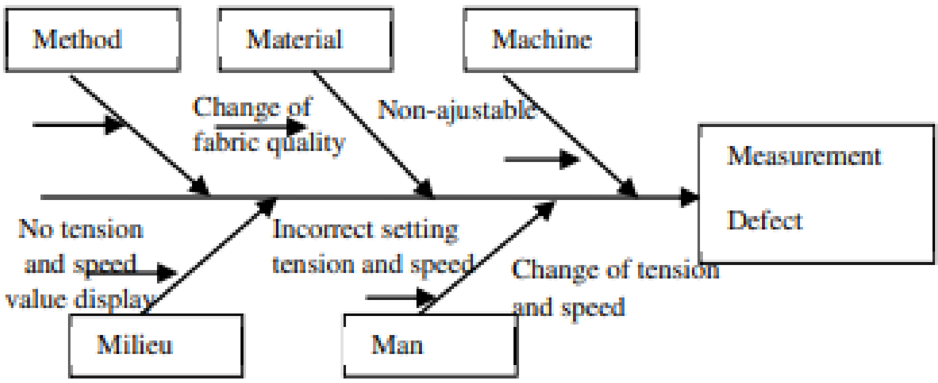


Figure 4: Fishbone diagram developed by Abbes et al. (2018)

Experiment

This tool is pretty straight forward, using experimental settings to assess if the proposed solutions are an improvement. This tool is powerful in validating the assumptions underlying the proposed solution. There are a lot of related tools such as hypothesis testing, ANOVA, statistical testing, and so on. This can lead to some confusion since these terms are used through one another very often. They all come down to the same principal, design a setting wherein the solution is assessed and validate whether it is an actual, significant, improvement. This tool is used during the implement phase and is generally measured by the same type of data previously used to measure the current process in the measure phase.

There is wide range of experimental designs, which is outside of the scope of this tool explanation. Abbes et al. (2018), however, used a two-by-two design wherein they assessed four different settings for the best performing alternative. Formulating and testing hypothesis is one of the most important ones, and inherently part of most models. Hypothesis testing is a strong tool to validate assumptions and to evaluate improvements.

Supplier-Input-Process-Output-Customer (SIPOC)

The SIPOC is a commonly used tool during the design phase. It is built up around a summarised version of the process in question, this process is typically narrowed down to five to eight steps. For each of these steps first the Supplier and Input side is filled in before the Output and Customer (can be in- and external) side in filled in. This provides the user with an overview of the different dependencies in the process. Sometimes an extra column that describes the requirements for each step is added in order to get a better overview. It is also possible to use these steps as different ‘bones’ when developing a fishbone diagram later in the analyse phase. This study adapted the same approach since the original categories for the fishbone diagram captured an insufficient amount of information on the problems occurring in the process.

Kanban

The Kanban tool is more of a method rather than single tool. It stems from the Agile project management and visualises the work the needs to be done. It aims to reduce the work in progress and clearly distinct between work to be done, work in progress, and work done to achieve this goal. The board itself has tasks that are often part of bigger tasks or goals which are assigned to a particular team member and ordered in columns based on the progress of this task.

Kaizen

Kaizen is a process improvement method in itself. It focusses on small and incremental improvement that are typically proposed or conducted from the bottom-up. It aims to include all possible stakeholder and their ideas on how the way of working can be improved. It is very related to the lean way of working and therefore often also includes the PDCA work cycle.

Brainstorming

Brainstorming is a tool that allows all different members to produce their own ideas without being distracted by others' ideas. It usually is done by taking 5 or 10 minutes of silence to come up and write down your ideas and discuss them afterwards. This will greatly improve the number of ideas and in extension the quality and originality of these ideas. Brainstorming is important for a team to avoid the focus of the team shifting to one or two ideas. This often happens when someone offers and idea and the team start discussing it, since the ideas one has other than that idea can easily be forgotten or discarded.

Poka yoke

Poka yoke is a method that aims to make certain processes fool proof. It analyses which mistakes are often made and looks for ways to force the users or stakeholder to not make that mistake. It in essence makes the use or process only possible in the correct manner.

Best practices

In the control phase, best practises are often defined to ensure that the novel solutions are used over the long term. This tool is focussed on communicating the best practices with all relevant stakeholders and training them in adapting these best practices. This way the risk of fallbacks can be decreased.

Control plans

Another important control tool is the control plans. For this tool, the user has to clearly define how often the new solution is used/deviated from, how this is monitored, what the threshold value is for action, and most importantly what these actions are. Having clear and concrete control plans in place increases the chances of sustaining the novel solutions over the longer term.

5. Case study: implementing Abbes' framework in an orthopaedic shoe manufacturing company.

This chapter describes the case study that is performed on applying the framework PDCA-applied-to-DMAIC (further to be referred to as PDCA-in-DMAIC or Abbes' framework) in a SP-SME context. It starts with a more elaborate description of the business case. It then continues to describe each phase of the framework (DMAIC) with the steps (PDCA) performed in these phases. As explained in the methodology section (section 2.2), the check steps were used for gathering information from the team members on how the current phase was perceived and what improvements could be made. For the initial phase, a meeting was planned wherein the researcher briefed the team members on the framework and its workings. These team members were defined based on initial talks with upper management, they functioned as a focus group for gathering information in this case study. During the initial meeting they were given a chance to add or remove team members based on the perceived needs for the project. The same meeting also included the plan step for the first phase. From there on the researcher tried to let the team define the periods for the preceding steps on their own. The tools that were used throughout the implementation are discussed together with the implications from and for the team that was part of this case study. Descriptions of these tools are provided in one of the previous sections (4.3). Afterwards, interviews were conducted on the team members to improve and/or add to the observations done during the case study, these interviews are discussed in the concluding section of this chapter (5.7)

5.1 Business case description.

The business case in question was about the last production process of an orthopaedic shoe manufacturing company, named Hanssen Footcare (HF). HF is a family business that was established in 1931 and is nowadays among the top leading companies in the Dutch orthopaedic shoe manufacturing market (Hanssen Footcare, n.d.). While the company's offer was initially composed of shoe repair for mine workers, it has evolved over the years towards the diagnosis and treatment of all kinds of foot complaints. It does so by providing orthopaedic shoes, insoles, specialized socks, podiatry, and other necessities. Within this range of treatments, several degrees of product complexity can be identified: insoles and standard shoes are examples of low complexity products while highly custom-made shoes for patients with neurological disorders and multiple deformities are considered as high complexity products. Hanssen

Footcare mainly operates in the southern, central, and western regions of the Netherlands through seven branches with about 90 employees, and almost 200 fitting locations. The company is led and owned by the CEO who is supported by a team of managers (MT), themselves representing several departments such as sales, manufacturing, Information Technology (IT), and Human Resources (HR).

The company is facing increasing external pressure due to the steady rate in which the Healthcare insurance companies are lowering their prices. This forces Hanssen Footcare to improve their production process. For their high-complex range of products they start out with building a last, this last allows the shoemakers to build a shoe that improves the client's mobility and relieves their symptoms. The production of this last is very time and resource consuming, therefore Hanssen Footcare wishes to improve this process. The last production process starts with the intake of a new client and ends with a last that can be used for the production of orthopaedic shoes. The last is of significant importance for the eventual manufacturing of the shoe itself and often has to be corrected multiple times throughout this process. There are several important stakeholders in this process, first the customer who often comes to HF through a referral from their doctor or other healthcare provider. They will make an appointment with a receptionist from HF who has to ensure the right resources (time, room, and measurer) are allocated for this case. Next, the intake takes place with the measurer and the customer, this appointment is for gathering data, diagnosing the client, and choosing a product. Based on this data and diagnosis another employee, the last maker, will design the last with CAD software and send it to an external party for production. As soon as the physical last is received by HF they will produce a fitting shoe, this is a hard plastic cover moulded over the last in order to assess whether the last's form is accurate. Possible deviations are noted on this fitting shoe and will be corrected by the last maker.

Each correction has to be combined with another fitting appointment where the last's accuracy is reassessed, corrections are again noted if necessary. As one might expect, the loop of creating a fitting shoe, having a fitting appointment, and correcting the last cost a lot of resources. Therefore, HF is looking to improve this production process in order to get a lower error rate for the last production. Appendix B depicts the process in question and the previously mentioned fitting loop. The process ends as soon as the measurer determines whether the last is accurate enough, albeit with some small but insignificant changes, for production.

5.2 The Define phase.

The first phase of the framework is the define phase, the most important aspect herein is to get a clear definition of what and who is part of the process in question. As part of the framework proposed by Abbes et al. (2018), each step will be split up into plan, do, check, act steps.

5.2.1 The Plan step in the Define phase.

The initial planning started by defining the scope of the project, the goal of the project was to decrease the number of fitting appointments during the last production project. The general aim was to create a process that produced a 'first time right' last. With this goal in mind, it was decided that the entire process from first contact to accepting the last would be taken into consideration. The two main operators in this process are the measurer and the last maker, therefore at least one employee belonging one of these group was included in this project. The other employees are merely supporting these operators. Then, with the scope and main operators defined, the tasks ahead were planned out for this phase. Following the suggestions by Abbes et al (2018), two main tools were used in this phase, namely CTQ and Pareto analyses.

As previously mentioned, a meeting was planned with the team members. These were the two key operators, a member of the management team, a middle manager that oversaw the branch, and an IT employee. They agreed on this setting as the main group of team members required for the project. Note that the researcher is not defined as a team member, the sole purposes of the researcher was to explain the tools and the framework, other than that this role was limited to providing information on the methodology and observing the progress. Other than planning the sessions, the researcher did not define the periods in which the phases had to be conducted or when the team should meet again. His key role was in making observations on the execution of the framework and the tools, and to support with knowledge hereof. The observations were focussed on the case study questions, see section 1.5.1 and 2.2 for more information on the questions and the set-up. The team and the researcher agreed on the set-up of having a small meeting to plan an upcoming phase followed by a larger meeting to execute it. When possible, the team tried to meet again for every step, albeit that sometimes check, act, and plan steps were combined due to time restrictions. During the plan meeting, the team also agreed on periods in which the phase should be conducted. Last but not least, the researcher only took the lead in discussing the impediments and scientifical take-aways from the phase during the check steps.

5.2.2 The Do step in the Define phase.

During the first sessions the members were informed on the general goal of the project and the way of working for this project. Both tools were explained based on their usage and the insights they provide for its users. The team then started to use these tools in order to map the state as is. Their findings and insights were noted and later processed by the research into a proper visualisation of the tools, the CTQ and Pareto analysis are depicted in Figure 5 and Figure 6 respectively. The conclusions from these tools were discussed together with the implications hereof for the project. It was also discussed what and how should be measured during later phases in the project.

The Conclusions from the CTQ indicated two main aspects that are of importance for the customer. The first one is a proper solution for their care question to ensure their mobility and pain relief. Another important aspect was the fact that this solution has to be provided as soon as possible, due to the fact that the customers tend to be severely hindered in their mobility. This led to the conclusion that several aspects are of utmost importance when delivering the product. First the correct indication has to be provided for diagnosing and measuring the customer, in other words the right appointment has to be made. Then it is crucial that the measurer makes a correct assessment of what product properties are required for the customer in question. Finally, this information has be communicated effectively to the last producer in order to be translated into an accurate last.

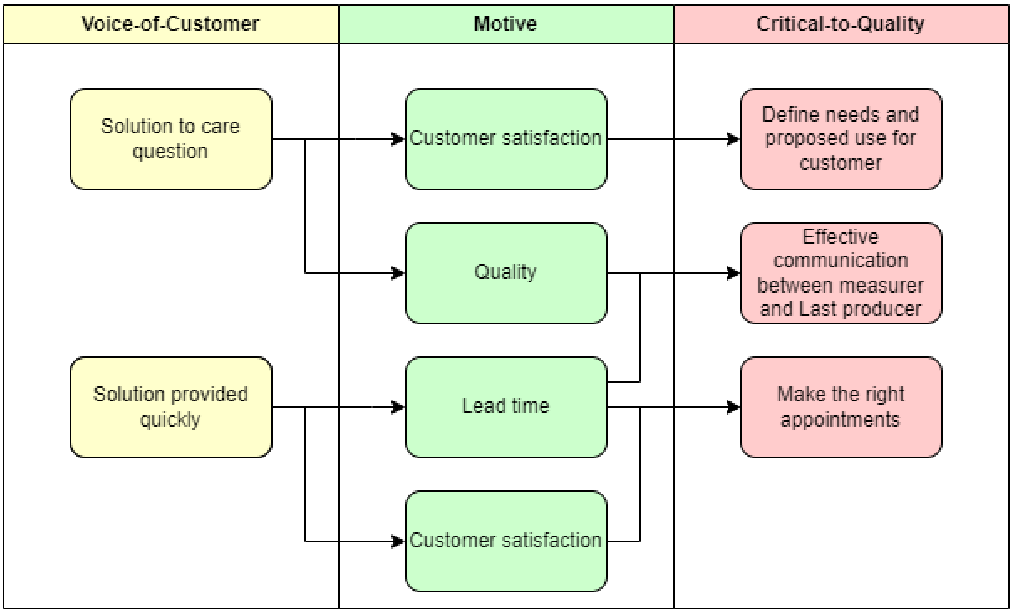


Figure 5: CTQ tree

The pareto diagram seemed to agree with the CTQ tree. Because the main sources of error came from poor data transfer, namely entering of incorrect data into the forms, wrong usage of these forms, or too long or short appointments. In addition, the other mistakes were also related to these domains. It therefore became evident that the measurement phase should focus on these main sources of error. Please note that the pareto diagram is depicted here but its main body was developed over the following phases, it is shown here since this is the first time it is mentioned, this is consistently the case for all tools developed over multiple phases.

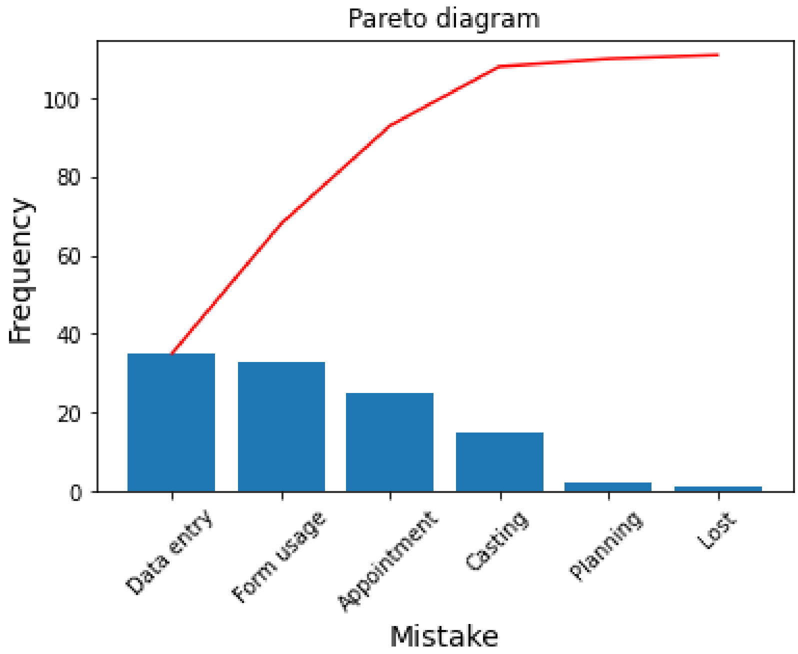


Figure 6: Pareto diagram

5.2.3 The Check step in the Define phase.

In a follow up session, the tools were evaluated, and the work was revised to see whether the team members still agreed with the conclusions from the tools and the way forward. Only some minor revisions were proposed. Finally, the tools were evaluated together with the way of working during this phase, their suggestions were noted and planned to be evaluated during the grander evaluation of the project. The team did agree on the fact that these tools provided valuable insight into the process and its main sources of error. However, some team members did find it a bit confusing that a pareto diagram was used before actual data was supposed to be collected. It would, in their opinion, be more fitting to start making the pareto just part of the measurement and analysis phase rather than also the define phase. They therefore initialised the Pareto in the define phase and finished it over the following phases. Another discussion point was the fact that it was hard for the team to grasp the boundaries of this case, a tool that visualises the process and thus its boundaries would be particularly useful in their opinion. A tool called process mapping was used for this goal, it is depicted in Appendix B.

5.2.4 The Act step in the Define phase.

With the tools and way forward clearly defined, the team decided to move on to the next phase. They actually continued their meeting and started on the plan step of the measure phase.

5.3 The Measure phase.

During the measurement phase it is important to measure the current process performance to foster later analyses which allows root-causes for the problems or inefficiencies to be found. In this phase control charts, capability indices, Pareto diagrams, Histograms, FMEA, VSM, and experiments were used to measure the current process.

5.3.1 The Plan step in the Measure phase.

The team started out by defining what departments were required to use which tools and divided the tasks based on these assumptions. This allowed the team members to perform the tasks more efficiently. The different departments and their tasks are depicted in Table 5. The team decided to reconvene in a couple of weeks in order to allow the different sub teams to perform the measurements. The explanation and usage of these tools was summarised for the purpose of dividing the tasks, more specific instructions were only provided to the sub-teams.

Table 5: Overview of departmental requirements of the tools used during the Measurement phase.

Tool	**Required departments.**
Control chart	Researcher, IT
Capability index	Researcher, IT, Upper Management
Pareto	Researcher, Measurer, Last producer
Histogram	Researcher, IT, Middle Management
FMEA	Researcher, Measurer, Last producer, Management
VSM	Researcher, Upper- and Middle management
Experimental design	Researcher, Upper- and Middle management, Measurer, Last producer

5.3.2 The Do step in the Measure phase.

As previously stated, the work for this phase was done in several sub-teams. These sub-teams got together regularly to coordinate their measurement efforts. The researcher attended most of these sessions in order to explain the tool usage and to foster the quality of the measurements. The first team focussed on the control charts. The team decided that the main variable for this chart should be the number of fitting appointments for a certain case. Since one appointment is inherently part of the last production process, more than one is seen as redundant. Thus, monitoring this variable over time and groups can provide great insight into current and future performance of the organisation. The time-based plot is created as control charts and is depicted in Figure 7. It showed some major disruptions in 2021, which would need to be investigated later in the analyse phase.

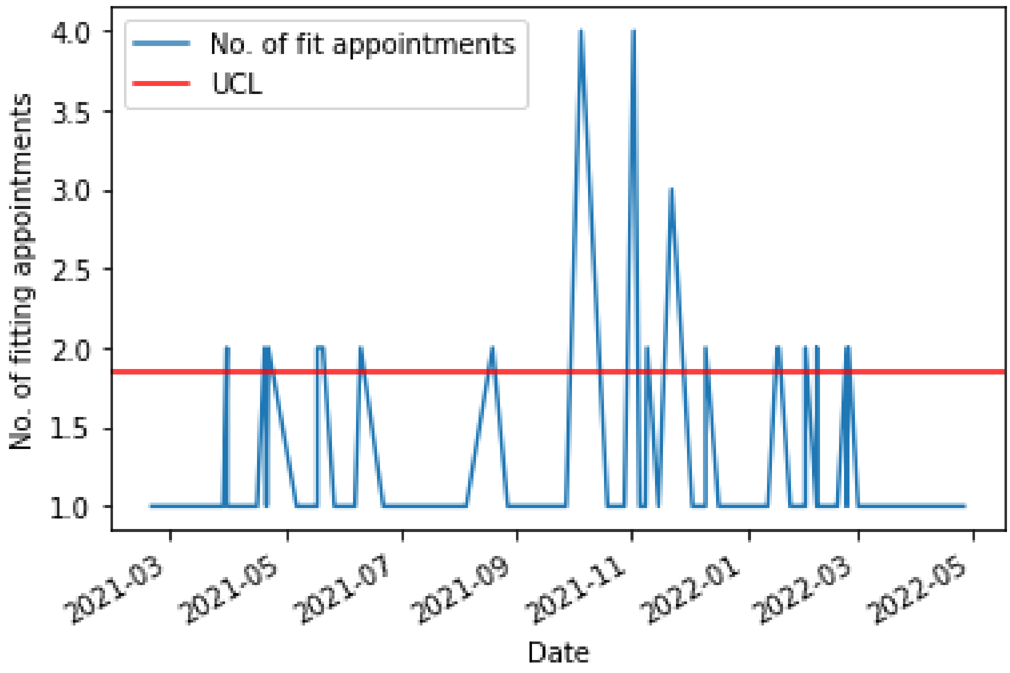


Figure 7: The control chart

The next tool that was used was the capability index, this tool displays the distribution of a particular variable. Management participated in order to set the proper boundaries for these distributions, namely the USL and LSL. The capability index focusses on the two main aspects, the number of fitting appointments and the lead time for the last production. Both these variables are plotted in Figure 8 and Figure 9 respectively. It has to be mentioned that the typical use for this tool is based on a two-sided, approximately normally distributed variable. In this case however, the distributions are severely skewed and there is no possible lower limit specification for the number of fitting appointments, other than one. Nevertheless, they still provide worthwhile insight into the current performance of the case company on these variables. It even showed that the lead time is well outside the boundaries of the USL, which was quite concerning to the team.

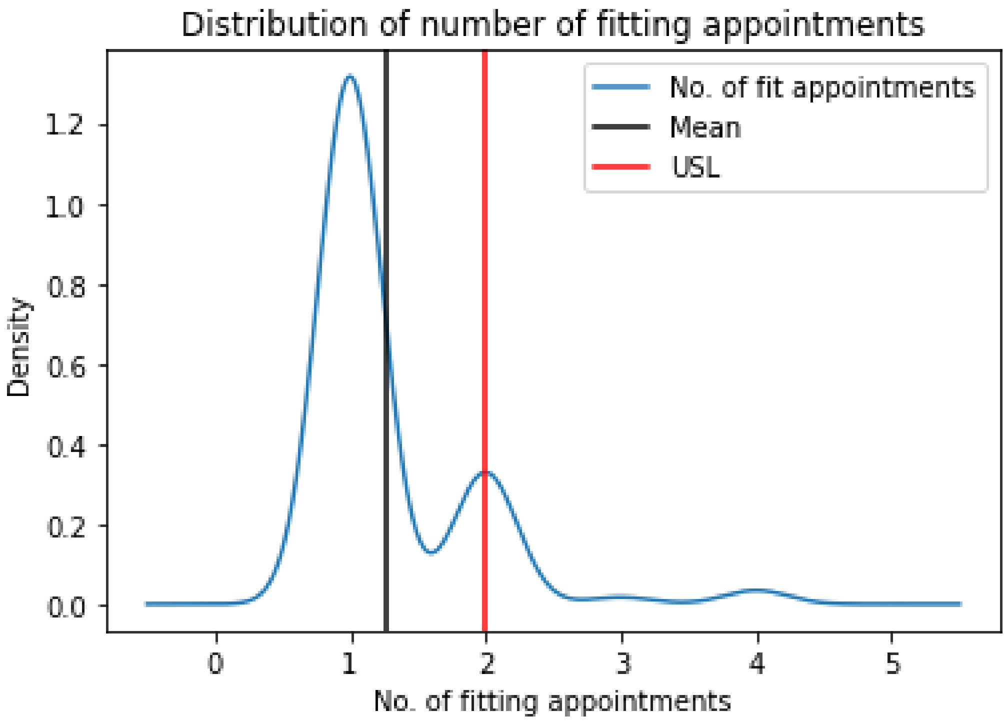


Figure 8: PCI plot for number of fitting appointments.

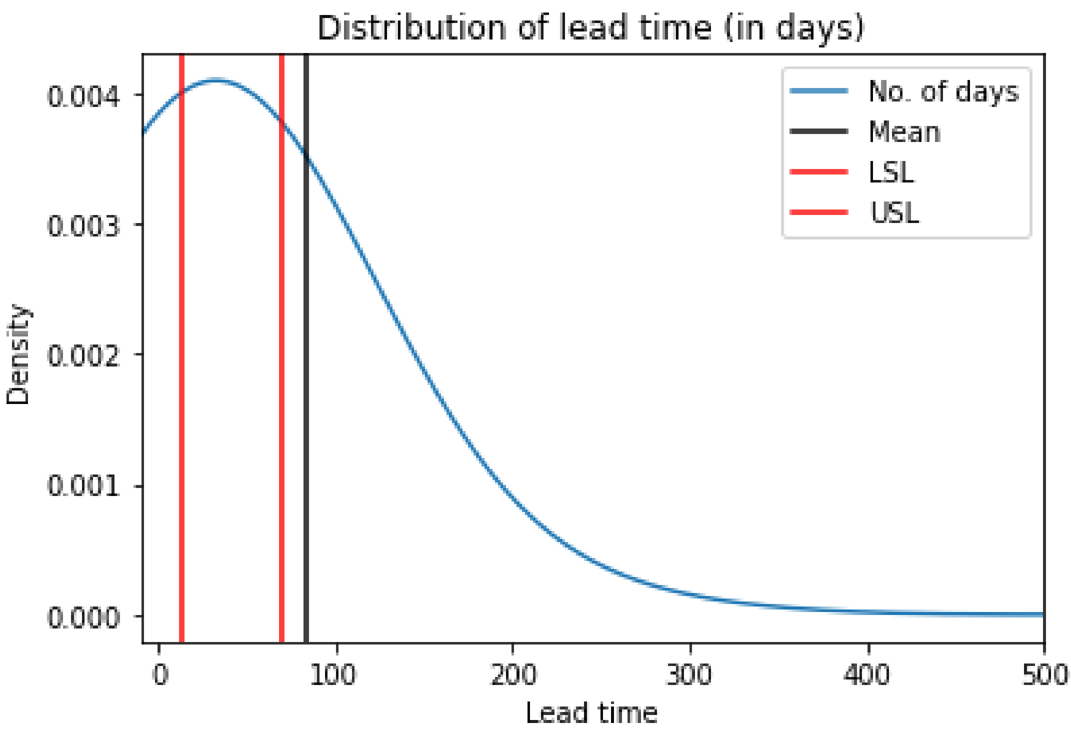


Figure 9: PCI plot for last production lead time.

The next tool was the pareto diagram, albeit that this tool was already used in the previous part and its data collection took place in this part. Therefore, there is no new plot or insight that should be mentioned here, the tool is depicted in Figure 6.

The histograms were used to get a better overview of certain variables over diverse groups of employees. In addition, another variable was added to gather information about form usage. Several plots were created, first the number of fitting appointments was visualised based on measurer, branch, and a combination factor of medical indication, age, and gender. These histograms are depicted in Figure 10Figure 11Figure 12. The second variable that was plotted was the changes made to the last during the production process, this was a single plot and is depicted in Figure 13. It depicted the amount of change (in mm) that is done throughout the process on a particular section of the foot. The variables indicate this by phase (e.g., Design, Fit, or Total) and section; (Oblique) Ball, Waist, Instep, and Heel. Which, in respective order, stands for the toe, middle, instep and heel parts of the foot. Finally, the form usage was visualised. The four most important forms were taken into consideration and visualised based on measurer, age, medical indication, and branch. The plot shows the percentage of the form that has been filled in. More complex cases will change the need for certain forms. It is therefore important to focus on the relative differences between the groups, which is why the plots have been standardized. They are depicted in Figure 14Figure 15Figure 16Figure 17.

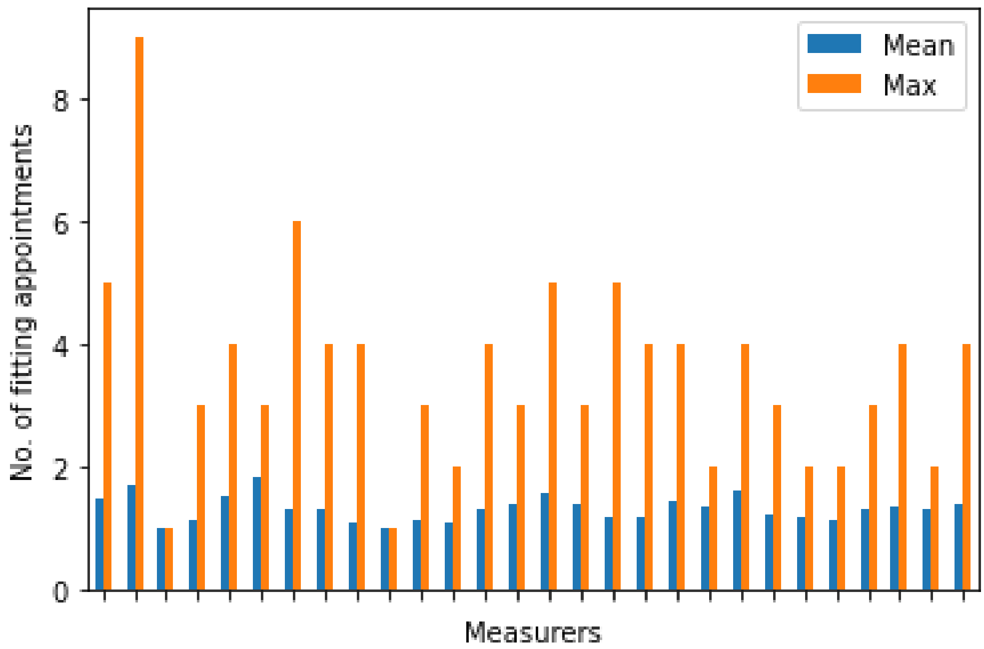


Figure 10: Number of fitting appointments per measurer

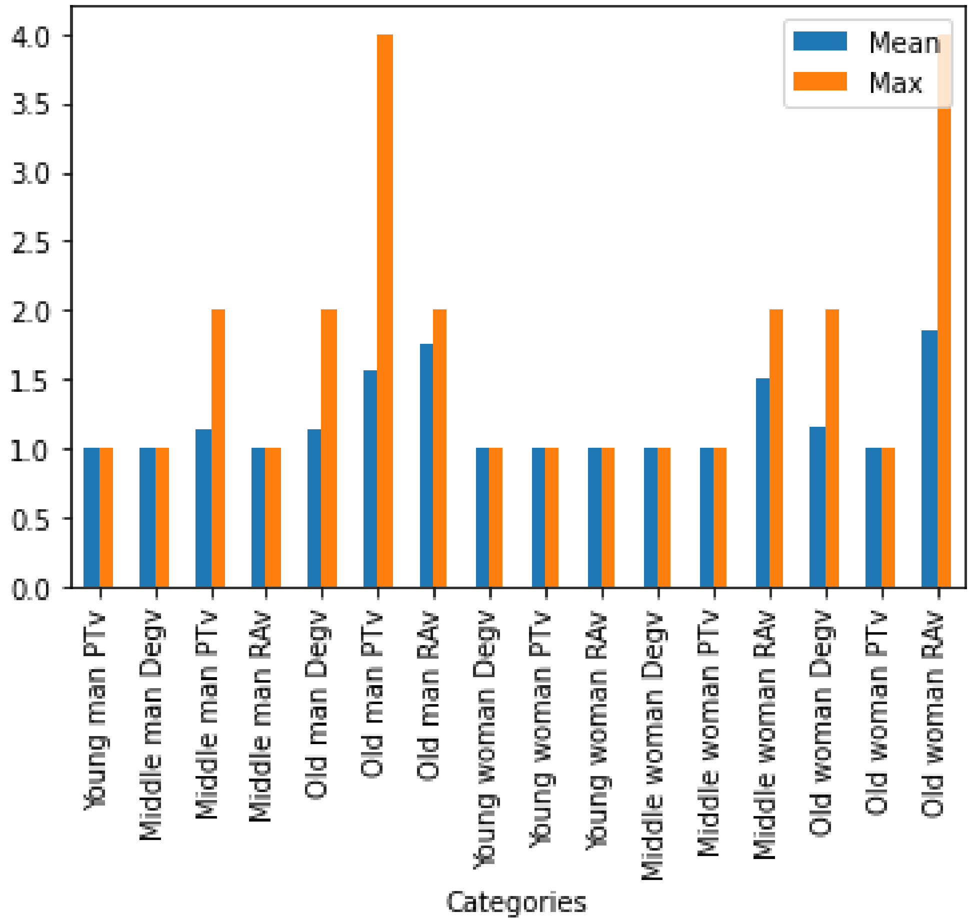


Figure 11: Combined factors histogram for number of fitting appointments

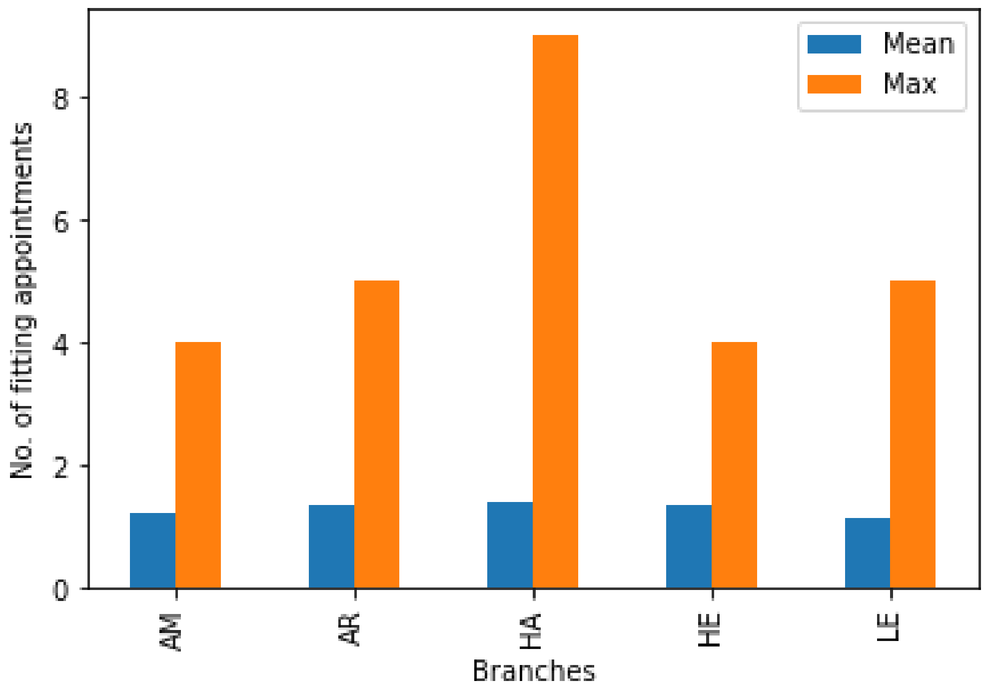


Figure 12: Number of fitting appointments per branch

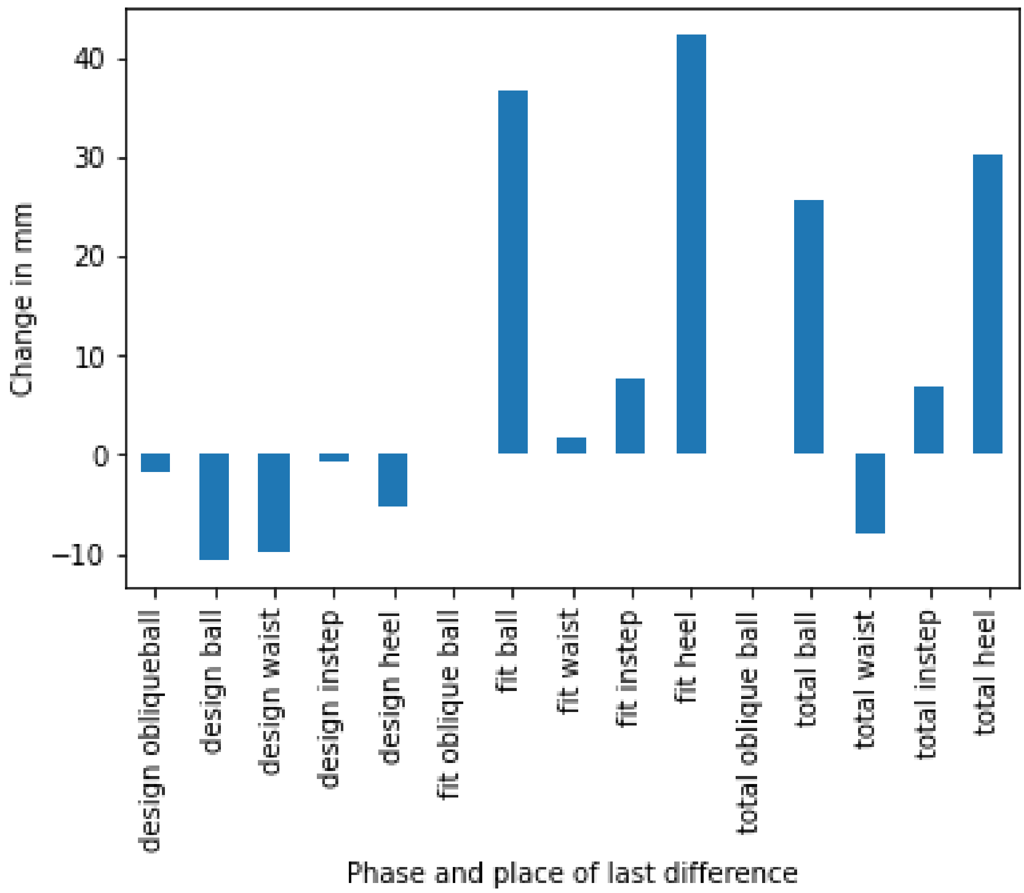


Figure 13: Histogram on changes made to the last during the process.

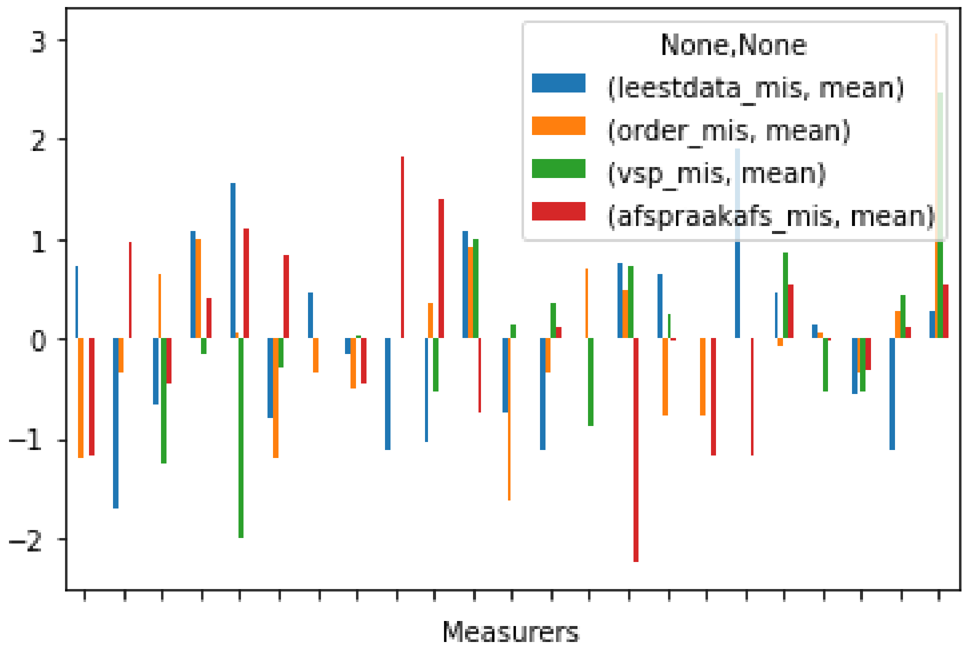


Figure 14: Form usage per Measurer

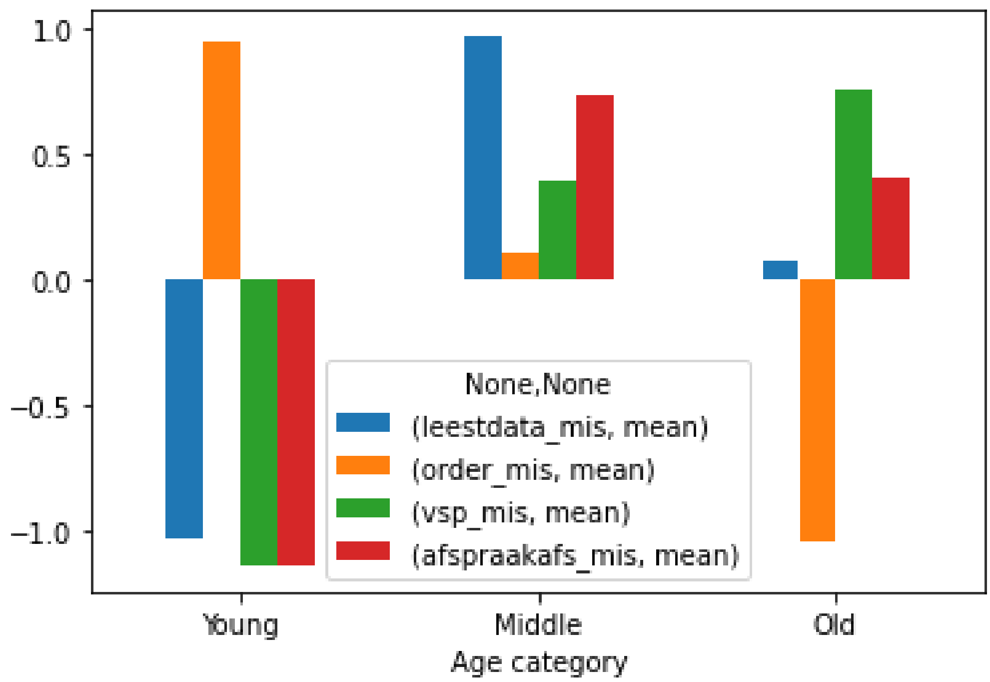


Figure 15: Form usage for different age groups

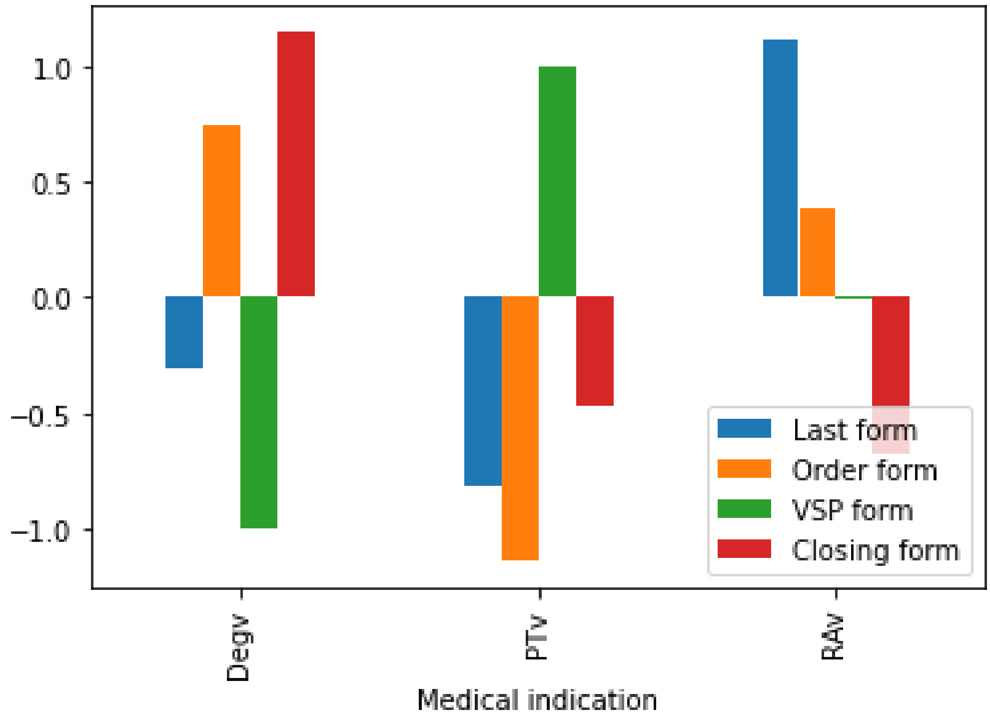


Figure 16: Form usage for different Medical indications

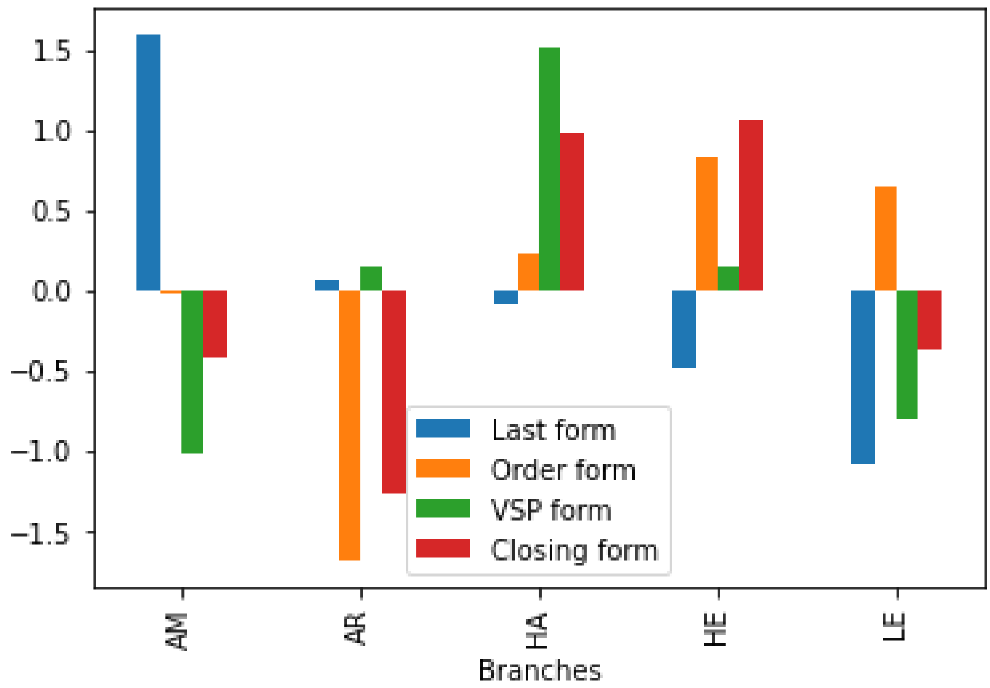


Figure 17: Form usage for different branches

The next tool was the FMEA, the team started by noting the mistakes they noticed over a couple of weeks or what they knew from experience. Then the team sat down to fill in the entire table that is part of the FMEA. The resulting FMEA is shown in Table 7. Other than that, the sub team responsible for the VSM created this for the state as-is, following Abbes et al (2018). The VSM was created based on the start where a doctor made a referral to the point that the last was deemed ready for production. The resulting VSM is shown in Figure 18.

Finally, an experiment was performed to test the assumption that an improvement in data transfer will decrease the number of mistakes and thus fitting appointments. In order to study this, the team found an interesting comparison, this was the branch in Leiden. This branch is unique since it designs its own lasts on site, rather than at the main branch in Heerlen. This fosters the communication between measurer and last producer, and it helps them to adapt to the way of working of the other colleague since the last producer works with a smaller number of different measurers. It is therefore assumed that this improved understandability of the information that is shared between these two parties will decrease the amount of rework, and thus fitting appointments. The hypothesis formulated for this purpose is as follows:

Lasts produced in Leiden require a lower average number of fitting appointments than lasts produced in Heerlen for other branches.

The results are shown in Table 6. They confirm the hypothesis or fail the reject the null hypothesis in statistical terms, and it is therefore safe to assume that better communication and data transfer decrease the amount of rework and fitting appointments.

Table 6: Experiment results

Branch	Mean	t-value	Degrees of freedom	P-value (sig)
Leiden	1.13	-	-	-
Arnhem	1.35	-5.361	677	.000
Amersfoort	1.23	-2.673	645	.008
Haarlem	1.40	-5.916	811	.000

5.3.3 The Check step in the Measure phase.

After the sub-teams completed their work, the entire team got together to discuss their findings and the implications hereof on the following stages. The main goal was to validate each other’s work, the team found no significant problems in this phase. However, there have been some problems that occurred during the collection of the data. Because multiple external parties are used for collection and transfer of data during certain steps in the process, it required significant effort to collect, combine and clean the data. This effort took a lot of time and required advanced understanding of data processing. It therefore can be a possible barrier when a firm considers using these data-based tools.

5.3.4 The Act step in the Measure phase.

With their measurements validated by the other team members the team decided that they could move to the next phase. For the tools that required info from another phase, namely the FMEA and pareto a discussion took place on whether all the requirements for this tool in the analyse phase were met in order to prevent shifting from phase to phase during the project. They decided that sufficient information had been gathered for these tools.

Table 7: FMEA

Process step	Failure mode	Occur rence	Effect	Seve rity	Cause	Detec tion	Risk Priority Nr (RPN)	Counter measure
Make appoint ment.	Wrong appointment type	7	Measurer either has too much or too little time.	6	Lack of information on agenda usage and customer requirements.	2	84	Inform on agenda, increase information requirement.
Intake visit	Incorrect form usage	8	Messes up data and patient file.	8	Lack of knowledge/interest on correct form usage	2	128	Enforce correct form usage.
Intake visit	Insufficient information collection	9	Measurer fails to provide sufficient information for last producer.	9	Time pressure, assumption that enough information is provided.	3	243	Force form usage
Scan cast	Too many folds	4	(Partly) Invalidates measurements.	7	Difference in Way-of-Working between measurers.	6	168	Standardize number of folds
Scan cast	Faulty cast	5	(Partly) Invalidates measurements.	8	Time pressure, assumption that enough information is provided.	4	160	Use scanner.
Make scan.	Corrupt(ed) scan file	5	(Partly) Invalidates measurements.	8	Improper training with 3D scanner	3	120	Create user manual.
Modify shape.	Failure to design proper solution.	7	Rework	7	Lack of orthopaedic insight from designer or lack of information provided.	3	147	Improve information position and designer's skills.
Make fit shoe.	Incorrect fit shoe	6	Increased error between actual last and fit shoe	5	Inherent to process step and result of some cases in particular	5	150	Hard to tackle other than adopting recent technology.
Mark fit shoe.	Unrealistic markings for rework	7	Impossible to include all remarks and thus follow measurer's suggestions.	9	Difference in Way-of-Working between measurers.	2	126	Hard to tackle other than adopting recent technology.

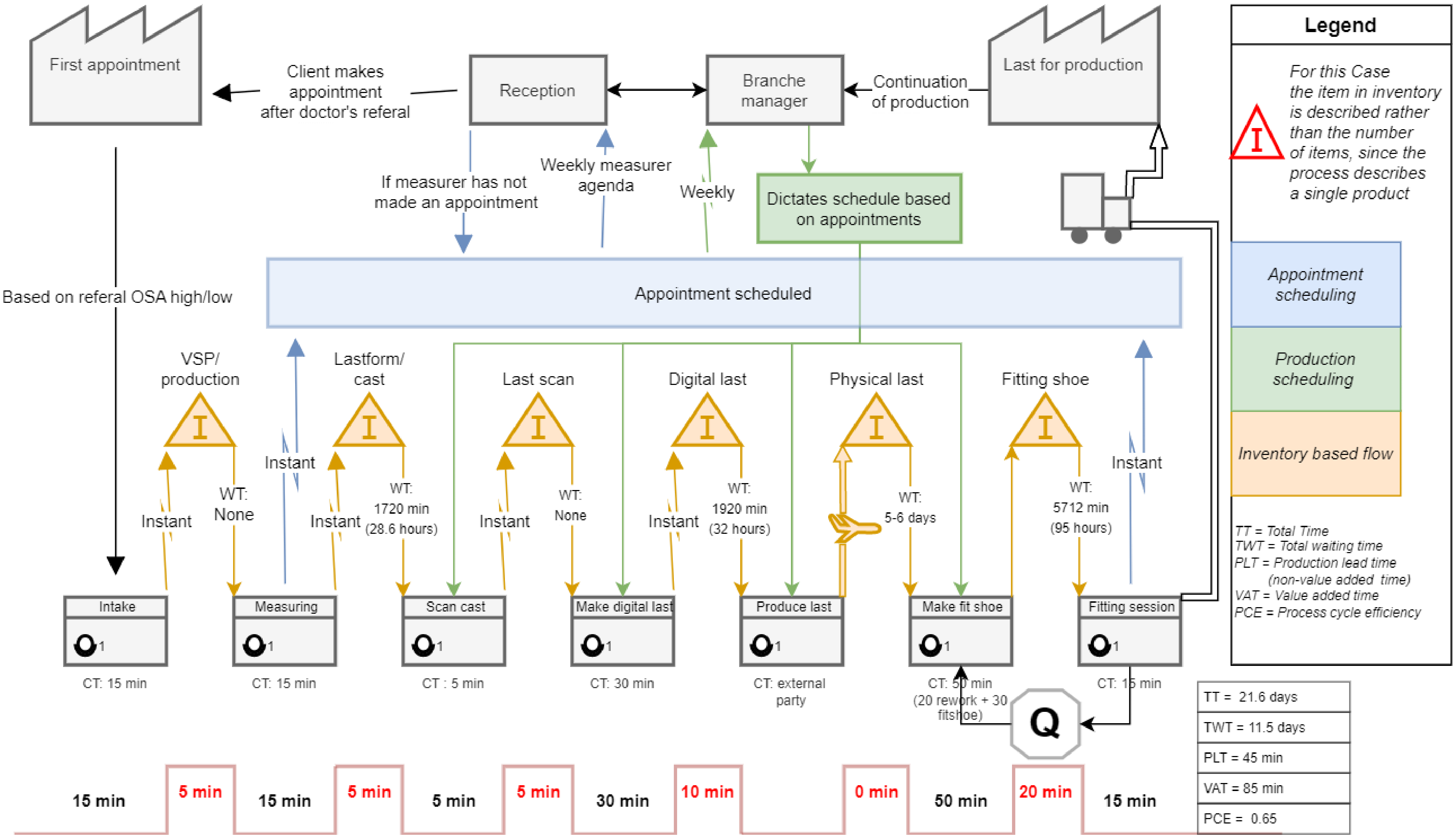


Figure 18: The VSM

5.4 The Analyse phase.

During the analyse phase, the following selection of tools was used; Cause and effect diagram, FMEA, Pareto diagrams, and SIPOC. In this phase, the Pareto and FMEA were finalised but in this report, they have already been discussed in previous phases.

5.4.1 The Plan step in the Analyse phase.

The plan for the analysis phase was not that important since it is an inherently short phase to begin with. The only actual planning that took place was to plan a meeting wherein the phase and its different steps would be executed. After a short briefing on the tools that should be used the team showed a preference for the execution of the cause-and-effect diagram to be in line with the SIPOC and thus be based on simplified steps rather than the usual 5M method.

5.4.2 The Do step in the Analyse phase.

During the meeting, the team discussed the findings from the measurements in light of the tools that will be used for this phase. They found that the experimental set-up of testing multiple branches gave a good indication of the problem. Further investigation showed what causes these miscommunications between the different stakeholders. A tool that maps this is the cause-and-effect diagram. As previously mentioned, the team chose the use the format that takes five simplified steps from the process and links possible mistakes to them. The diagram that was created is shown in Figure 19.

This was combined with finalising the FMEA, since now more information on occurrence and causes was known, it can be found in Table 7. The same is true for the Pareto diagram, which was finished in this phase but was already depicted in an earlier phase description as Figure 6. Another mentionable aspect was the insights that came from the histograms, it showed clearly how separate groups of stakeholders performed on a particular set of domains. This allowed the team to go into depth on why certain groups do or do not perform better and helped to formulate potential causes for these problems.

The team continued to create a SIPOC diagram about the process in question. The SIPOC they created is shown in Figure 20. Note that the colours are used for grouping based on the process. So, all red boxes belong to Intake, orange to Measure and so on. Multiple colours indicate relevance for multiple groups. The dependencies from this figure seemed to match the conclusion from the data analysis, namely the conclusion that improper data transfer between measurer and last producer harmed the production effectiveness and thus increased the amount of rework. This was supported by the sigma the team calculated based on the gathered data, the sigma calculated for this phase was 2.2, the calculation was as follows:

$$N = 1924, D = 462, O = 1$$

$$DPMO = 1.000.000 \times \frac{D}{N \times O} = 1.000.000 \times \frac{462}{1924 \times 1} = 240.124{,}74$$

$$Gives\ 24\%\ mistakes\ \ => \ \sigma \approx 2{,}2$$

The team concluded this step by defining a couple of root-causes for the inefficiencies, these were poor data transfer and improper planning.

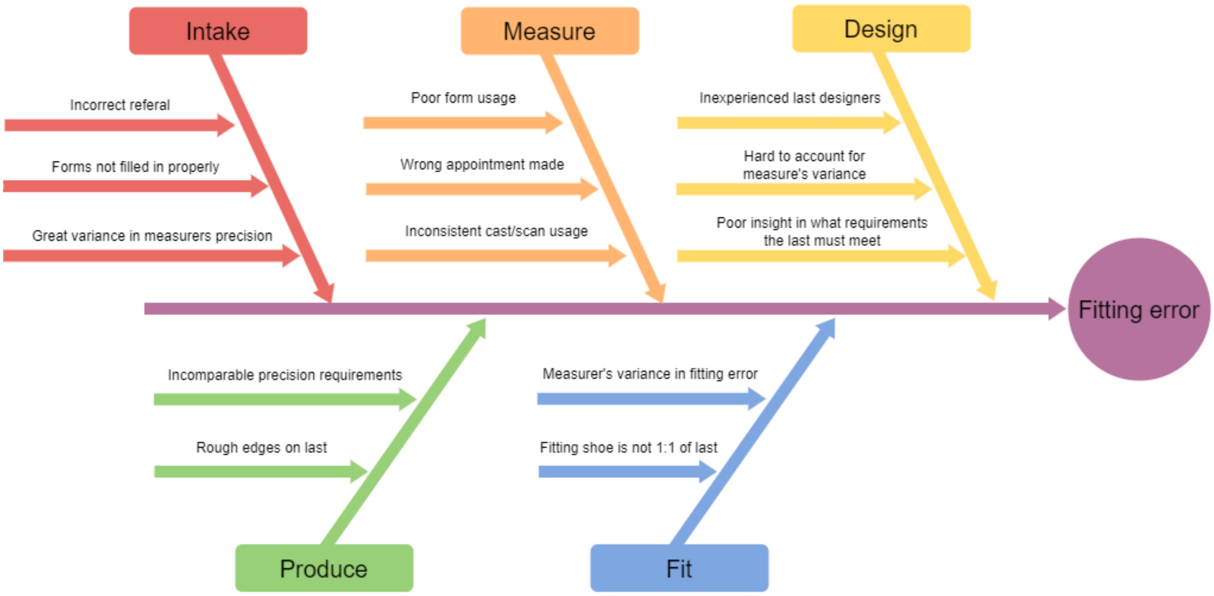


Figure 19: Cause and effect diagram based on simplified process steps.

5.4.3 The Check step in the Analyse phase.

In the same meeting the team moved on to the check step, the conclusions were reviewed in light of the grander scheme of things. It was important to assure that these conclusions are in-line with the tools and methods used in previous phases, incongruencies herein were found between the expectations formulated in the CTQ and the actual defined root-causes. Therefore, the CTQ was revised to fit these assumptions, this helped the team to gain a better understanding of the incongruency between their assumptions of the process and its inefficiencies in reality. The team also chose to adopt another widely used tool for LSS, which is the 5 why method, in order to find the root-causes. This tool is quite simple and yet effective since it continues to question a statement until a fundamental problem is brought to light, namely the root cause itself.

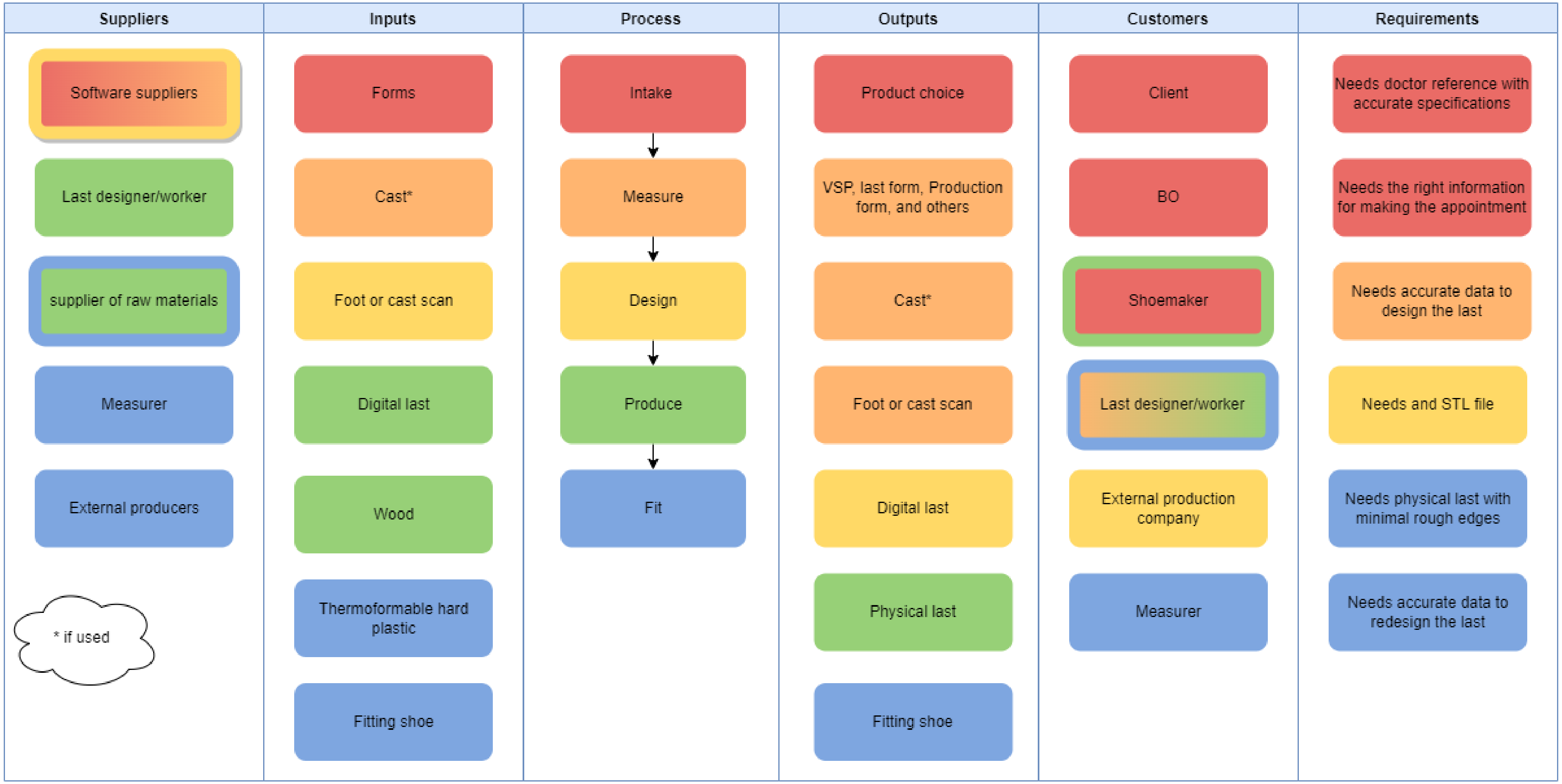


Figure 20: The SIPOC created for this project.

The team went on to revise the performance indicators since they felt that calculating the Sigma in itself was better than also including capability indices and analyses. This had to do with the perceived ease of usage and limited resources required for Sigma while it gave a significant amount of insight, whereas capabilities were less relevant and more complicated.

5.4.4 The Act step in the Analyse phase.

In conclusion of the meeting for the analysing phase, the team decided that the next phase will be specified towards the previously defined root causes. Meaning that practical solutions should focus on tackling either one of these causes. All team members were tasked with producing viable solutions for the next meeting.

5.5 The Improve phase.

The improve phase started fairly quick after the analyse phase and took a couple of weeks. Due to the iterative nature of this phase the team made use of different sub teams that worked out a certain solution again. Following the framework, several tools were to be included in this phase. These were the 5M methodology, then came SMED, Kanban, Experimental, Kaizen, and finally Brainstorming.

5.5.1 The Plan step in the Improve phase.

The team got together to discuss their ideas; these were noted on a whiteboard. The team voted on what ideas were best applicable and divided sub teams to work them out. They agreed on a timespan of one month to allow teams to work out and assess their solutions. They created a Kanban board to track the sub teams' progress, an example hereof is depicted in Figure 21 (note that the tasks are masked since there were also other unrelated tasks depicted in this board because the team liked its use). In reality this was already the meeting in which both brainstorming, and Kanban were used. Whereas brainstorming was also used in advance of this meeting.

5.5.2 The Do step in the Improve phase.

As previously mentioned, the team started with brainstorming. This was done by means of giving every team member the task to produce possible solution for one of the two root causes on forehand. These ideas were noted, and every team member got five minutes to choose the best ideas. Five ideas were selected and worked out by different sub-groups; these groups are shown in Table 8. For each group, a further analysis on the ideas and implications was expected for the next meeting. After the initial brainstorming and planning session, the teams started experimenting with viable solutions. There were five solutions being assessed at the same time, most solution were assessed with a control condition experiment.

Table 8: The different solutions and their sub teams

Solution	**Departments**
Implementing the bin 3D scanner	Measurers, Middle management, IT
Implementing the hand 3D scanner	Measurers, Middle management, IT
Improving the agenda types	Middle- and Upper management, Measurer, Reception, IT
Improving the last design with 2D and 3D drawings	Last producer
Improving the forms	Measurer, Last producer, IT, Middle management

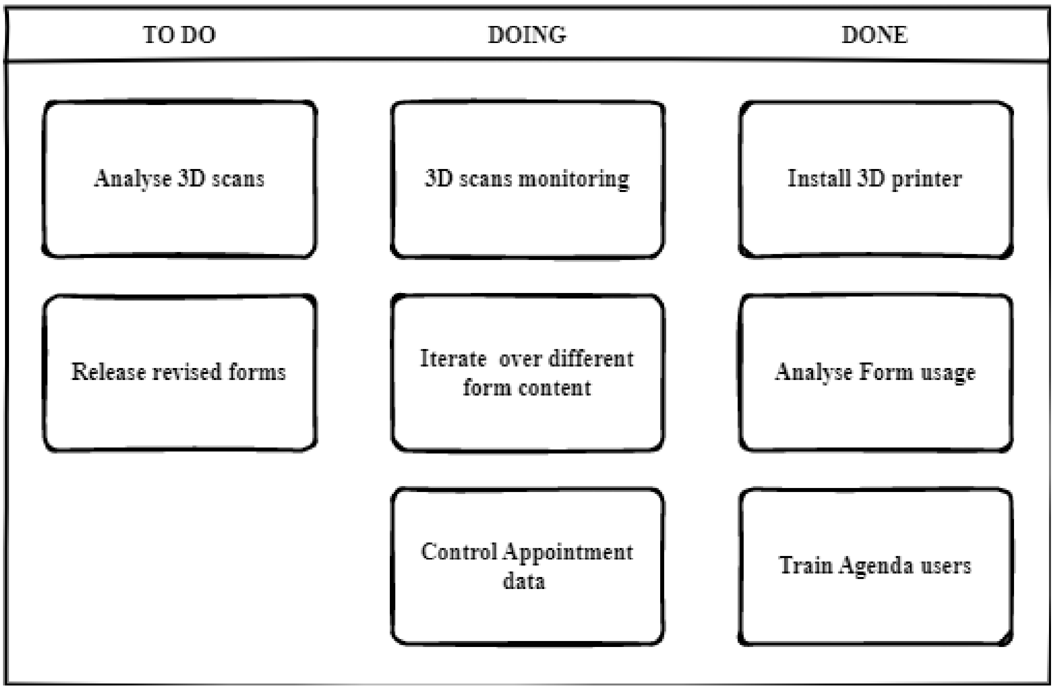


Figure 21: Kanban example used for project implementation.

The implementation plans for these experiments, completed with expected costs and planning, were discussed in the following meeting together with senior management. They agreed on working out three possible solution directions, working with the scanners, creating a new agenda, and revising the forms. Starting with the scanner, the team figured out fairly quickly that the scanner placed on the ground (bin scanner) was more precise than the hand scanner. This had to do with both technical limitations of hand scanner, but mainly with the fact that the bin scanner is far more fool proof. They therefore decided to focus on the bin scanner. After 50 cases were scanned, the results of each scan were noted and discussed. Two of the first cases were excluded from the dataset since their mistakes purely came from beginner mistakes when using the scanners, like pushing the wrong button or failing the save the file in the right format. Further mistakes from technical limitations were not excluded. The resulting sigma was as follows:

$$N = 49, D = 7, O = 1$$

$$DPMO = 1.000.000 \times \frac{D}{N \times O} = 1.000.000 \times \frac{7}{49} = \; 142.857{,}143$$

$$Gives\ 14{,}29\%\ mistakes => \sigma \approx 2{,}6$$

The team also estimated that the required time for using the scanner was significantly lower than the usual measurement process, especially if a cast had to made. Meanwhile the other branches remained at an approximate sigma of 2.2. So, both in time and error proneness the scanner performed better than the usual way of working. However, the scanner was a significant investment and requires quite some space and a proper (digital) environment to operate.

The following experiment focussed on improving the appointment types in order to prevent planning the wrong appointments. First an indexation on the possible mistakes was done, then solutions for these problems were defined and incorporated into the new appointment types. Both the problems and new types can be viewed in Appendix C. The new appointment types were introduced and monitored in one branch, namely Heerlen. The were introduced together with a scheme that showed how and when each type is to be used. The results showed a 17% (from 8,3 to 6,9 on average per week) decrease in planning too long or short measure appointment (aanmeten OSA hoog vs laag) in the first two months. This seemed to drop over time, so even fewer mistakes.

The final solution has not yet showed any results, this comes from the fact that the forms are parts of a digital measuring portal (aanmetersportaal) which is maintained and created by an external party. This makes iterating over different changes to these forms fairly complicated. Especially since they prefer not to make too many changes too often. They did analyse what fields of the forms were used most often and which ones are the most important, Appendix D gives an overview of the forms, their fields, and percentages of usage of these fields.

5.5.3 The Check step in the Improve phase.

After the solutions were assessed, the team got together to discuss the results. However, there was some critique on the set-up of this phase. Primarily, they found the SMED tool to be useless in this context since their work is case based in itself and therefore not applicable for this tool. Moreover, the boundaries of this project were set based on a high or low OSA shoe last, SMED could be relevant for analysing the transition of production/processes towards OSB, OSC, VLOS, or insoles. This, however, was beyond the reach of this project. The same was partly true for the new appointment types, since it would not make sense to merely do it for the appointments belonging to this project. Therefore, the choice was made by management to revisit all appointment types. Furthermore, the 5M as suggested by Abbes et al. (2018) was very much alike the previously defined cause and effect diagram (or fishbone diagram). It was therefore discussed, but not used to further extend since root causes have already been defined and no significant new insights were discovered during the implementation phase.

5.5.4 The Act step in the Improve phase.

After managerial review, three main solutions were processed further. These were the implementation of the 3D scanner during intake, a review of the forms used, and the new appointment types. The actual implementations would be piloted in their main branch before rolling it out nationwide. The implementation phase assessed these solutions in controlled experiments in a single branch, both the scanner and appointment types were deemed fit for further implementation. The new forms are still being assessed and are therefore not considered for wider roll out yet.

5.6 The Control phase.

The control phase started after the pilot of the solutions to define the controlling mechanisms that would be used for a successful roll out and ensuring longevity of the solutions. The toolbox for this phase consists of Poka yoke, FMEA, Performance indicator, Quality indicator, and Control chart.

5.6.1 The Plan step in the Control phase.

The control phase started as a continuation of the solutions that were piloted and accepted in the previous phase. In other words, as soon as the results showed promising results the pilot was turned into a broader implementation plan, of course with the necessary managerial blessings. Therefore, there is no distinct line between the two final phases, other than the fact that this phase focussed on rolling out and controlling the solutions rather than assessing them. The team got together afterwards to discuss the implications. The form usage thus still remains in the improve phase while the other two solutions have already progressed to the control phase.

5.6.2 The Do step in the Control phase.

During the meeting, the team defined a couple of KPIs that should be monitored, these are in line with the data gathered and analysed during the previous phases. The most important were Sigma, number of fitting appointments, form usage, and lead time. Procedures for monitoring these KPIs were put into place by making the codes for them part of their Power Bi dashboard. They started out by making monthly reports on these KPIs and might later extend this period to quarterly reporting. The team also started focussing on a more elaborate roll-out of these solutions. This was of most importance for the 3D scanner since it required a significant investment and the redesign of the treatment rooms together with the procedures for measuring. The solution required some level of training which should be done during the monthly measurer meeting. Instructions for using the scanner were written by IT and the required data infrastructure was also provided by them. In order to prevent mistakes Poka Yoke was applied to find foul-proof solution that could be rolled out. This came down to ensuring the files are saved in a certain format and a pre-defined directory. Also, certain accessories were created to foster the use of the scanner, allowing the measures to make certain stand corrections whilst scanning. For making this investment for other branches, it would make sense to start out with the one that has the most first-time appointments and thus highest last production requirement. Then it would need a proper working environment both digitally and physically in order to function properly. The most challenging part, however, would be in retraining measurers to work with the scanner. Since even in the pilot one measurer had severe problems with scanning. First, he would make regular mistakes with finding the right set up, making the scan worthless. Next to this, he was extremely sceptical of the output and thus erred on the side of caution in making the fitting assessments, thus increasing the number of fitting appointments. Additionally, from anecdotic evidence it seems to be the case that there are several measurers like this, complicating future improvement efforts. However, in the end he seemingly got the hang of scanning and thus the hurdle, albeit with a significantly higher effort, was overcome.

Time was dedicated to explaining the new appointment types and their implications. For the front desk employees who regularly make the appointments as for the measurers making appointments. The key-users already knew the appointment types, since they helped to define them, and would only need to be explained to the remaining users. The remaining roll-out would therefore be based on making the types applicable for the users and providing them with the training and information about the appointment types. The progress on this domain was regularly evaluated by the key users meeting. Overall, the roll-out went exceptionally smooth and only had to be monitored in the future.

The team worked on the forms solution to make certain crucial pieces of information in the forms required before sending it in. They also found ways to make certain information fill in automatically. This way the most crucial data transfer will always be present, there are however limited possibilities in this domain and work still needs to be done to get the forms ready for optimal use. In order to map the problems, the team encountered whilst rolling out/ further evaluating the solutions, they improved the previous FMEA, it is shown in Table 10.

5.6.3 The Check step in the Control phase.

After a couple of weeks, the team got together to evaluate the pilots and their monitoring devices. They found that still some mistakes are being made in the process, but the solutions are still sustained. Other than that, the team reflected on their way of working during this phase and concluded that the sub teams sometimes lacked coordination with broader team. As did team member sometimes fail to communicate the progress of this project to their colleagues which made some solutions come as a surprise to their colleagues. This communication would need to be improved for future projects.

5.6.4 The Act step in the Control phase.

The team had decided that both the agenda and scanner were to be rolled out further in time over the entire organisation and that the form usage would be evaluated over time as it progressed. There are however, at the time of this writing still no clear results on the optimal form usage.

5.7 Evaluation of the Implementation project.

A couple of weeks after the implementation project, the team members were requested to be interviewed. Notes were made during these interviews to add them to the observations made during the case study. The first interview was with a last producer, he mentioned that the structure worked well for him. Since even though he has limited knowledge on business processes and management in general, he was able to cooperate and provide relevant insights. He very quickly got a better understanding of the process and his role herein. Moreover, he stated that some tools were irrelevant as a response to what weak points the framework had. He continued to say that this was already discussed in the check steps. He also found it annoying that some phases seemed to take forever whilst others were noticeably short. This was most prevalent when sub-teams were made to complete tools in parallel. Other team members had similar replies by mail as a response the interview request and questioned whether an interview would be necessary since their mail response captures it all. Another team member had failed to respond or to plan a meeting.

For a while, a limited number of responses came in. Other than the simple replies by mail and referrals to the already discussed changes in the check steps, no interviews were done. But in order to at least get some extend of validation of the observation done throughout the study, the observations were listed, and four overarching themes were defined. This analysis was based on grouping as much as observations as possible. These themes are listed in the following chapter (6). This overview was shared with the team members for validation and most of them did reply in agreement with these conclusions. A final interview was conducted with a manager to validate these findings and the aid to formulation of answers to the research questions. The manager mentioned that he very much liked to new framework and definitely would aim to further roll it out over the company. He also liked the fact that some tools were already becoming part of the way of working, the Kanban and Poka Yoke in particular. They also made a process map for another part of the business processes. He was proud of the improvements that were made in the last production process and aimed to use the framework to even improve it further. Last but not least, the success factors that they were made aware of helped him and the HR manager to focus on new aspects that help to keep their employees happy and productive. So, he very much appreciated the new insights. An overview of the interviews and validations that took place is provided in Table 9.

Table 9: Interviews and validations conducted after the case study.

Team member	Status	Feedback
Measurer	Only validation reply	Agreed with findings.
Last producer	Interviewed and validated.	Discussed in section 5.7
Upper manager	Interviewed	Discussed in section 5.7
Middle manager	Replied by mail both times.	Agreed with findings.
IT employee	Replied by mail both times.	Agreed with findings.

Table 10: Second FMEA that includes the solutions.

Process step	Failure mode	Occurrence	Effect	Severity	Cause	Detection	Risk Priority Nr (RPN)	Counter measure
Make appointment.	Wrong appointment type	4	Measurer either has too much or too little time.	6	Lack of information on agenda usage and customer requirements.	2	48	Inform on agenda, increase information requirement.
Intake visit	Incorrect form usage	7	Messes up data and patient file.	8	Lack of knowledge/interest on correct form usage	2	112	Enforce correct form usage.
Intake visit	Insufficient information collection	6	Measurer fails to provide sufficient information for last producer.	9	Time pressure, assumption that enough information is provided.	3	162	Force form usage
Make scan.	Wrong file storage	2	Significant effort to find or make new scan.	9	Improper training with 3D scanner	9	162	Predefine directory.
Make scan.	Wrong set-up	4	Invalidates scan.	8	Improper training with 3D scanner	7	224	Provide scanner training.
Make scan.	Corrupt(ed) scan file	5	(Partly) Invalidates measurements.	8	Improper training with 3D scanner	3	120	Create user manual.
Modify shape.	Failure to design proper solution.	7	Rework	7	Lack of orthopaedic insight from designer or lack of information provided.	3	147	Improve information position and designer's skills.
Make fit shoe.	Incorrect fit shoe	6	Increased error between actual last and fit shoe	5	Inherent to process step and result of some cases in particular	5	150	Hard to tackle other than adopting recent technology.
Mark fit shoe.	Unrealistic markings for rework	7	Impossible to include all remarks and thus follow measurer's suggestions.	9	Difference in Way-of-Working between measurers.	2	126	Hard to tackle other than adopting recent technology.

6. The case study results.

The observations done during this case study and afterwards were distilled into themes. They were send to the team for confirmation, the team mostly agreed on these impediments and improvement directions. Section 5.7 describes this process. During the analysis of all observations from the check steps and interviews, a couple of broad themes emerged. The observations were focussed on finding answers to the case study questions, Table 11 relates these questions to the themes that emerged from these observations. They are both discussed in this chapter. The chapter concludes by formulating answers to the case study questions.

Table 11: Relations between themes and research questions.

Theme	Research question
PDCA-in-DMAIC provides a good structure for LSS implementation.	3 & 4
There is room for improvement in tool selection.	4 & 5
Poor data knowledge or access can seriously delay/harm the project.	5
Not all possible challenges are captured in this framework.	4

6.1 The case study findings.

6.1.1 PDCA-in-DMAIC provides a good structure for LSS implementation.

The implementation team was quite positive about the whole set-up of the project. The distinct phases helped to have an overview of the activities and tools that were to take place. They also mentioned that the PDCA-in-DMAIC set-up helped them in understanding the tools and processes much better. However, it was also restrictive at times, when a certain solution popped up during the measurement phase it was hard not to discuss it. Even though writing it down was a feasible alternative, some team members struggled not to get ahead of the framework at times. Some suggested a little more flexibility in iterating between phases would have been nice in the beginning, as was the case for the final two phases where two solutions were already carried over while the other one was still in progress. In the end, the team understood that this was best not applied during the earlier phases and generally agreed on the effectiveness of the structure.

6.1.2 There is room for improvement in tool selection.

An issue became apparent when the Pareto diagram was discussed as part of the define phase, since it clearly had dependencies on both the measurement and analysis phase afterwards and was also depicted as such in the framework. It would have been better the start it in the measurement phase. However, this would greatly limit the number of tools used in the define phase and thus make it hard to comprehend the boundaries of the actual production process in question. In order to get everyone on the same page a process map was created, it is depicted in Appendix B. This solved the problem and provided more insight during the define phase. The restriction in the tools from this framework caused serious opposition from the team at times, since they sometimes were deemed irrelevant for this project. At other times, they missed tools in the framework. The first example was the process map that was included, but in the analysis phase the team also included the ‘5 why’ method to find the root-causes for the problems in the process. This also led them to revise their findings on the CTQ, it would thus be advised to include this method from the beginning. In a later phase, namely the improve phase, they were confronted with the SMED. This tool caused the most resistance since it was perceived as unapplicable to their cases since there is no ‘exchange of dies’ like part in the last production process. This might have been applicable to their intake process as a whole, but since lasts are only created for OSA shoes it was deemed redundant. The capability indices were not preferred as well for future usage, since the sigma previously used was easier and better. The last change in tools was the 5M diagram, first because it was used in another way. But the main change came from the fact that a root-cause-diagram is the same as a 5M diagram. Therefore, the latter was not used. Apart from the slight deviation in tools the entire tool usage was a positive experience for the team. The tools provided workable insights and helped them define effective solutions that in the end improved the process. The added tools are discussed separately in the following two paragraphs.

Process mapping

A process map gives a detailed overview of what steps occur in what order and who performs these steps. This map often includes a wider range of information on decision points and criteria. In other words, it describes the flow of activities and actors in a particular part of the organisation. This tool is especially useful in finding what players are affected by a certain process and for defining the scope of the project, so what activities do and do not belong in the project. This tool was included early on in the project to clearly define the boundaries and stakeholders for the project, it would therefore be advised to use it as part of the design phase. This tool also greatly helped in defining what stakeholders are affected by the project and should therefore be included further in it. In the end, this reduced the friction because direct colleagues were better able to guide people in the adoption of the solutions. Biazzo (2002), has shown that process mapping is a powerful tool, and that it can be of significant use for all kinds of organisations. It would therefore be a good addition to the current framework.

5 why

The 5 why method is a quite simple tool that questions the underlying assumptions of perceptions of the problems that occur during the process. Basically, it will ask 'why' five times, this can be more or less depending on the complexity, to discover a root-cause for a problem. It is a widely adopted and effective tool. This study adopted it whilst searching for the root-causes for the errors occurring in this process. It would be advised for use during the analysis phase. Finally, a study on effective lean tools in small enterprises by Deb et al. (2010) showed that 5 why is a simple yet effective tool to apply for these companies. This is in line with the result from this study.

6.1.3 Poor data knowledge or access can seriously delay/harm the project.

Furthermore, the measurement phase was severely complicated by the lack of ease in collecting data. The IT department had to collect, combine, and clean data from several dissimilar sources. To some extent, there were also complications in the measurements, this came from the fact that time pressure made several operators forget to note directly afterwards. So, for a framework that focusses on implementing LSS, a method that has quite some reliance on data, there are few tools that guide these efforts. It could therefore be a barrier to the implementation.

6.1.4 Not all possible challenges are captured in this framework.

Another aspect that was mentioned was the lack of external communication, mainly the measurers seemed to fail to communicate their progress to their colleagues, which made the scanner pilot come as a surprise. The framework provided no specific tool for this problem. So, with resistance management being one of the success factors for LSS implementation, this is a factor that might be useful to include in the framework. Albeit that eventually the framework did tend to perform well in this domain, just without direct tools. It is therefore hard to ensure this will always go well. Finally, the final solution about form usage showed another critical aspect, namely that sometimes the suppliers can cause resistance to changes. They severely delayed to development of the solution and the framework provided no clear guidelines on how to tackle this. The importance hereof is that all companies are in some way collaborating with suppliers, and in extension their projects will therefore often include dependencies on suppliers. Hence, it is important to look into supplier management.

6.2 The case study questions.

This section goes over the different case study question and uses the observational themes to formulate an answer to them.

6.2.1 How well does the framework perform in implementing LSS in a SP-SME context? (Research Question 3)

The first case study question (research question 3) for this part was focussed on how well the framework performed in implementing LSS in a SP-SME context. The answer to this question is twofold, namely it worked well on getting the team members up to speed on the new methodology as did it help them to make real improvements in the organisation. The PDCA-in-DMAIC offered the team members a terrific way to getting to know LSS and ensured that they had enough time to learn the tools and methods, and to reflect on their workings. After completing the framework, albeit that the control phase never is really completed in practise, they found two root-causes and three solutions for these root-causes. The root causes were poor planning and bad data transfer. The solutions they produced improved the uniformity of data transfer together with build-in safeguards for better data transfer and streamlined the agenda to improve the appointments. They realised a sigma improvement of 0,4 (from 2,2 to 2,6) which translates to almost 10% less mistakes and 97.267,597 fewer defects per million opportunities (DPMO) (from 240.124,74 DPMO to 142.857,143 DPMO). See section 5.4.2 and 5.5.2 for both calculations on the original and improved state respectively. Other than that, they decreased the number of faulty appointments with approximately 17%, see section 5.5.2 for the exact numbers. The estimated effect on lead time reduction is 2-4 weeks since each new fitting appointment or follow-up appointment due to lack of time will increase lead time by 1 or 2 weeks.

6.2.2 What aspects of the framework are better or worse equipped to deal with the specific challenges coming from the SP-SME context? (Research Question 4)

However, the project did bring some strengths and weaknesses of this framework to light. A strength of this framework is the multi-cycle lay-out. It greatly improves the quality of the greater cycle and the tools used in that cycle. It helps with planning the project and estimating the time required for that cycle. Especially in the case of unexperienced adopters of the framework, it aided their understanding and reflection on the project. This, however, also exposes a weakness. It sometimes over-regulates the flow of the project an restricts the users in continuing to work out solutions. Another important shortcoming of the framework for the application in a SP-SME context is the tools that were included. Even though they made sense for the original context, they did not for this application. In specific, the SMED and Capability indices were unapplicable in this context due to the nature of the SP-SME context. In addition, the Pareto tool was seemingly misplaced as part of the define phase, due to its measuring requirements. The 5M method was also confusing since a similar tool with another name was already being used. The framework also missed some tools, mainly one to map the process early on and to find root-causes.

6.2.3 Which of the previously defined Success Factors are most important when implementing LSS in a SP-SME? (Research Question 5)

A final sub question (research question 5) was about the previously defined Success Factors (Section 3.2.3). These success factors came from the answer formulated for the second review question (research question 2). The observations gave insight in what success factors were most applicable for the SP-SME context. The answer to this question is therefore structured based on the most important success factors. The success factors: Alignment of LSS with the Organisational Strategy, Clear Goals and Expectations of the LSS Project, Effective Training and Design of Curriculum for different LSS Roles, Development of Reward and Recognition System, LSS Leadership & Culture, Linking LSS to Customer and Employee Needs, and Ensure Infrastructure and Resources for Project were less apparent during the implementation of LSS in SP-SMEs. This is not to say that they are not important, but less so than the other factors. They are therefore not discussed as a response to this research question. The following paragraph links the most important aspect to observations in this study as a response to research question 5.

LSS and data strategy

Over the course of the project, it became evident that the lack of data access and insights was problematic at times, this means that LSS and data strategy is an important success factor in the SP-SME context. An important observation that supports this was made during the measurement phase, since the collection and processing of data in this phase was a lot of work. The data that they collected had some problems with its validity and required extensive effort to be processed for further analysis. A clear data strategy on forehand and in general could thus have greatly benefitted the project.

Tool selection and prioritisation

Secondly, tool selection and prioritisation were often debated, and failures is this domain sometimes caused resistance. Which to some extend can be caused by the prescriptive nature of validating an existing framework with a pre-defined set of tools. Chapter 5 already provides and elaborate overview of the tools that were changed during the implementation, so it is not discussed here again. It is important to note however, that the right tools are crucial in getting a good understanding of the current process and the best way forward. This success factor is therefore important to keep in mind.

Employee involvement and resistance management

Another mentionable success factor was the employee involvement and resistance management. Resistance was often perceived, but because their colleagues were part of the project team and were able to explain the benefits and guide them in their adoption of the novel solutions, it greatly decreased. This helped in creating a more bottom-up improvement project and greatly helped it in succeeding. Providing the specialists with tools and means to gain a better insight in their way of working and having them discuss this insight with peers, seemed to have greatly improved the cooperation with their peers in implementing these new processes.

Top management support

The previous success factor also connects to the success factor of top management support, since this became especially important when choosing what solutions were to be worked out. The solution that did not make the cut, the improvement of the designing method was almost immediately discontinued. So, it was particularly important to have explicit blessing from upper management.

7. Conclusion

This chapter draws the conclusions based on the aforementioned case study results (chapter 6) and the SLR results (chapter 3). This section formulates a response to the main research question. A discussion on these results and the limitations of this study is provided as well.

An answer to what lessons are learned when a SP-SMEs adopts LSS to improve their business processes, would be that in order to apply the PDCA-in-DMAIC framework (as defined by Abbes et al.), slight alterations are required. The following paragraph provides an overview of these recommendations. First it is important to note that improvement is not captured in a single project, LSS aims to create a culture in an organisation where the employees are continuously looking for new improvements. In this study, the employees adopted some tools for usage in their daily way of working, so not related to the LSS implementation project. They saw opportunities for LSS (tools) beyond the last production process, which ranged from using Kanban to plan activities for other unrelated projects to creating control charts and sigma's for other business process (e.g. footbed production). So, even though they had successfully finished the current project, the challenge was in sustaining this LSS mindset over the longer term. This will allow them to improve their Sigma and other KPIs even more, since there still is a long way to go. So ideally, the framework will become part of the business processes after the initial pilot. This is important to keep in mind during the initial implementation.

In order to make the PDCA-in-DMAIC framework relevant for businesses operating in the SP-SME context, some minor changes have to be made. Some tools are more or less applicable for the SP-SME context. Two tools were not used, these were the 5M method and the SMED. The 5M was not included because a similar and better applicable tool, namely the cause-and-effect diagram was already included. The SMED would have been particularly useful for the regular production context but was not for the SP-SME context. Furthermore, Kaizen was also listed as a tool for the improve phase. However, Kaizen is, like LSS, more of a mindset rather than a single tool. So, even though it sure is wise to include aspects of it, it was somewhat awkward to cramp it into one single phase. The advice would thus be to take its lessons into the broader project. Which to some extend has already be done by using the PDCA cycle, since this comes from Kaizen initially. Finally, another conclusion of this study is that the Pareto diagram is better applicable in the measurement and analyse phase, rather than also in the define phase. Then, the decision was made to include some tools that provided a lot of additional insight. The reason that a lot of tools were available to add in part comes from the fact that the framework from Abbes et al. (2018) is based on mostly SS, while this study also includes Lean in the process. In addition, it is a more complex case which increases the need for more insight. The suggested framework for application is a SP-SME context is depicted in Figure 22.

From literature, 12 success factors came to light, namely Alignment of LSS with the Organisational Strategy, Ensure Top Management Support, LSS Project Selection and Prioritisation, Clear Goals and Expectations of the LSS Project, Effective Training and Design of Curriculum for different LSS Roles, Development of Reward and Recognition System, LSS Leadership & Culture, LSS and Data Strategy, Proper Tool Selection and Knowledge on Tool Usage, Linking LSS to Customer and Employee Needs, Employee Involvement and Resistance Management, and Ensure Infrastructure and Resources for Project. This study showed that for the SP-SME context four of these success factors are most important, these are LSS and data strategy, Tool selection and prioritisation, Employee involvement and resistance management, and Top management support.

Finally, it is important to keep in mind the limitations of this framework. There are no tools that help to keep a good line of communication between the implementation team and the affected employees. It is therefore the responsibility of this team to ensure this line of communications is fostered. Other than that, the suppliers should be kept informed and included to some extend during the project. Their understanding and involvement can possibly avoid miscommunications and/or unnecessary delays in the project.

7.1 Limitations

This study had some limitations, the first one was inherent the methodology followed in this study, namely a single case study. This means that the actual sample that is analysed is one, and even though it is analysed in depth, this still limits the generalisability of the findings in this study. It could for example that the organisational readiness for LSS from the case company was relatively high. This would be greatly beneficial during the actual implementation and thus bias the conclusions towards that specific level of organisational readiness. Another limitation is the fact that the framework on which it was based, the PDCA-in-DMAIC framework, was well-defined but not properly worked out by Abbes et al. (2018). Therefore, significant effort had to be made to work out the explanations and implications of the different tools and steps. Thus, there is the possibility that interpretation differences in tool usage occurred during the project. This study aimed to be as clear as possible in the definition of its tools and how they were used in the SP-SME context, in order to foster future usage of this framework.

Other than that, the check steps that took place during each phase seemed almost too powerful. The team directly started reflecting on the tools and their implications for the project. They also provided valuable feedback on what should and should not be changed in the current framework. This became a limitation when reviewing the implementation project since multiple team members started referring to these steps as improvement points. Therefore, the evaluation in general is based on the feedback gathered in these steps. In scientific terms this is a limitation because the interviews are an important aspect for distilling results on the case study. Thus, having part of the framework fulfilling a scientifical role rather than just practical, causes an unwanted spill-over between the theory and practise. The choice was made on forehand to use part of these steps to gather essential information for the case study, but it was not expected that this would harm the interviews afterwards. As only two interviews were conducted in the end, this limitation was somewhat countered by letting some team members validating the conclusions coming from the observations. A final limitation is the fact that the project was not really finished due to ongoing discussions with the supplier of the software used for the forms. The results of this solutions are thus not included in this study.

7.2 Future Research

For future studies on this framework, it would be interesting to evaluate other markets and production types. Even more healthcare-based company can be interesting due to its specialist's nature without the production. Other company sizes can also be of interest since the current company has approximately 100 employees, whereas the initial study from Abbes et al (2018) was smaller. Also, an iteration over other possible tools could be helpful to find a more optimal set of tools. A final suggestion would be to look into additions that improve supplier involvements and management, since this was a problem that occurred in this study.

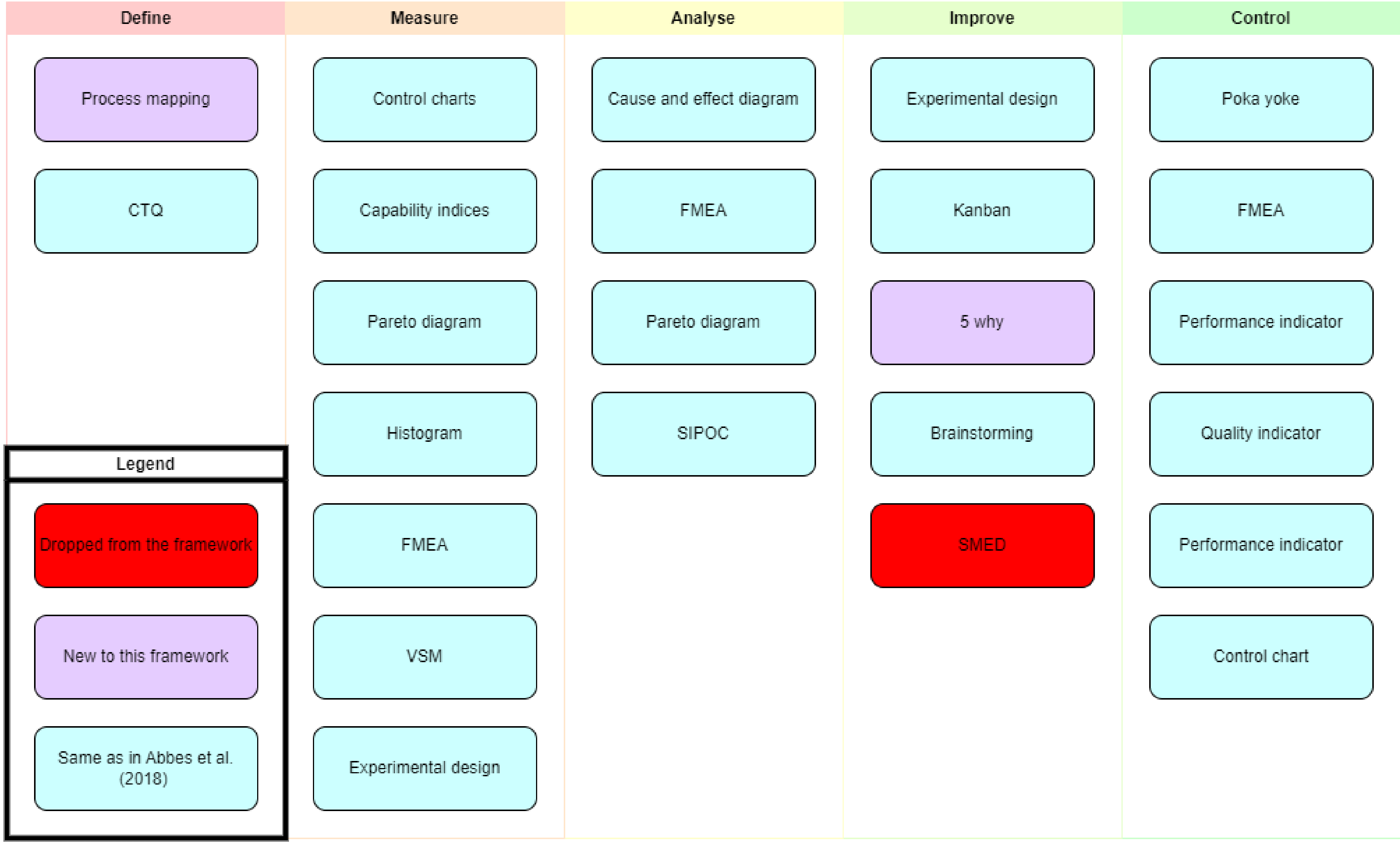


Figure 22: Recommended framework for application in a SP-SME context

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Appendix A: Papers used for Success/Failure Factors

Table A12: Papers used for the success and/or failure factors

Authors	Year	Title
Ahmed, Page, and Olsen	2019	Enhancing Six Sigma methodology using simulation techniques
Alexander, Antony, and Rodgers	2018	Lean Six Sigma for small- and medium-sized manufacturing enterprises: a systematic review
Alreqz	2021	Bibliometric Analysis of Lean Production Applications within Local Government Organizations
Antony and Sony	2019	An empirical study into the limitations and emerging trends of Six Sigma in manufacturing and service organisations
Antony et al.	2018	An evaluation into the limitations and emerging trends of Six Sigma: an empirical study
Bednarek et al.	2020	Postgraduate Studies on Lean Management—A Review of Initiatives
Bertnagnolli et al.	2021	The Application of Lean Methods in Corporate Sustainability—A Systematic Literature Review
Davidson, Price, and Pepper	2019	Lean Six Sigma and quality frameworks in higher education – a review of literature
do Nascimento et al.	2021	APPLICATION OF LEAN MANAGEMENT TOOLS IN INDUSTRY 4.0: A SYSTEMATIC REVIEW
Dorval, Jobin, and Benomar	2018	Lean culture: a comprehensive systematic literature review
Farrukh, Mathrani, and Taskin	2020	Investigating the Theoretical Constructs of a Green Lean Six Sigma Approach towards Environmental Sustainability: A Systematic Literature Review and Future Directions
Fonou-Dombeu and Nomlala	2022	A COMPARATIVE ANALYSIS OF IMPLEMENTATION OF LEAN ACCOUNTING IN MANUFACTURING AND HEALTHCARE SECTORS
Gaikwad and Sunnapwar	2019	An integrated Lean, Green and Six Sigma strategies A systematic literature review and directions for future research
Gijo et al.	2021	Ten commandments for successful implementation of Design for Six Sigma
Gil-Vilda, Yagüe-Fabra, and Sunyer	2021	From Lean Production to Lean 4.0: A Systematic Literature Review with a Historical Perspective
Gupta, Sunder, and Gijo	2017	Ten commandments of Lean Six Sigma: a practitioners' perspective
Honda et al.	2018	How Lean Six Sigma Principles Improve Hospital Performance
Hudnurkar, Ambekar, and Bhattacharya	2018	Empirical analysis of Six Sigma project capability deficiency and its impact on project success
Isfahani, Tourani, and Seyedin	2018	Lean management approach in hospitals: a systematic review
Iyede, Fallon, and Donnellan	2017	An exploration of the extent of Lean Six Sigma implementation in the West of Ireland

Khorasani, Cross, and Maghazei	2019	Lean supply chain management in healthcare: a systematic review and meta-study
Lande, Shrivastava, and Seth	2015	Critical success factors for Lean Six Sigma in SMEs (small and medium enterprises)
Mangaroo-Pillay and Coetzee	2021	Lean Frameworks: A Systematic Literature Review (SLR) Investigating Methods and Design Elements
Marin-Garcia, Vidal-Carreras, and Garcia-Sabater	2021	The Role of Value Stream Mapping in Healthcare Services: A Scoping Review
Mehrjerdi	2011	Six-Sigma: methodology, tools and its future
Muraliraj et al.	2017	Annotated methodological review of Lean Six Sigma
Null, Cross, and Brandon	2019	Effects of Lean Six Sigma in program management
Parkhi	2018	Lean management practices in healthcare sector: a literature review
Parmar and Desai	2019	A systematic literature review on Sustainable Lean Six Sigma
Patel and Patel	2020	Critical review of literature on Lean Six Sigma methodology
Patel and Patel	2021	Prioritization of Lean Six Sigma Success Factors using Pareto Analysis
Pathiratne, Khatibi, and Johar	2017	CSFs for Six Sigma in service and manufacturing companies: an insight on literature
Permana, Steven, and Purba	2021	A SYSTEMATIC LITERATURE REVIEW OF SIX SIGMA IMPLEMENTATION'S BENEFIT TO THE ORGANIZATION
Prasanna and Vinodh	2021	Lean Six Sigma in SMEs: an exploration through literature review
Psomas	2021	Future research methodologies of lean manufacturing: a systematic literature review
Psomas	2018	The originality of the lean manufacturing studies
Psomas, and Antony	2018	Research gaps in Lean manufacturing: a systematic literature review
Psomas, Antony, and Bouranta	2017	Assessing Lean adoption in food SMEs: Evidence from Greece
Puram and Gurumurthy	2021	Celebrating a decade of International Journal of Lean Six Sigma – a bibliometric analysis to uncover the "as is" and "to be" states
Raval, Kant, and Shankar	2020	Analyzing the Lean Six Sigma enabled organizational performance to enhance operational efficiency
Rodgers and Antony	2018	Lean and Six Sigma practices in the public sector: a review
Rossi et al.	2022	Lean Tools in the Context of Industry 4.0: Literature Review, Implementation and Trends
Sahu, Manoria, and Tripathy	2021	Application of Lean Tools in different Industries: A review
Santos et al.	2021	The Synergic Relationship Between Industry 4.0 and Lean Management: Best Practices from the Literature

Singh and Rathi	2018	A structured review of Lean Six Sigma in various industrial sectors
Sodhi, Singh, and Singh	2019	A conceptual examination of Lean, Six Sigma and Lean Six Sigma models for managing waste in manufacturing SMEs
Solaimani et al.	2019	On the application of Lean principles and practices to innovation management
Sony, Naik, and Therisa	2018	Why do organizations discontinue Lean Six Sigma initiatives?
Sordan et al.	2019	Lean Six Sigma in manufacturing process: a bibliometric study and research agenda
Souza et al.	2021	A Systematic Review on Lean Applications' in Emergency Departments
Sunder, Ganesh, and Marathe	2017	A morphological analysis of research literature on Lean Six Sigma for services
Witt and Baker	2017	Personality characteristics and Six Sigma: a review
Zimmermann, Siqueira, and Bohomol	2020	Lean Six Sigma methodology application in health care settings: an integrative review

Appendix B: Overview of the Last Production Process

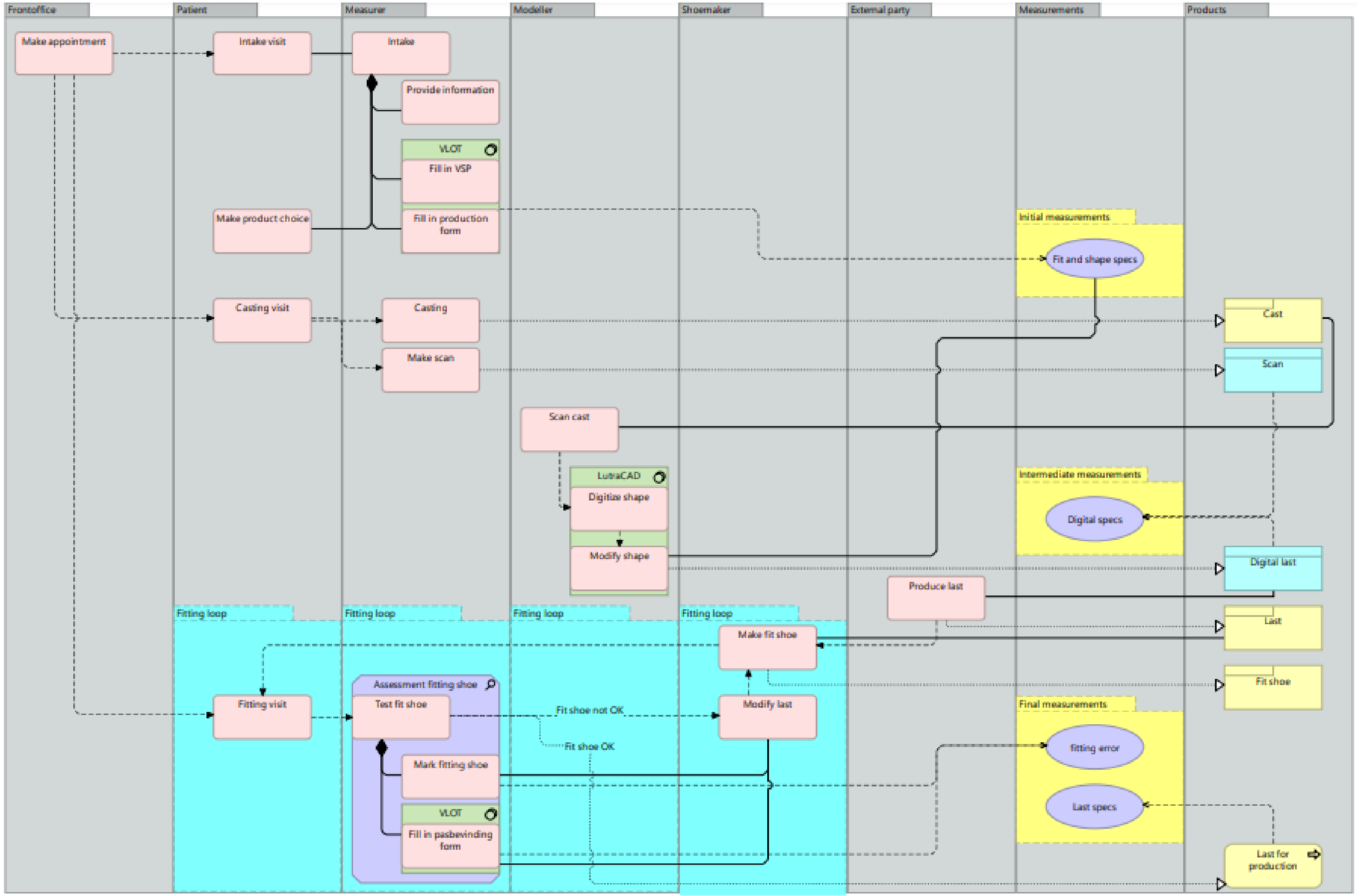

Figure B23: The process map of the last production process

Appendix C: Identified problems for the agenda items.

Table C13: identified problems for the agenda items.

Aanmetersportaal:	reactie
Voor de behandelaar:	
Dropdown velden worden langer	klopt
Agenda afspraak maken	?? Duurt langer vanwege langere dropdown??
Hoe ziet de afspraaksoort in de agenda uit?	bedoel je hard copy of in de digi-agenda in het scherm?
Beheer:	
Afspraak afsluiting	
Standaard teksten samenvatting per afspraak (opnieuw inrichten)	als het nu dekkend is voor meerdere afspraaksoorten is het ook dekkend voor 1 afspraaksoort. In de tijd kunnen we reduceren van niet gebruikten
Vervolgacties	als het nu dekkend is voor meerdere afspraaksoorten is het ook dekkend voor 1 afspraaksoort. In de tijd kunnen we reduceren van niet gebruikten
Voorkeur actielijst per afspraak	als het nu dekkend is voor meerdere afspraaksoorten is het ook dekkend voor 1 afspraaksoort. In de tijd kunnen we reduceren van niet gebruikten
Pasbevindingen formulier opnieuw inrichten	graag uitleg hierover
Categorieën koppelen aan afspraak soorten	graag uitleg hierover
Algemeen:	
Afspraak soorten Intake + 1e …………. alleen te gebruiken bij HF spreekuren, bij externe spreek uren heb je geen idee wat de productsoort wordt bij nieuwe klanten. Welke afspraak soorten dan te gebruiken	de afspraaksoort is productafhankelijk, moet bekend zijn, zie toelichting kolom. Of dit 100% zo is is de vraag
Splitsing herhaling OSA – OSB – OSC niet noodzakelijk. Zie je aan klantnummer.	tijden zijn verschillend
Splitsing controle 1e levering niet noodzakelijk. Zie je aan klantnummer	tijden zijn niet benoemd maar dit zou een splitsing kunnen afdwingen
Splitsing controle + Herhaling OSA-OSB niet noodzakelijk	mee eens, maar hoeveel afpr-soorten kunnen gecombineerd en bij procesmatige automatiserng [folder mee sturen van product]
Pauze lunch-morgen-middag, noodzaak ?	indien je op het bedrijf werkt vind ik het colegiaal als je in de pauze bij je collega's kunt zitten

Appendix D: Form usage analysis.

Table D14: Form usage for the appointment closing and last forms.

Closing the appointment (afspraak afsluiting)		Last information (leesten formulier)	
Field name	**% used**	**Field name**	**% used**
aan_uittrek_hulpmiddel	1,5	aanmeetlocatie	92,8
aandoening	1,5	behandelaar	100
aangrijpingspunt_voorziening	3,1	bsn	99,5
aanmeetlocatie	96,3	diepstand	6,3
aanmerking_hulpmiddel	1,5	diepstand_tenen	2,3
aanpassingen_binnen_specs_fabrikanti	1,5	filiaal	98,2
aanpassingen_hakaanpassing	3,1	geboortedatum	99,5
aanpassingen_overige	3,1	geslacht	100
aanpassingen_schachtaanpassing	3,1	group_aanlever_afwijkend_rechts	22,2
aanpassingen_voetbed	3,1	group_aanlever_afwikkeling_afwijkend_rechts	5
afsluiting_contact_aanmaken	91,4	hoogte_tenen	4,1
afsluiting_contactcategorie	88,5	index_leesten_beenmaten_measure_card_links	17,2
afsluiting_contactstatus	88,5	index_leesten_beenmaten_measure_card_rechts	16,7
afsluiting_nr_soortafspraak	89,2	index_leesten_maten_measure_card_links	42,1
afsluiting_samenvatting	96,6	index_leesten_maten_measure_card_rechts	43,4
afsluiting_samenvatting2	91,1	invuldatum	100
afsluitingsoortafspraak	71	leest_aangeleverd_belast_links	51,1
afsluitingtijdafspraak	71	leest_aangeleverd_belast_rechts	52
afspraak_datum	1,5	leest_aangeleverd_cast_kopieren_links	0,5
afspraak_tijd	1,5	leest_aangeleverd_cast_kopieren_rechts	0,5
afwijkend_beeld_gaan_staan	1,5	leest_aangeverd_multi_links	160,2
afwijkend_beeld_gaan_staan_aanwezig	1,5	leest_aangeverd_multi_rechts	162
beenlengteverschil	1,5	leest_achtervoet_pronatie_child_links	3,2
beenlengteverschil_aanwezig	1,5	leest_achtervoet_pronatie_child_rechts	4,1
beenlengteverschil_cm	1,5	leest_achtervoet_pronatie_links	6,8
beenlengteverschil_opmerking	1,5	leest_achtervoet_pronatie_rechts	7,2
behandelaar	99,7	leest_achtervoet_supinatie_child_links	5,9
belasting_voorziening	1,5	leest_achtervoet_supinatie_child_rechts	5,9
beperking_beweeglijkheid	1,5	leest_achtervoet_supinatie_links	10,4
beperkingen_handen	1,5	leest_achtervoet_supinatie_rechts	10

beperkingen_in	1,5	leest_beenstand_achteraanzicht_anders_links	100
beperkingen_verminderen	4,6	leest_beenstand_achteraanzicht_anders_rechts	100
breiwerk_L	1,5	leest_beenstand_achteraanzicht_links	52
breiwerk_R	1,5	leest_beenstand_achteraanzicht_rechts	52
bsn	99,9	leest_beenstand_zijaanzicht_lateraal_anders_links	100
client_akkoord_productkeuze	1,5	leest_beenstand_zijaanzicht_lateraal_anders_rechts	100
client_gemotiveerd	1,5	leest_beenstand_zijaanzicht_lateraal_links	52,5
clientenfolder_levering	1,5	leest_beenstand_zijaanzicht_lateraal_rechts	52,9
datum_levering	1,5	leest_cast_links	88,2
doelmatiger_hulpmiddel	1,5	leest_cast_rechts	1,8
drukwaarde_L	1,5	leest_diepstand_links_1	3,6
drukwaarde_R	1,5	leest_diepstand_links_2	0,5
enkelhoogte_reiken	1,5	leest_diepstand_links_3	0,9
filiaal	99,2	leest_diepstand_links_4	0,5
firstStart	1,5	leest_diepstand_rechts_1	3,2
functionaliteit_voorziening	4,6	leest_diepstand_rechts_2	0,5
functionaliteitsdiagnose	0	leest_diepstand_rechts_3	0,5
garantie_levering	1,5	leest_diepstand_rechts_5	1,8
geboortedatum	99,9	leest_hoog_laag_links	90,5
gepast_levering	1,5	leest_hoog_laag_mm_links	10
geslacht	100	leest_hoog_laag_mm_rechts	10
hulpmiddel_adequaat_gebruiken	1,5	leest_hoog_laag_rechts	91,9
hulpmiddelen_protocol_relevant	1,5	leest_neusmodel	81,4
indicatie_gebied	1,5	leest_pronatie_links	17,2
informatie_financien	1,5	leest_pronatie_rechts	17,6
instructie_aan_uittrekken	1,5	leest_stofrand_links	100
invuldatum	100	leest_stofrand_rechts	100
klachten_arm_L	1,5	leest_supinatie_links	5,9
klachten_arm_R	1,5	leest_supinatie_rechts	5
klachten_arterielepulsatie_L	1,5	leest_teen_diepstand_links_1	1,4
klachten_arterielepulsatie_R	1,5	leest_teen_diepstand_links_2	0,5
klachten_been_L	1,5	leest_teen_diepstand_links_3	0,5
klachten_been_R	1,5	leest_teen_diepstand_links_4	0,5
klachten_behandeling_L	1,5	leest_teen_diepstand_links_5	0,5
klachten_behandeling_R	1,5	leest_teen_diepstand_rechts_1	1,4
klachten_diagnosearts	1,5	leest_teen_diepstand_rechts_2	0,9
klachten_overigeklachten_L	1,5	leest_teen_diepstand_rechts_3	0,9
klachten_overigeklachten_R	1,5	leest_teen_diepstand_rechts_4	0,9
klachten_palpatie_L	1,5	leest_teen_diepstand_rechts_5	0,5
klachten_palpatie_R	1,5	leest_teenmaat_links_1	0,9
klachten_visueleinspectie_L	1,5	leest_teenmaat_links_2	1,8

klachten_visueleinspectie_R	1,5	leest_teenmaat_links_3	0,9
kleur_L	1,5	leest_teenmaat_links_4	0,9
kleur_R	1,5	leest_teenmaat_links_5	0,9
laten_aanschaffen_schoenen	1,5	leest_teenmaat_rechts_1	1,4
lengte_L	1,5	leest_teenmaat_rechts_2	2,3
lengte_R	1,5	leest_teenmaat_rechts_3	0,9
leveren_definitieve_voorziening	1,5	leest_teenmaat_rechts_4	1,4
lichaamsgewicht	1,5	leest_teenmaat_rechts_5	0,9
lichaamslengte	1,5	leest_toegift_links	25,8
maakcontact_enabled	0,4	leest_toegift_mm_links	99,5
maatcontrole_levering	1,5	leest_toegift_mm_rechts	99,5
maken_aanpassingen	1,5	leest_toegift_rechts	25,3
medische_indicatie_lookup	81,9	leesten_beenmaten_measure_card_2_links	0,5
medische_informatie	1,5	leesten_beenmaten_measure_card_3_links	1,4
merk_uitvoering_L	1,5	leesten_beenmaten_measure_card_3_rechts	0,9
merk_uitvoering_R	1,5	leesten_beenmaten_measure_card_4_links	10,9
motivatie_geen_prefab_voorziening_zonder_aanpassing	0	leesten_beenmaten_measure_card_4_rechts	10,4
naamOST	1,5	leesten_beenmaten_measure_card_5_links	20,4
naamverwijzer	1,5	leesten_beenmaten_measure_card_5_rechts	19,9
onderhoud_levering	1,5	leesten_beenmaten_measure_card_6_links	22,2
overhandigen_gebruiksaanwijzing	1,5	leesten_beenmaten_measure_card_6_rechts	21,7
overige_aandoeningen	3,1	leesten_beenmaten_measure_card_7_links	17,6
overige_aandoeningen_aanwezig	1,5	leesten_beenmaten_measure_card_7_rechts	17,2
overige_aandoeningen_anders	1,5	leesten_beenmaten_measure_card_8_links	0,9
participatieproblemen	4,6	leesten_beenmaten_measure_card_8_rechts	0,9
partner_behulpzaam	1,5	leesten_beenmaten_measure_card_9_links	17,6
pasvorm_L	1,5	leesten_beenmaten_measure_card_9_rechts	17,6
pasvorm_R	1,5	leesten_beenmaten_measure_card_links	16,3
pijn_aanwezig	1,5	leesten_beenmaten_measure_card_rechts	16,3
pijn_onderbeen_voet	3,1	leesten_maten_cast_links	13,1
pijn_positie	3,1	leesten_maten_cast_rechts	12,2
positie	1,5	leesten_maten_measure_card_links	29,4

positie_value	1,5	leesten_maten_measure_card_rechts	32,1
prefab_voorziening_met_aanpassing	3,1	leesten_opmerking	27,6
probleem_aan_uittrekken	1,5	leesten_voorvoet_links	40,3
prognose_functioneren	0	leesten_voorvoet_links_mm	40,7
schoenvoorziening_geschikt	1,5	leesten_voorvoet_positie_links	19
sectie1_voltooid	1,5	leesten_voorvoet_positie_links_anders	98,6
sectie2_voltooid	1,5	leesten_voorvoet_positie_rechts	18,6
sectie2a_voltooid	1,5	leesten_voorvoet_positie_rechts_anders	99,1
sectie3_voltooid	1,5	leesten_voorvoet_rechts	40,3
sectie4_voltooid	1,5	leesten_voorvoet_rechts_mm	37,6
sectie6_voltooid	1,5	medische_indicatie_lookup	56,6
sectie7_voltooid	1,5	sectie_leesten_voltooid	99,5
selected_vervolgacties	8,4	upload_blauwdruk_files	100
selected_vervolgacties_datum	2	verwijzer	62,4
selected_vervolgacties_ontvanger	6,5		
selected_vervolgacties_tekst	8,3		
selected_voorkeurvervolgacties	16,3		
selected_voorkeurvervolgacties_datum	7,6		
selected_voorkeurvervolgacties_ontvanger	0,6		
selected_voorkeurvervolgacties_tekst	16		
siliconenboord_L	1,5		
siliconenboord_R	1,5		
soort_voorziening	1,5		
soortkous	1,5		
stand_delen_voet	3,1		
stand_voet_aanwezig	1,5		
stand_voet_geheel	3,1		
stiffness_L	1,5		
stiffness_R	1,5		
stoornissen_heupgewricht	3,1		
stoornissen_heupgewricht_aanwezig	1,5		
stoornissen_heupgewricht_anders	1,5		
stoornissen_verminderen	3,1		
tab_afsluiting_voltooid	72,6		
teenstuk_L	1,5		
teenstuk_R	1,5		
text_vervolgacties	65,2		
thuiszorghulp	1,5		
uitvoering_L	1,5		
uitvoering_R	1,5		
verminderde_beweeglijkheid	3,1		
verminderde_beweeglijkheid_aanwezig	1,5		
verwijsdiagnose	1,5		
verwijzer	82,3		
voorziening_voldoet	1,5		

woont_verzorgingshuis	1,5
zorgdeskundige	1,5
zorgdeskundige_levering	1,5

Table D15: Form usage for the diagnosing and order forms

Diagnosing and care question form (vsp) **Field name**	**% used**	**Order form (order formulier)** **Field name**	**% used**
aan_uittrek_hulpmiddel	0,6	aan_uittrek_hulpmiddel	3
aandoening	0,6	aandoening	3
aangrijpingspunt_voorziening	1,3	aangrijpingspunt_voorziening	6
aanmeetlocatie	92,2	aanmeetlocatie	98
aanmerking_hulpmiddel	0,6	aanmerking_hulpmiddel	3
aanpassingen_binnen_specs_fabrikanti	0,6	aanpassingen_binnen_specs_fabrikanti	3
aanpassingen_hakaanpassing	1,3	aanpassingen_hakaanpassing	6
aanpassingen_overige	1,3	aanpassingen_overige	6
aanpassingen_schachtaanpassing	1,3	aanpassingen_schachtaanpassing	6
aanpassingen_voetbed	1,3	aanpassingen_voetbed	6
activiteiten	95,6	aanvullende_informatie	7,9
activiteiten_niveau	10,7	aanvullende_informatie_jaren	1
activiteiten_verbeteren	72,1	aanvullende_informatie_maanden	0,7
activiteiten_verbeteren_omdat	5	adressering	100
afspraak_datum	0,6	afspraak_datum	3
afspraak_tijd	0,6	afspraak_tijd	3
afwijkend_beeld_gaan_staan	0,6	afwijkend_beeld_gaan_staan	3
afwijkend_beeld_gaan_staan_aanwezig	0,6	afwijkend_beeld_gaan_staan_aanwezig	3
akkoord_partijen	88,1	beenlengteverschil	3
beenlengteverschil	0,6	beenlengteverschil_aanwezig	3
beenlengteverschil_aanwezig	0,6	beenlengteverschil_cm	3
beenlengteverschil_cm	0,6	beenlengteverschil_opmerking	3
beenlengteverschil_opmerking	0,6	behandelaar	100
behandelaar	100	belasting_voorziening	3
behandeldiensten	1,9	beperking_beweeglijkheid	3
behandeldiensten_details	1,3	beperkingen_handen	3
behandeldoel	237,9	beperkingen_in	3
behandeldoel_toelichting	41,4	beperkingen_verminderen	8,9
behandelmethode_gewenste_functionaliteit	473,4	breiwerk_L	3
behandelmethode_gewenste_functionaliteit_details	53	breiwerk_R	3
belasting_voorziening	0,6	bsn	99,7
beoogd_functioneren	77,1	calculatie_tekst	26,2
beoogd_functioneren_verbeteren	13,2	calculatie_wacht_machtiging	100
beoogd_gebruik_hulpmiddel	93,7	client_akkoord_productkeuze	3
beperking_beweeglijkheid	0,6	client_gemotiveerd	3

beperkingen_handen	0,6	clientenfolder_levering	3
beperkingen_in	0,6	datum_levering	3
beperkingen_verminderen	1,9	doelmatiger_hulpmiddel	3
besproken_betaling	83,1	drukwaarde_L	3
besproken_product	82,1	drukwaarde_R	3
besproken_voor_en_nadelen	90	enkelhoogte_reiken	3
bijkomende_stoornissen	46,1	filiaal	99
bijkomende_stoornissen_handfunctie	9,4	firstStart	3
bijkomende_stoornissen_overgewicht	1,9	functionaliteit_voorziening	8,9
bijkomende_stoornissen_overig	11,3	functionaliteitsdiagnose	0
bijkomende_stoornissen_visus	2,5	garantie_levering	3
bijkomende_stoornissen_voetbereik	8,8	geboortedatum	99,7
breiwerk_L	0,6	gepast_levering	3
breiwerk_R	0,6	geslacht	100
bsn	100	hulpmiddel_adequaat_gebruiken	3
client_akkoord_productkeuze	0,6	hulpmiddelen_protocol_relevant	3
client_gemotiveerd	0,6	indicatie_gebied	3
clientenfolder_levering	0,6	informatie_financien	3
datum_levering	0,6	instantie	99,7
doelmatiger_hulpmiddel	0,6	instantiekantoor	99,7
drukwaarde_L	0,6	instructie_aan_uittrekken	3
drukwaarde_R	0,6	invuldatum	100
eerdere_hulpmiddelen	24,5	kd_artikel_samart_1	98
enkelhoogte_reiken	0,6	klachten_arm_L	3
externe_factoren	41,4	klachten_arm_R	3
externe_factoren_details	31	klachten_arterielepulsatie_L	3
filiaal	98,7	klachten_arterielepulsatie_R	3
firstStart	0,6	klachten_been_L	3
functionaliteit_voorziening	1,9	klachten_been_R	3
functionaliteitsdiagnose	0	klachten_behandeling_L	3
gangbeeld_lopen	172,4	klachten_behandeling_R	3
gangbeeld_opstaan	8,5	klachten_diagnosearts	3
gangbeeld_staan	43,6	klachten_overigeklachten_L	3
gangbeeld_symmetrie	21,9	klachten_overigeklachten_R	3
garantie_levering	0,6	klachten_palpatie_L	3
geboortedatum	100	klachten_palpatie_R	3
gepast_levering	0,6	klachten_visueleinspectie_L	3
geslacht	100	klachten_visueleinspectie_R	3
hanssen_vsp_opmerking	7,8	kleur_L	3
hulpmiddel_adequaat_gebruiken	0,6	kleur_R	3
hulpmiddelen	69,9	laten_aanschaffen_schoenen	3
hulpmiddelen_overig	10	lengte_L	3
hulpmiddelen_protocol_relevant	0,6	lengte_R	3
hulpvraag	195	leveren_definitieve_voorziening	3
hulpvraag_overig	30,7	lichaamsgewicht	3
indicatie_gebied	0,6	lichaamslengte	3
informatie_financien	0,6	maatcontrole_levering	3

instructie_aan_uittrekken	0,6	maken_aanpassingen	3
invuldatum	100	medische_indicatie	96,7
klachten_arm_L	0,6	medische_indicatie_lookup	95,7
klachten_arm_R	0,6	medische_informatie	3
klachten_arterielepulsatie_L	0,6	merk_uitvoering_L	3
klachten_arterielepulsatie_R	0,6	merk_uitvoering_R	3
klachten_been_L	0,6	motivatie_geen_prefab_voorziening_zonder_aanpassing	0
klachten_been_R	0,6	naamOST	3
klachten_behandeling_L	0,6	naamverwijzer	3
klachten_behandeling_R	0,6	onderhoud_levering	3
klachten_diagnosearts	0,6	opmerkingen_orderadministratie	21,5
klachten_overigeklachten_L	0,6	order_akkoord_1	38,7
klachten_overigeklachten_R	0,6	order_datum_1	38,7
klachten_palpatie_L	0,6	order_email_1	24,5
klachten_palpatie_R	0,6	order_gemaakt	97
klachten_visueleinspectie_L	0,6	order_handtekening_1	9,9
klachten_visueleinspectie_R	0,6	order_naam_1	38,7
kleur_L	0,6	order_plaats_1	8,9
kleur_R	0,6	order_product_selector	100
laten_aanschaffen_schoenen	0,6	order_product_selector_onderdelen_overig	104
lengte_L	0,6	order_product_selector_onderdelen_overig_aantal	75,2
lengte_R	0,6	order_product_selector_onderdelen_overig_posities	73,2
leveren_definitieve_voorziening	0,6	order_product_selector_order_amount	1
lichaamsgewicht	0,6	order_product_selector_order_gph	98
lichaamslengte	0,6	order_product_selector_samart_artikelen	86,4
maatcontrole_levering	0,6	order_product_selector_samart_artikelen_aantal	61,3
maken_aanpassingen	0,6	order_product_selector_samart_artikelen_posities	67,2
medische_indicatie_lookup	62,4	order_upload_bestand_1_files	99,3
medische_indicatie_ontvangen	82,1	os-order_voltooid	33,4
medische_indicatie_ontvangen2	93,1	overhandigen_gebruiksaanwijzing	3
medische_indicatie_overig	67,1	overige_aandoeningen	6
medische_informatie	0,6	overige_aandoeningen_aanwezig	3
merk_uitvoering_L	0,6	overige_aandoeningen_anders	3
merk_uitvoering_R	0,6	participatieproblemen	8,9
motivatie_geen_prefab_voorziening_zonder_aanpassing	0	partner_behulpzaam	3
naamOST	0,9	pasvorm_L	3
naamverwijzer	0,6	pasvorm_R	3
onderhoud_levering	0,6	pijn_aanwezig	3
onderzoek_afwijking_voorvoet	173,7	pijn_onderbeen_voet	6

onderzoek_afwijking_voorvoet_overig	32,6	pijn_positie	6
onderzoek_algemene_toelichting	21,3	planning_ontvanger	2,6
onderzoek_amputaties	2,2	planning_versturen	0,3
onderzoek_bestaand_schoeisel	172,1	positie	3
onderzoek_bestaand_schoeisel_overig	4,4	positie_value	3
onderzoek_circulatiestoornis	47,6	prefab_voorziening_met_aanpassing	6
onderzoek_circulatiestoornis_overig	5	probleem_aan_uittrekken	3
onderzoek_functionaliteitsdiagnose	74	prognose_functioneren	0
onderzoek_gevoelstoornis	27	routing	57
onderzoek_gevoelstoornis_overig	0,9	schoenvoorziening_geschikt	3
onderzoek_gewrichtsbeperking	181,2	sectie1_voltooid	3
onderzoek_gewrichtsbeperking_overig	5,6	sectie2_voltooid	3
onderzoek_huid_en_gevoel	74,6	sectie2a_voltooid	3
onderzoek_huid_en_gevoel_overig	20,1	sectie3_voltooid	3
onderzoek_motoriek_coordinatiestoornis	16,6	sectie4_voltooid	3
onderzoek_motoriek_coordinatiestoornis_overig	1,6	sectie6_voltooid	3
onderzoek_musculatuur_bandenstoornis	66,8	sectie7_voltooid	3
onderzoek_musculatuur_bandenstoornis_overig	1,3	siliconenboord_L	3
onderzoek_pijn	91,8	siliconenboord_R	3
onderzoek_pijn_locatie	66,8	soort_levering	99,3
onderzoek_pijn_mate	47,6	soort_voorziening	3
onderzoek_pijn_moment	65,2	soortkous	3
onderzoek_statiekstoornis	20,4	stand_delen_voet	6
onderzoek_statiekstoornis_overig	13,5	stand_voet_aanwezig	3
onderzoek_tekening_voeten	3,8	stand_voet_geheel	6
onderzoek_vorm_standafwijking	326,3	stiffness_L	3
onderzoek_vorm_standafwijking_overig	14,4	stiffness_R	3
overhandigen_gebruiksaanwijzing	0,6	stoornissen_heupgewricht	6
overige_aandoeningen	1,3	stoornissen_heupgewricht_aanwezig	3
overige_aandoeningen_aanwezig	0,6	stoornissen_heupgewricht_anders	3
overige_aandoeningen_anders	0,6	stoornissen_verminderen	6
participatieproblemen	1,9	teenstuk_L	3
partner_behulpzaam	0,6	teenstuk_R	3
pasvorm_L	0,6	thuiszorghulp	3
pasvorm_R	0,6	uitvoering_L	3
pijn_aanwezig	0,6	uitvoering_R	3
pijn_onderbeen_voet	1,3	verminderde_beweeglijkheid	6
pijn_positie	1,3	verminderde_beweeglijkheid_aanwezig	3
positie	0,6	verwijsdiagnose	3
positie_value	0,6	verwijzer	57,3
prefab_voorziening_met_aanpassing	1,3	verwijzer_instelling	6,6
probleem_aan_uittrekken	0,6	verwijzer_naam	92,1
productkeuze_behandeling	99,1	verwijzer_specialisme	71,9

productkeuze_behandeling_osa_KEVO	0,9
productkeuze_behandeling_osa_hoogte	84,6
productkeuze_behandeling_osa_proeffase	6
productkeuze_behandeling_osb_hoogte	5
productkeuze_behandeling_vlos_comp	0,6
productkeuze_niet_mogelijk	81,8
productspecificaties	502,5
productspecificaties_basis_links	12,5
productspecificaties_basis_rechts	11
productspecificaties_details	58
productspecificaties_dorsaal	8,5
productspecificaties_hak	12,9
productspecificaties_hak_overig	0,9
productspecificaties_lip_links	4,1
productspecificaties_lip_rechts	5,3
productspecificaties_modelleringsverlenging_links	0,3
productspecificaties_omsluitingsvoorziening_links	15,7
productspecificaties_omsluitingsvoorziening_rechts	16,3
productspecificaties_plantair	9,4
productspecificaties_voetbed_links	86,8
productspecificaties_voetbed_links_corrigerend	13,5
productspecificaties_voetbed_rechts	86,5
productspecificaties_voetbed_rechts_corrigerend	12,9
prognose_functioneren	0
relevante_operaties	23,2
schoenvoorziening_geschikt	0,6
sectie1_voltooid	0,6
sectie2_voltooid	0,6
sectie2a_voltooid	0,6
sectie3_voltooid	0,6
sectie4_voltooid	0,6
sectie6_voltooid	0,6
sectie7_voltooid	0,6
siliconenboord_L	0,6
siliconenboord_R	0,6
soort_voorziening	0,6
soortkous	0,6
stand_delen_voet	1,3
stand_voet_aanwezig	0,6
stand_voet_geheel	1,3
stiffness_L	0,6
stiffness_R	0,6
stoornissen_heupgewricht	1,3
voorziening_voldoet	3
woont_verzorgingshuis	3
zorgdeskundige	3
zorgdeskundige_levering	3

stoornissen_heupgewricht_aanwezig	0,6
stoornissen_heupgewricht_anders	0,6
stoornissen_verminderen	1,3
tab_vsp_protocol_voltooid	34,8
teenstuk_L	0,6
teenstuk_R	0,6
thuiszorghulp	0,6
uitvoering_L	0,6
uitvoering_R	0,6
verminderde_beweeglijkheid	1,3
verminderde_beweeglijkheid_aanwezig	0,6
verwachte_ongewenste_neveneffecten	21,6
verwachtingen_acceptatie	90,6
verwachtingen_gebruik	89
verwachtingen_therapie	89,3
verwijsdiagnose	0,6
verwijzer	67,1
voorgaande_productkeuze_niet_mogelijk	170,8
voorgaande_productkeuze_niet_mogelijk_anders	0,3
voorvoet_pronatie_links	5,3
voorvoet_pronatie_rechts	6,6
voorziening_voldoet	0,6
vsp_dmv_optie	2,5
vsp_gangbeeldanalyse_geen_bijzonderheden	98,7
vsp_medische_indicatie_ontvangen_toggle	88,4
vsp_onderzoek_afwijking_voorvoet_geen_bijzonderheden	98,4
vsp_onderzoek_amputaties_geen_bijzonderheden	98,4
vsp_onderzoek_bestaand_schoeisel_geen_bijzonderheden	98,4
vsp_onderzoek_circulatiestoornis_geen_bijzonderheden	98,4
vsp_onderzoek_gevoelstoornis_geen_bijzonderheden	98,7
vsp_onderzoek_gewrichtsbeperking_geen_bijzonderheden	98,4
vsp_onderzoek_huid_en_gevoel_geen_bijzonderheden	98,7
vsp_onderzoek_motoriek_coordinatiestoornis_geen_bijzonderheden	98,4
vsp_onderzoek_musculatuur_bandenstoornis_geen_bijzonderheden	98,7
vsp_onderzoek_statiekstoornis_geen_bijzonderheden	98,1
vsp_productkeuze_behandeling_sub_hoogte	13,2

vsp_upload_verwijzing_files	0,3
vsp_vorm_standafwijking_geen_bijzonderheden	98,7
woont_verzorgingshuis	0,6
zelfredzaamheid	95,3
zorg	64,6
zorg_overig	24,1
zorgdeskundige	0,6
zorgdeskundige_levering	0,6