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Proving competence whilst improving competence: How Field Service Engineers can be qualified within Structured On the Job Training

A Design Science Research

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Keywords

Structured On the Job Training (SOJT), Qualification, Occupational Competence, Assessment, Formative Assessment, Summative Assessment, Design Science Research (DSR), Qualitative Research, Field Service Engineers (FSE)

Abstract

This research investigates how Field Service Engineers can be qualified within Structured On the Job Training. The research was conducted at ASML, a developer and manufacturer of microchip manufacturing equipment. According to Design Science Research both a literature review and exploratory semi-structured interviews were conducted. By looking at the findings from literature and interviews to see how they can be combined into a working process, the findings were used to design a qualification process. This qualification process exists of three main phases: formative assessment, summative assessment, and evaluation of results. By this combination the present research contributes to literature on evaluation of SOJT, thereby adding to a research area that is currently scarce.

Management Summary

This research was performed at ASML, an organisation that develops and manufactures microchip manufacturing equipment, and is specialized in lithography. Lithography is an essential aspect in the chip making process and is being applied in microchip manufacturing plants around the world. The machines of ASML are very comprehensive in regards of both hardware and software. To ensure the best services, ASML provides its customers with field service engineers (FSE) to maintain and repair the machines. FSEs work in the field at the customer sites, hence they are the first to respond to issues that may occur. Seeing many high-tech organisations, including ASML, are aiming to deliver products and services of high quality, it is implied that the FSEs need to be highly qualified as well (Benešová & Tupa, 2017; Gehrke et al., 2015; Pfeifer et al., 2004). Therefore, the FSEs develop their competences via a curriculum existing of different learning blocks. One of these learning blocks is structured on the job training (SOJT). SOJT is defined as a planned system-based process for training in the work setting, where a novice employee is trained by an experienced employee, a supervisor, a job coach, a subordinate, or a facilitator (Ahadi & Jacobs, 2017; Jacobs, 2003). Although SOJT has been proved to be effective (Choi et al., 2015; Jacobs, 2003; Jacobs & Bu-Rahmah, 2012; Jeon et al., 2011; Molnar & Watts, 2002), limited research has been performed on how employees trained with SOJT can be qualified (Ahadi & Jacobs, 2017; Ellström, 1997; Palter et al., 2013). Qualification is defined as the set of competences that are required by the work task or prescribed by the employer (Ellström, 1997, p. 267). Hence to secure the quality of training output and services, this research focused on how the FSEs of ASML can be qualified within SOJT.

This research was performed according to the problem-solving cycle of the design science research methodology (Van Aken & Berends, 2018). This methodology is used in field problem-solving projects in organisations, and approaches problem-solving in a theoretically and empirically informed way. For the theoretical aspect, both orienting and systematic literature reviews were conducted on SOJT, qualification, occupational competence, and assessment. For the empirical aspect exploratory semi-structured interviews were conducted. The interview sample existing of twenty-one individuals was spread out over six different job roles, five different countries, different experience levels, and different customer site sizes.

After analysing the findings from literature and interviews the results were combined in order to answer the main research question: *How can the FSEs of ASML be qualified within SOJT?* Thereby, the qualification process (as shown in Figure 6 of this thesis report) was

designed. The qualification process exists of three main phases: formative assessment to improve competence, summative assessment to prove competence, and evaluation of results. The qualification process has been validated by various stakeholders. They have accepted the process and are eager to implement it at ASML. The following four key elements provide an overview of the qualification process:

- A focus on proving competence whilst improving competence by combining formative and summative assessment methods, focusing on learning through continuous SOJT, and providing feedback to FSEs;
- Having qualification established locally as desired by the stakeholders and managed globally to assure quality and standardization;
- FSEs are active participants in the qualification process as an incentive to motivate them. This becomes visible through self-assessments they perform during formative assessment, having room to indicate readiness to qualify, and the use of process data in establishing qualification;
- Consistent delivery of quality by implementing reliable assessments, mentor and examiner trainings, standardized checklists to use with observations, and a tracking system.

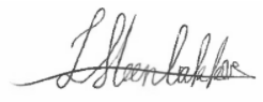
The qualification process provides ASML with a way to qualify their FSEs within SOJT. However, before implementing the qualification process, there are some conditions that are recommended for ASML to adhere to. These conditions are: the implementation of mentor training, allocating more time for SOJT, developing standardized checklists, developing a more substantial set of performance standards and qualification criteria, implementing examiner training, and appointing a global process owner. Hence, to achieve successful implementation of the qualification process, it is recommended for ASML to first have these conditions in place, and then start implementing the qualification process.

Preface

After graduating as an academic primary school teacher at the Kempel University of Applied Sciences last year, I knew I wanted to expand and deepen the knowledge I had gained on learning and education. Having specialised in ICT & Media and being interested in technology, the Master Educational Science and Technology at University of Twente attracted my attention. Hence, I enrolled and moved to the city of Enschede. During my time in Twente, I broadened my horizon and learned what the world of learning has to offer. It was when I was introduced to Human Resource Development that my interests started to shift from the more 'traditional' side of education to learning and development (L&D) within organisations. I quickly learned that this is the aspect of learning that makes me enthusiastic and gives me energy, and that I wanted to experience myself.

That is when I was given the opportunity to write my thesis for ASML, for which I am very thankful. ASML is a high-tech organisation that makes the world work by innovating and creating lithography machines used to produce microchips. For me, this internship has been the cherry on top of everything I have learned in my master's during the past year. I have been enjoying every minute of it and I have learned a lot about L&D, business processes, and of course the technology ASML produces. Above all, I have met countless individuals that have all inspired and taught me in their own way. Therefore, I would like to thank all of my colleagues, but especially the members of the FKX team. Ad, Stephanie, Cas, Evert-Jan, and Cas: thank you for your guidance, feedback, sparring sessions, and teaching me about ASML. I could not have done this without you. Furthermore, I want to thank all respondents who freed up their time to participate in this research: your valuable contributions have enabled the outcome of this research. Finally, I would like to thank my academic supervisor Dr. Hans Luyten for trusting me, his listening ear, his attention, thinking along, and the countless hours he spent reviewing my work.

Sincerely,



Lonneke Steenbakkers

Veldhoven, September 2021

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List of abbreviations

Abbreviation	*Meaning*
CS	Customer Support
DSR	Design Science Research
DUV	Deep ultraviolet
EUV	Extreme ultraviolet
FKX	Field Knowledge eXchange
FSE	Field Service Engineers
KM	Knowledge Manager
OJT	On the Job Training
PSC	Problem-solving cycle
SMT	Skill Management Tool
SOJT	Structured On the Job Training
VP	Vice President
YS	YieldStar

1. Introduction

1.1 Description of organisational context

ASML is a developer and manufacturer of microchip manufacturing equipment, specialized in lithography. Lithography is an essential aspect in the chip making process and is being applied in microchip manufacturing plants around the world. These manufacturing plants produce microchips for many electronic applications, such as consumer electronics, automotive, and medical equipment. ASML is dominant in the semiconductor industry with a market share of 62% and market capitalisation of around €114bn in the beginning of 2020 (The Economist, 2020). Hence, ASML sells their lithography machines to customers worldwide.

ASML provides its customer with the hardware, software, and services required for the lithography production process. The four main products they produce, are extreme ultraviolet (EUV) machines, deep ultraviolet (DUV) machines, YieldStar (YS) optical metrology, and software applications for these machines. To successfully meet customer requirements, the organisation is divided in different divisions, each having their own departments. The organisational structure is visualised in Appendix A. This research is conducted at the Field Knowledge eXchange (FKX) department, which is part of the Customer Support (CS) division. FKX aims to drive knowledge exchange and enable engineers to learn fast. They do this by identifying skill gaps, providing structured knowledge management solutions, and enabling coaching opportunities.

1.2 Research Problem

The machines of ASML are very comprehensive, in regards of both hardware and software. To ensure the best services, ASML provides its customers with field service engineers (FSE) to maintain and repair the machines. Because the FSEs work in the field at the customer sites, they are the first to respond to issues that may occur.

It has been found in prior research that training is one of the major methods to enhance the performance of individuals (Ahadi & Jacobs, 2017; Alipour et al., 2009; Fan & Wei, 2010; Gupta et al., 2010; Karia & Asaari, 2006). Hence, to develop the knowledge and skills that FSEs require, they have to participate in a curriculum existing of different learning blocks. One of these learning blocks is structured on the job training (SOJT), which is performed at the customer site. In this research SOJT is defined as a planned system-based process for training in the work setting, where a novice employee is trained by an experienced employee, a supervisor, a job coach, a subordinate, or a facilitator (Ahadi & Jacobs, 2017; Jacobs, 2003).

Preliminary studies found that SOJT improves the creativity and quality of work of employees and the achievement of organisational objectives (Alipour et al., 2009; Gorman et al., 2004; Orser, 2001). However, limited research has been performed on how employees trained with SOJT can be qualified (Ahadi & Jacobs, 2017; Ellström, 1997; Palter et al., 2013). Qualification is defined by Ellström (1997, p. 267) as the set of competences that are required by the work task or prescribed by the employer. Qualifications are linked with certificates and diplomas (Stoof et al., 2002), which can serve as physical proof of qualification and hence competence (Dufaux, 2012). Occupational competence is defined by Ellström (1994, as cited in Ellström, 1997, p. 267) as "the potential capacity of an individual to successfully handle certain situations or complete a certain task or job". This capacity is focused on hard skills and soft skills. The example in Text Box 1 illustrates how the concepts of qualification, occupational competence, and certification relate to one another. These concepts are discussed in more detail in section 3.2.

Text Box 1

FSE Kevin and his road towards qualification

FSE Kevin is in training to become a qualified fab ready FSE, which means he is allowed to work individually at the customer site and does not need supervision anymore. He has acquired a lot of competences in the last months: how to install parts, swap parts, diagnose, troubleshoot, order new parts, and even how to converse with the client in compliance with the guidelines. Kevin has almost finished his SOJT training block and will soon attend his final qualification exam. The competences required by ASML to be a fab ready FSE are installing and swapping parts, diagnosing, and troubleshooting. As Kevin is in the possession of these specific competences, it is expected he will pass his exam and be qualified. This will be the formal recognition that Kevin is a fab ready FSE. To have proof of this recognition, Kevin can be rewarded with a certificate once he passes the exam. With his certificate, Kevin will have proof of being a qualified FSE.

Many high-tech organisations, including ASML, are aiming to deliver products and services of high quality. This implies that employees need to be highly qualified as well (Benešová & Tupa, 2017; Gehrke et al., 2015; Pfeifer et al., 2004). Hence, it is crucial to identify how employees can properly be qualified such that organisations can secure their quality of output. For ASML, qualifying FSEs within SOJT seems meaningful, as this training method is proved to be effective (Choi et al., 2015; Jacobs, 2003; Jacobs & Bu-Rahmah, 2012; Jeon et al., 2011; Molnar & Watts, 2002). Additionally, with SOJT FSEs can apply in practice what they have learned in other learning blocks. Although extensive curriculum descriptions

exist for the FSEs, it is yet to be decided how qualification can be established. Therefore, this research focuses on how the FSEs of ASML can be qualified within SOJT.

1.3 Research Background and Motivation

This research is part of an existing project at ASML that aims to set up a worldwide qualification process for the FSEs. This project was assigned by the vice presidents (VP) of CS and covers all learning blocks of all machine platforms from ASML.

Four CS VPs were separately interviewed to explore why a worldwide qualification process is needed. These interviews were semi-structured and conducted with the project team via Microsoft Teams.

In the interviews, three main drivers were captured that underline why qualification of FSEs is needed. These are:

- To manage service capability per site, per region, and globally;
- To motivate engineers to develop, grow, and be the best they can be;
- To demonstrate service capability and quality towards customers consistently

As qualification of FSEs within SOJT is also part of this worldwide qualification process, the input provided by the VPs provides the background and motivation for this research. The rationale for this is that due to their position, the VPs' opinions will be conclusive in determining whether the solution design this research will generate will be implemented.

1.4 Research Questions

Based on the research problem and the exploratory interviews, the main research question can be derived: *How can the Field Service Engineers of ASML be qualified within Structured On the Job Training?*

To answer the main research question, two sets of sub-questions need to be answered. The first set of sub-questions, question 1 to 4, is posed to better understand the research problem and will be answered via literature review.

1. *What is SOJT and what are its objectives?*
2. *What are the fundamental elements of SOJT?*
3. *What is qualification and what are its objectives?*
4. *Which assessment method is most suitable to establish qualification of FSEs within SOJT?*

The second set of sub-questions, question 5 to 7, is posed to understand the current and desired situations regarding the research problem at ASML. To answer this set of sub-questions, empirical data will be gathered by conducting exploratory semi-structured interviews. Eventually, the answers to these two sets of sub-questions will provide the necessary input to create a solution design that answers the main research question.

5. *How is SOJT currently put into practice?*
6. *How and to what extent are the fundamental elements currently present within SOJT?*
7. *Which fundamental elements are needed to establish qualification of FSEs within SOJT, and how should they be represented?*

1.5 Thesis Outline

Chapter 1 defines the research problem to be investigated. Chapter 2 describes the research design and methodology used in this research. This includes the design science research methodology (Van Aken & Berends, 2018), the strategies applied for both literature review and exploratory semi-structured interviews, and the quality of the research. Chapter 3 presents the results from the literature review and thereby answers sub-questions 1 to 4. Subsequently, chapter 4 presents the results of the exploratory semi-structured interviews and thereby answers sub-questions 5 to 7. Chapter 5 describes how the data acquired from literature and the interviews will be used to establish design requirements and design propositions. The design requirements and propositions will be used together to create a solution design, which will be described in chapter 6. This chapter will also describe the validation of the solution design. Lastly, in chapter 7 this research is concluded and discussed. Implications, limitations and recommendations for future research are also described here.

2. Research Design

2.1 Design Science Research

This research will be performed according to the problem-solving cycle (PSC) of the design science research (DSR) methodology (Van Aken & Berends, 2018). This methodology is used in field problem-solving projects in organisations, and approaches problem-solving in a theoretically and empirically informed way. A field problem is defined by Van Aken and Berends (2018, p. 30) as "a state of affairs in the real world with which one or more important stakeholders are dissatisfied, while they believe that things can be improved". The aim of DSR is to improve the performance of a specific business system on one or more criteria by (re)design.

A field problem is open-ended, indicating that multiple solution designs are possible and not solely one. Examples of solution designs are an organisational structure, an operational process, a decision-making process, and a quality control system. In this research, the specific business system is the SOJT-system, and the intended improvement is to design a qualification process for FSEs participating in SOJT. To operationalize the design science research methodology in this research is suitable, because the researcher immerses himself/herself in the problem by applying the PSC (Van Aken & Berends, 2018). This allows for a thoroughly developed and justified solution design. Additionally, the field of DSR is strongly related to the field of education (Dresch et al., 2015; Simon, 1996), which suits the SOJT-system and the intended improvement under consideration.

The PSC, depicted in Figure 1, consists of five process steps: (1) Problem definition, (2) Analysis and diagnosis, (3) Solution design, (4) Intervention, and (5) Evaluation and learning. These five steps are not restricted to a strict sequence and therefore allow the researcher to work on the different process steps flexibly. This research focused on the in-depth performance of the definition, analysis and design steps.

Figure 1

Problem-solving cycle (Van Aken & Berends, 2018)

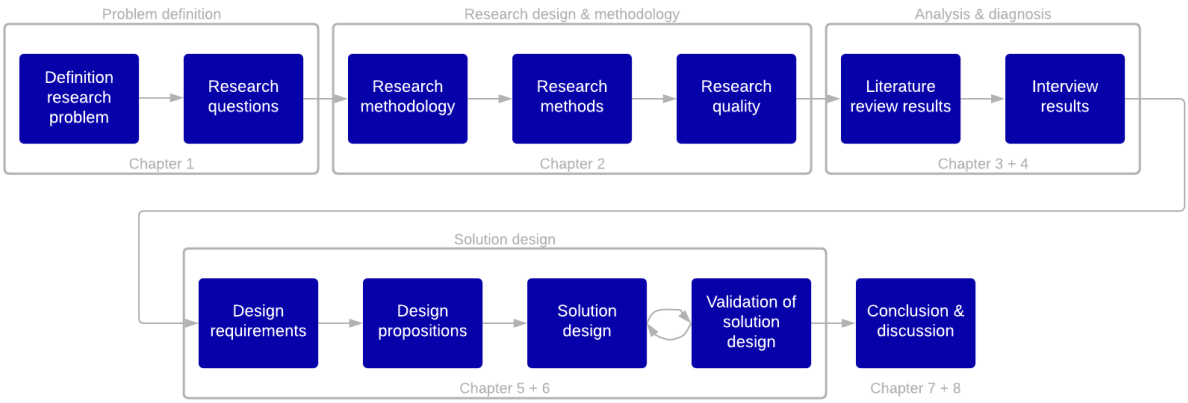
The first step of the PSC is to define the problem, which is described in Chapter 1. Secondly, the analysis and diagnosis should be performed. Analysis is essential to diagnose the specifics of the problem, gather input for the definition of design requirements, and to create a solution design

(Van Aken & Berends, 2018). To analyse the current and desired situation, a theoretical analysis will be performed via literature review and empirical data will be collected by conducting exploratory semi-structured interviews. Thirdly, the solution design; which aims to solve the field-problem; should be created.

Although it is called a *problem*-solving cycle, in some cases it is preferred to speak of an *opportunity* instead of a *problem* (Van Aken & Berends, 2018). Since this research focuses on a desired situation that does not yet exist, the term opportunity is desired and will be used from now on. For clarity purposes a schematic overview of the research design is depicted in Figure 2. It shows the different steps of this research, the steps that are performed, and the chapters in which they are described.

Figure 2

Schematic overview of research design



2.2 Literature review method

To ensure the solution design is theoretically informed, both an orienting and a systematic literature review have been performed. The orienting review was performed to become familiar with the relevant literature. The systematic review was performed to search for evidence regarding research questions and solution concepts. A systematic approach improves the quality of a review by increasing the reproducibility and the chances of covering much of the relevant literature. In addition, it decreases the chance of a biased review (Van Aken & Berends, 2018). A systematic approach to literature review is important in design science research, because it can provide a reliable foundation off which to build the solution design (Tranfield et al., 2003). The results of both literature reviews were merged in order to generate a thorough theoretical framework. This framework is displayed in chapter 3.

2.2.1 Orienting review method

While applying the orienting review method, the literature was mainly explored for definitions, theoretical models, and advantages and disadvantages of concepts. Nevertheless, other relevant information discovered in the orienting review has been included as well.

Since the aim of the orienting review method is to become familiar with the relevant literature, it does not necessarily need a systematic approach. However, in this research the orienting review has also been approached in a somewhat systematic way, as the 'snowball' method has been applied (Van Aken & Berends, 2018).

2.2.2 Systematic review method

The information yielded in the orienting literature review led to the establishment of search queries for the systematic literature review, which are depicted in Table 1. The search indexes for which these queries were used are title, keywords, and abstract.

Table 1

Search queries for systematic literature review

Search queries		
Trainer OR Mentor	AND	Structured on the job training OR SOJT
Trainee OR student	AND	Structured on the job training OR SOJT
Assess* OR Observation OR Results OR Checklist OR Format	AND	Structured on the job training OR SOJT
Tracking system OR Record System	AND	Structured on the job training OR SOJT
Job performance standard	AND	Structured on the job training OR SOJT
Management support OR Management commitment	AND	Structured on the job training OR SOJT

While applying the systematic review method, two techniques were applied, namely the 'snowball' method and using search engines (Van Aken & Berends, 2018). Both backward and forward snowballing were done. Backward snowballing was done by tracing references. Forward snowballing was done by searching for articles that cite a specific article. The search engines used were ERIC, Web of Science, Scopus, PsychINFO, Business Source Elite, and Google Scholar. The first four were used because these are the most important databases in

educational science. Business Source Elite was used since it covers the top business and management journals. This is suitable, because this research is performed within an organisation. Google Scholar was used as an additional search engine because it displays highly relevant citations first. Therefore, Google Scholar was used as an additional check to ensure that the relevant literature has been found.

The articles found in the systematic literature review were judged according to certain inclusion and exclusion criteria, which are depicted in Table 2. The articles included are peer-reviewed journal articles that have been published between 1990 and the present, because research on SOJT has increased from 1990 onwards. The articles must be published in English and fully accessible. As the literature base on SOJT is limited, the articles must have at least three citations. This number of citations means the article is considered to be relevant seeing the number of articles that is available.

Table 2

Inclusion and exclusion criteria for the systematic literature review

Inclusion criteria	*Exclusion criteria*
Peer-reviewed journal article	Literature reviews
Period 1990 – present	
Published in English	
Full access	
Number of citations ≥ 3	

2.3 Interview method

2.3.1 Interview type

To ensure the solution design is empirically informed, exploratory semi-structured interviews were conducted. As the opportunity investigated involves people working for organisations, this qualitative research method is suitable to answer the research question. This is because through exploratory semi-structured interviews, the interviewees are able to explain their current experiences and their desires for the future. According to Van Aken and Berends (2018, p. 154), “such understanding is needed” as “there can be large and multifaceted differences between people and situations”. Thereby, exploratory semi-structured interviews make it possible to go in-depth by asking follow-up questions. These follow-up questions provide crucial information, as the interviewees eventually have to deal or work with the qualification process.

For exploratory semi-structured interviews an interview guide has to be created beforehand. In semi-structured interviews it is okay to deviate from the list of questions, and for example ask questions in different orders, ask follow-up questions, and modify or change questions (Cassell, 2015; Given, 2008; O'Reilly & Dogra, 2017). The purpose of the interviews is exploratory, as they will be used to 'explore a particular organisational issue from a range of different perspectives' (Cassell, 2015). In this research, the interviews will be used to explore the creation of a qualification process and discover possible design requirements.

2.3.2 Interview guides

The results from the literature review have been used as input in the development of the interview guides. Interview guides are used to improve the quality and reliability of interviews. Van Aken and Berends (2018) recommend creating a specific interview guide for each interview. Hence, multiple interview guides have been created that match with the specific characteristics of the job roles included in the interview sample. The interview guides consist of open-ended questions. By creating the interview guides, more time and effort was invested in the pre-interview phases of thematizing and analysing. Thematizing was done by studying the literature and therefrom creating interview questions that are likely to provide the information needed to answer the research question(s). Analysing was done by assessing the quality and construct validity of the interview questions. These actions increased the possibility of conducting high-quality interviews (Brinkmann & Kvale, 2018). High-quality interviews, in turn, made the post-interview phases of transcribing, analysing, verifying, and reporting less complicated because the structure of the interview guides provided guidance, and elaborate answers were given due to the quality and construct validity of the questions. Hence, the interview guides also increased the possibility of the interviews providing new valuable information (Brinkmann & Kvale, 2018).

In the creation of the interview guides, the quality criteria for interviews as proposed by Brinkmann and Kvale (2018) were taken into account. These quality criteria are crucial for the quality of analysing, verifying, and reporting the interviews. The following criteria were applied:

- The questions shall aim to induce rich, specific, and relevant answers from the interviewee;
- The questions should be brief, but able to lead to longer answers

The interview guides are included in Appendix B. The interview questions have been justified by the researcher and assessed for construct validity by the supervisors. These results are

included in Appendix C. The supervisors all either agreed or strongly agreed with the assessed statements. Hence, it was concluded that the construct validity of the interview guides is acceptable, and that they enable the researcher to measure what is intended to measure.

2.3.3 Interview sample

In problem-solving projects, buy-in from stakeholders is essential (Van Aken & Berends, 2018). To create a qualification process that is not only accepted by the people working in the field, but also supported by management both stakeholders from the field and the management should be included in the sample. Therefore, the interview sampling in this research is purposive. Besides the alignment with the characteristics of problem-solving projects, this sampling strategy fits with the characteristics of exploratory semi-structured interviews (Cassell, 2015). Purposive sampling means interviewees are chosen with a purpose, because their knowledge can lead to answering the research question (Cassell, 2015). Purposive sampling has two aims: to ensure all key stakeholders are involved; and to ensure diversity within the interview sample (Cassell, 2015; Ritchie et al., 2014). The following paragraphs describe how the aims of purposive sampling were accomplished in this research.

To increase the chances of creating a solution design that is effective and accepted by the organisation, all key stakeholder roles are incorporated in the interview sample. Hereby, the first aim of purposive sampling is accomplished. These people are stakeholders, because they will all either be working with, affected by, or reporting on the qualification process. Hence, people to be interviewed are: FSEs, shift leads, knowledge managers (KMs), a CS VP, the manager of CS learning, and the program owner of SOJT. A description of each of these job roles is included in Appendix D. By interviewing stakeholders, a thorough analysis of possible design requirements for the qualification process may be possible (Ritchie et al., 2014). No SOJT mentors will be interviewed, as no employees have officially been assigned to this role yet. The second aim of purposive sampling is to ensure diversity within the interview sample (Cassell, 2015; Ritchie et al., 2014). By incorporating people from six different roles, five different countries, different experience levels, and different customer site sizes, the interview sample has been diversified.

In total twenty-one people were interviewed for this research. This amount is common in interview studies (Brinkmann & Kvale, 2018). The interview sample is spread over three continents, namely: Asia, Europe, and North America. Eleven FSEs from five different sites were interviewed. This happened mostly in pairs, because the FSEs are hard to reach as their priority lies with the customer. Distinctions were made regarding experience levels and sizes

of sites. All ten other interviewees were interviewed individually, which allowed them to speak freely and without influencing each other's answers (Gubrium et al., 2012). Next to FSEs, two shift leads were interviewed. FSEs and shift leads are working directly in the field at the customer sites. Additionally, five KMs were interviewed, who also work in the field. To include perspectives from management, a CS VP and the manager of CS learning were interviewed. To conclude, the program owner of SOJT was interviewed, as this person drives and coordinates the worldwide development of SOJT and its implementation in the field. Table 3 displays an overview of the interviews that were conducted.

Table 3

Overview of interviews

Role	*# of interviews*	*# of interviewees*	*Location*
FSE	7	11	Ireland, Korea, Taiwan, USA
Shift lead	2	2	Korea, Taiwan, USA
KM	5	5	Ireland, Korea, Taiwan, USA
CS VP	1	1	Korea
Manager CS learning	1	1	Netherlands
Program owner SOJT	1	1	Netherlands

2.3.4 Conducting the interviews

It was determined to use a predefined number of interviews instead of achieving saturation, as the interviewees in the sample are hard to reach. However, after all interviews had been conducted it was concluded that saturation has still been achieved, since the results show clearly visible patterns. These results are described in chapter 4.

All interviews lasted approximately 40 minutes. Before the start of the interviews, the interviewees were informed about the research and asked for consent according to the plan that was submitted to the ethical committee (request number 210805). The interviews were conducted online via Microsoft Teams. During the interview, the researcher sought to clarify the meaning of answers if needed and interpret the answers in the course of the interview, so the interpretations could already be verified by the interviewee (Brinkmann & Kvale, 2018). All interviews were recorded and transcribed. After an interview was transcribed, member checking was performed by immediately sending the transcript to the interviewee to confirm whether (s)he agrees with everything that is stated in the transcript (Carlson, 2010).

2.3.5 Interview coding

The interview transcripts were analysed using ATLAS.ti 9. To analyse the interviews an inductive coding strategy was applied (Silver & Lewins, 2014), which was illustrated by Saldaña (2013) and is depicted in Figure 3. The inductive coding strategy exists of three phases.

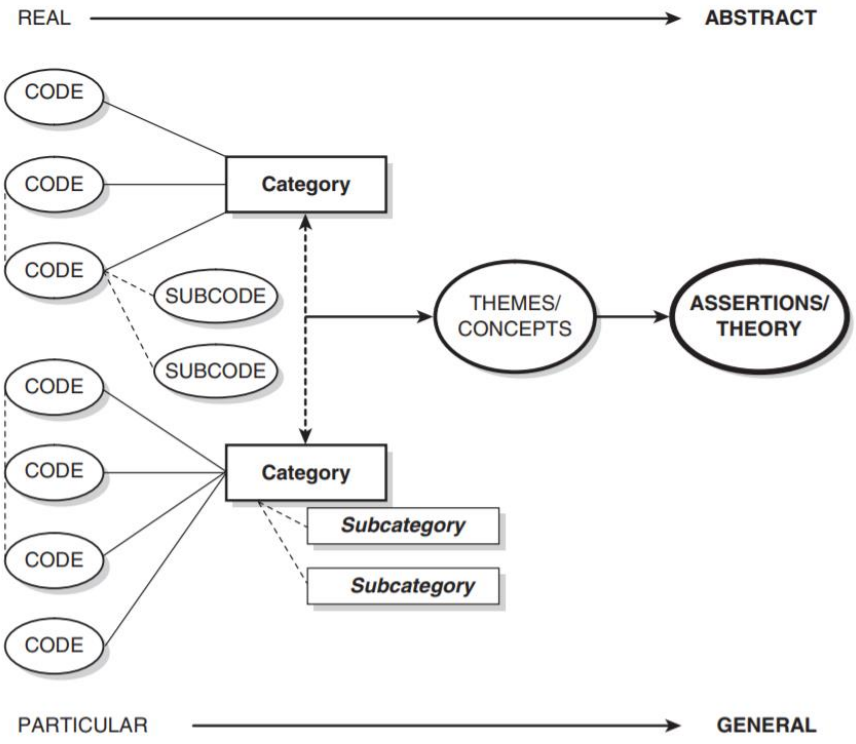
The first phase is open coding. Within this phase the raw data was divided into small pieces, referred to in Figure 3 as codes. These codes were carefully studied and compared with other raw data and codes. The link between the codes and the raw data was constantly considered while examining whether the codes are representative of the data. In this phase a large number of codes were produced, which is common for the open coding phase.

The second phase is axial coding. This phase is more abstract, as it is meant to explore the relationships between the data and codes. Here the codes produced in the open coding phase were reconsidered. Code labels and data linked to the codes were compared for similarities and differences. Similar codes were merged, grouped into higher-level categories, or subdivided into more detailed codes as visualised in Figure 3. Therefore, the coding process should not be seen as linear, but iterative.

The final phase is selective coding. During selective coding the data and codes were revisited again. Relevant themes, concepts, and relationships discovered in the data were established and form an abstract overview of the data. The results from selective coding are described in chapter 4, and are used to substantiate conclusions and discuss in the final section of this research report. During selective coding an extensive set of tasks and responsibilities was established for the stakeholders. To add structure, the tasks and responsibilities were categorized as being either facilitative or regulative (Endedijk & Cuyvers, accepted for publication; Kyndt & Baert, 2013). Eventually, the coded set of data consisted of 470 individual codes, 80 ‘umbrella’ codes, and 25 categories. All of these codes and categories have been divided into three dimensions: current, desired, and past. The coded set of data was discussed and aligned with a researcher who is knowledgeable in inductive coding for qualitative research. This researcher indicated that the number of codes is plausible for inductive coding and makes it likely for the aim of this research to be met.

Figure 3

Codes-to-theory model for qualitative inquiry



2.4 Quality of the research

Many authors agree that the main objective of research is to strive for inter-subjective agreement, which is to reach consensus between the actors dealing with a research problem (Van Aken & Berends, 2018). The most important quality criteria for research are controllability, reliability, and validity. They do not only constitute the basis for inter-subjective agreement, but are also important in problem-solving projects or opportunities to investigate. Therefore, this section is dedicated to the discussion of how the controllability, reliability, and validity of this research are assured. Additionally, quality criteria that are specific for problem-solving projects will be discussed.

2.4.1 Controllability

Controllability refers to how a research project was executed and is required in order to assess its reliability and validity (Van Aken & Berends, 2018). Chapter 2 of this report explains every step that has been taken in conducting this research to secure the controllability of this research.

2.4.2 Reliability

A research project is reliable when the results are independent of its characteristics. According to Van Aken and Berends (2018), this means that reliable research should produce similar results when replicated by another researcher, with a different research method, in another situation, or with other respondents. They argue that without reliability, there is little ground for inter-subjective agreement.

To enhance the reliability of this research, triangulation was applied. In qualitative research triangulation is used to achieve completeness (Farmer et al., 2006). In this research space triangulation was applied, which is a category of data triangulation (Curtin & Fossey, 2007; Denzin, 1989; Flick, 2018). Space triangulation is defined by Shih (1998, p. 636) as "the collection of data on the same phenomenon at different sites (two or more settings)", and is used to "test multi-site consistency and rule out cross-site variation." In this research, space triangulation has been obtained by interviewing individuals from both different locations and different job settings. This enabled the researcher to obtain a more complete picture of the opportunity that was investigated.

2.4.3 Validity

According to Van Aken and Berends (2018), a research project is valid when the results are justified by the way they are generated. The validity of this research is assured on the basis of three types of validity: construct validity, internal validity, and external validity. However, in qualitative research the term transferability is preferred over external validity (Poortman & Schildkamp, 2012), hence this term will be used in this research.

Construct validity

Construct validity entails the extent to which a measuring instrument measures what it is intended to measure (Van Aken & Berends, 2018). This has two implications: firstly, the concept measured should be fully covered. Secondly, the measurement should have only components that fit the meaning of the concept measured.

To ensure construct validity of the interviews, the university supervisor and two company supervisors have formed a panel to assess how effective the interview questions are to answer the respective research questions. In this assessment, the interview questions were assessed against two aspects: the implications for construct validity, and the quality criteria for interviews proposed by Brinkmann and Kvale (2018) (see section 2.3.2). Following Belotto (2018), a 4-point Likert scale was used to avoid general answers. This means that for each

statement, the panel members had four options to choose from: strongly disagree, disagree, agree, and strongly agree. Additionally, there was space for written comments for each statement. The panel members chose ‘agree’ or ‘strongly agree’ for each statement, meaning they assessed the construct validity of the interview questions to be acceptable. The results of the assessment are included in Appendix C.

Internal validity

In design science research, internal validity is focused on the conclusions of a research project. Here, the internal validity is considered to be high when the conclusions are justified and complete (Van Aken & Berends, 2018).

A way to achieve justified and complete conclusions is by studying the opportunity from multiple perspectives (Van Aken & Berends, 2018). As described in section 2.3.3, the interview sample is very diverse and allows the opportunity to be studied from different perspectives. In addition to the use of multiple perspectives, internal validity can be increased by systematic analysis (Van Aken & Berends, 2018). This is performed for part of the theoretical analysis of this research.

Transferability

Transferability entails the extent to which the results apply to other situations, and is also referred to as analytical generalization (Krathwohl, 1998, as cited in Poortman & Schildkamp, 2012; Poortman & Schildkamp, 2012). The more detailed illustrations a research report contains, the higher the transferability; it enables outsiders to assess how and to what extent the results apply to them and their situation.

In this research, transferability is enlarged by describing the organisational context, using the curriculum spider web (Van den Akker, 2007), employing a diverse interview sample, providing an overview of both the current and the desired situations within the organisational context, and the concreteness of the solution design.

2.4.4 Quality criteria for problem-solving projects

As this is a problem-solving project according to the design science methodology, the quality criteria that can be specifically set for problem-solving projects are described here. The quality criteria are twofold. First, Van Aken and Berends (2018) discuss five characteristics of a good problem-solving project. These are that a problem-solving project should be performance-focused, design-oriented, theory-informed, justified, and client-centred. Second,

and partly overlapping with the five characteristics, the authors argue that the members of the organisation should recognize the results as being reasonable, plausible, or at least possible. Hence, the solution design created should be justified on the basis of pragmatic validity. The pragmatic validity and justification of the solution design are described in section 6.3.

3. Literature Review

In this section, research questions 1, 2, 3, and 4 will be answered. At the end of each sub-section, a summary of each answer is displayed.

3.1 What is SOJT, what are its objectives, and what are its fundamental elements?

3.1.1 Definition of SOJT

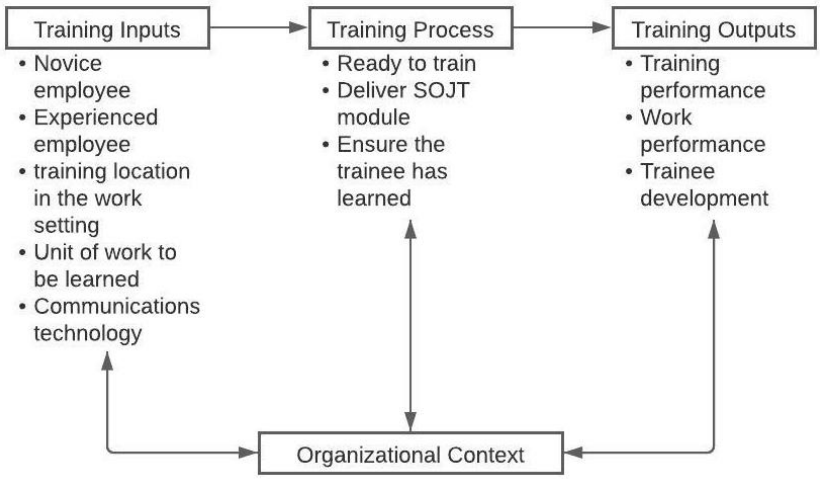
As described in section 1.2, SOJT is defined as a planned system-based process for training in the work setting, where a novice employee is trained by an experienced employee, a supervisor, a job coach, a subordinate, or a facilitator. The planned system-based process is what distinguishes SOJT from unstructured OJT (Ahadi & Jacobs, 2017; Jacobs, 2003). In literature the novice employee is generally referred to as a trainee. However, in this research the trainee is also referred to as the FSE, as this is the novice employee being trained in this specific context.

3.1.2 The SOJT-system

The SOJT-system should be developed and implemented systematically, and comprises of four interacting components: training input, training process, training output, and organisational context (Jacobs, 2003, 2014). These components (depicted in Figure 4) work together to accomplish common goals. SOJT takes place in a planned and systemic training environment, and because of this it is argued that SOJT is a form of intentional learning (Van Der Klink, 1999; Van Der Klink & Streumer, 2002). Moreover, Choi et al. (2015) found that this planned training environment, along with training support, has significant effects on the successfulness of SOJT activities. More advantages of SOJT are described in Appendix I.

Figure 4

The SOJT-system (Jacobs, 2003, 2014).

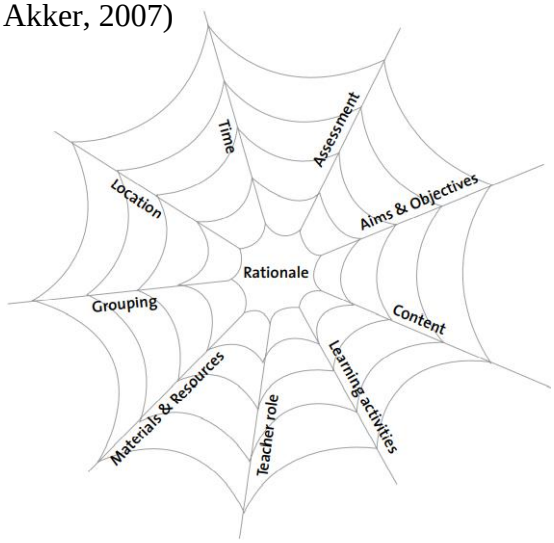


SOJT takes place during the training and learning process, and this research focuses on qualification within SOJT. The curriculum spider web of Van den Akker (2007) focuses on curriculum design (creating a plan for learning). All aspects of a curriculum should be concrete in order to develop a qualification process that is clear, concrete, and fits the context. Therefore, the SOJT-system will be described according to the curriculum spider web, to add structure and make the results concrete. The curriculum spider web is displayed in Figure 5 and explained further in Appendix E.

3.1.2.1 Rationale

The rationale behind why the FSEs of ASML are learning through SOJT can be better explained by ASML than by literature. This rationale is that ASML wants to deliver the best services to its customers (see section 1.2). Since SOJT allows the FSEs of ASML to apply what they have learned in other learning blocks in the actual work setting, it prepares the FSEs to deliver the services of ASML in the right conditions.

Figure 5
The Curriculum Spider Web (Van den Akker, 2007)



3.1.2.2 Aims and Objectives

The objective of SOJT is to improve organisational performance through improving employee competence. By combining the training inputs of the SOJT-system during the training process, a successful output may follow. The objective of SOJT is met when the trainee (FSE) is able to comply with the demands of the training objectives, perform work at the required level, and achieve personal development goals (Jacobs, 2003).

3.1.2.3 Trainer role

In the case of SOJT at ASML, the experienced employees are not referred to as trainers, but as mentors. Therefore, the term ‘mentor’ will be used from now on. SOJT happens in a one-on-one situation (Ahadi & Jacobs, 2017; Choi et al., 2015) and the relationship between the trainee and the mentor is fundamental (Jacobs, 2003). Hence, the actions of the mentor largely determine the effectiveness of SOJT.

Mentor responsibilities

The mentor has several responsibilities to ensure successful SOJT, all of these can be categorised into two facets: career development and psychosocial support; and role modelling (Chen, 2018; St-Jean, 2012). The different mentor responsibilities are shown in Table 4. Depending on where the FSE is in his/her development, one facet can be more relevant than the other. For example, more psychosocial support may be desired by the FSE in the beginning stages of SOJT compared to later (Allen et al., 1997).

Table 4

Mentor responsibilities

Career development and psychosocial support	*Role modelling*
Facilitate time for study	Prepare SOJT
Facilitate time for reflection	Secure the FSE has learned
Prepare the FSE	Practicing and setting goals with the FSE
Align with FSE's needs	Compose plan to reinforce knowledge and skills not fully developed during SOJT period
Deliver SOJT	Protect work and learning processes
Provide feedback	Be confident in and committed to the SOJT-system
Coach the FSE	
Strengthen the FSE's self-efficacy	

Note. Adapted from Cho (2009), Choi et al. (2015), De Jong and Versloot (1999), Huang and Jao (2016), Jacobs (2003), Jacobs and Bu-Rahmah (2012), Molnar and Watts (2002), and Van Zolingen et al. (2000).

Role modelling behaviour by the mentor is proven to be able to elevate the FSE's self-efficacy (Huang & Jao, 2016), this points out the importance of the mentor-mentee relationship. Self-efficacy is an important characteristic to have for the mentors themselves too, as this positively influences the delivery of SOJT (Cho, 2009). Next to the mentor behaviours mentioned, mentor commitment also has significant effects to the success of SOJT (Choi et al., 2015). When the mentor is committed to the mentor-mentee relationship because of for example perceived matching personalities or interests, the mentor becomes intrinsically motivated. This intrinsic motivation then becomes the impetus for the mentor to be committed to his/her role and make an effort to help the FSE develop.

Mentor training

Mentors are the cornerstone of successful SOJT. Therefore, it is important that the employee that will function as the mentor is competent both in the unit of work and as a trainer (Choi et al., 2015; Jacobs, 2003; Jacobs & Bu-Rahmah, 2012). In SOJT mentors generally lack

a background in teaching or learning (Cho, 2009). Hence, to ensure the mentors are competent they should be carefully chosen, and trained in real-life situations from the work environment (De Jong & Versloot, 1999; Levine, 1996; Molnar & Watts, 2002). This means that mentor training can take place during the SOJT process (Hua, 2008, as cited in Chen, 2018).

It was found that a training program for mentors positively affects mentors' self-efficacy, competence, and delivery of SOJT (Burkett, 2002; Cho, 2009; De Jong & Versloot, 1999). Naturally, some aspects to effective mentoring, like trust and perceived similarities between the mentor and the FSE (Ghosh, 2014; St-Jean, 2012) cannot be trained. Yet, many other knowledge and skills that are essential to effective mentoring can be trained. The knowledge and skills mentors can be trained in, how mentors can be trained, and other information regarding mentor training is described in Appendix I.

3.1.2.4 Content

When it comes to the unit of work to be learned, SOJT focuses on smaller units of work rather than a job in its entirety, such as specific tasks or procedures (Jacobs, 2003). Establishing measurable job performance standards is crucial when operating SOJT successfully. There are two reasons for this: they concretize the learning content, and they form the basis for measuring employee performance. Communicating these standards often leads to enhanced employee performance (Rothwell & Kazanas, 2004).

3.1.2.5 Learning activities

The responsibilities of the mentor have been described, however trainees (FSEs) share responsibility for the effectiveness of SOJT as well (Rothwell & Kazanas, 2004). The trainee should behave in a way that is supportive of the acquirement of new knowledge and skills. To achieve this, three activities are important for the trainee to perform during the training process: forming a mental model by observing the mentor's actions, practicing specific procedures for training tasks, and critically reflecting on the process and progress made (Choi et al., 2015). To be successful in performing these activities, trainees should put their active listening and questioning skills to use (Rothwell & Kazanas, 2004).

To support their learning behaviour, it is desirable for trainees to possess certain characteristics that positively affect the SOJT process: learning agility, person-job fit, and self-efficacy. Choi et al. (2015) found these three characteristics to have significant effects on SOJT. A description of these concepts and why they are important is included in Appendix I.

3.1.2.6 Location, Materials, and Resources

SOJT takes place in the actual work setting. This makes it more likely for trainees to meet the objectives of SOJT, as it is expected that they learn in a productive learning environment: the work pressure, atmosphere, resources present, and possible constraints make the trainee prepare for what is actually needed (Jacobs, 2003; Kim & Lee, 2001).

As SOJT takes place in the actual work setting, the SOJT-system exists within a larger context. Because of this, SOJT is in immediate contact with other systems in the organisation. Hence, the components of the SOJT-system are influenced by matters that arise from the organisational context. Some matters that influence the SOJT-system are the organisational business and priorities such as quality control and increasing production, ongoing change efforts such as the implementation of Lean Six Sigma methods (Yadav & Desai, 2016), and alignment between training and organisational objectives.

Because of this, support and commitment given by management are essential when it comes to SOJT. When management does not invest in the resources needed, SOJT is likely to fail (Levine, 1996). However, when management does invest in the structuring of the OJT process, it is likely to increase the return of investment (Choi et al., 2015; De Jong & Versloot, 1999; Levine, 1996; Molnar & Watts, 2002; Van Der Klink & Streumer, 2002). Examples of management support are displayed in Appendix I.

Another organisational aspect that influences SOJT is the level of standardization and structure, and consistency present. When job roles, procedures and other factors involved are standardized, the training process will be more structured. This could lead to greater effects of SOJT (Choi et al., 2015). The same goes for selecting and using materials and resources that enhance the SOJT-system's consistency: mentors, checklists, training materials (e.g. the ASML machines), and training formats (Ahadi & Jacobs, 2017; Levine, 1996; Molnar & Watts, 2002).

3.1.2.7 Grouping and Time

As mentioned before, SOJT happens in a one-on-one situation (Ahadi & Jacobs, 2017; Choi et al., 2015). In the case of ASML this situation consists of a mentor and a FSE. For the SOJT setting to be successful, the training schedule is required to be structured, flexible, and aligned between mentors and FSEs (De Jong & Versloot, 1999; Molnar & Watts, 2002). This is because the training should interfere minimally with work activities, and the environment should be favourable for training and learning (De Jong & Versloot, 1999; Jacobs, 2003).

Therefore, SOJT is ideally performed in the quieter hours of the workday, so work processes are hindered as little as possible (De Jong & Versloot, 1999). However, in some settings quieter hours are non-existent or difficult to anticipate. In those instances it seems more plausible to increasingly but steadily let trainees engage in the execution of tasks and procedures, where they start with relatively easy ones and grow towards tasks and procedures of higher complexity (De Jong & Versloot, 1999).

3.1.2.8 Assessment

Securing the FSE has learned and composing a plan to reinforce knowledge and skills not fully developed during SOJT are responsibilities of the mentor. Hence, the mentor should regularly provide evaluations and assess the FSE's progress for SOJT to be effective (Molnar & Watts, 2002). Hassanein et al. (2021) found on-job skill assessment to be effective for competence development. This underlines the usefulness of assessing (and qualifying) FSEs within SOJT. However, mentors should not assess FSEs too often, as this could negatively influence FSEs' openness towards mentors and hence disrupt their relationships (Ferayanti M. & Siswandari, 2020; Hobson & McIntyre, 2013; St-Jean, 2012).

Implementing a procedure to assess whether a FSE has obtained the knowledge and skills necessary to perform the job is advisable. This can be done by using observation, results, and checklists (Jacobs, 2003). Checklists reduce rater bias during observations and so enhance the assessment quality. Along with this, they are supportive in the provision of clear and specific feedback, which aids the mentor during both the SOJT training and assessment processes (De Jong & Versloot, 1999; Fletcher et al., 2018; MacDonald & Sulsky, 2009; Molnar & Watts, 2002). More information regarding checklist usage is included in Appendix I. To use results from the training process for assessment, tracking and record systems should be used by both mentors and trainees for the SOJT-system to be accountable (Ahadi & Jacobs, 2017; Jacobs & Bu-Rahmah, 2012; Levine, 1996; Orser, 2001). In Figure 4 Jacobs (2003, 2014) refers to tracking and record systems as 'communications technology'.

Text Box 2

Answer to research question 1: What is SOJT and what are its objectives?

SOJT is a planned system-based process for training in the work setting, where a novice employee is trained by an experienced employee, supervisor, job coach, subordinate, or facilitator (Ahadi & Jacobs, 2017; Jacobs, 2003). The SOJT-system comprises four interacting components: training input, training process, training output, and organisational context (Jacobs, 2003, 2014). These components work together to meet the objective of SOJT, which is to improve organisational performance through improving employee competence.

Text Box 3

Answer to research question 2: What are the fundamental elements of SOJT?

Through conducting the orienting and systematic literature review it became apparent there are six elements that are fundamental to SOJT and its effectiveness. The first one is the mentor, because SOJT happens in a one-on-one situation (Ahadi & Jacobs, 2017; Choi et al., 2015) and the relationship between the mentor and the FSE is fundamental (Jacobs, 2003), the mentor's actions largely determine the effectiveness of SOJT. However, the FSE is also fundamental to the effectiveness of SOJT (Choi et al., 2015; Rothwell & Kazanas, 2004). The behaviour an FSE portrays and the characteristics (s)he displays influence the level and speed of competence improvement.

The third factor that is fundamental to the successfulness of SOJT is assessment. Assessments should be conducted regularly to monitor progress and secure the FSE is learning (De Jong & Versloot, 1999; Molnar & Watts, 2002). Along with assessment, measurable job performance standards are crucial in order to operate SOJT successfully. This is because they form the basis for measuring employee performance, and communicating these often leads to enhanced employee performance (Rothwell & Kazanas, 2004).

To support the whole process of assessment and ensure accountability, tracking systems should be used by both mentors and FSEs (Ahadi & Jacobs, 2017; Jacobs & Bu-Rahmah, 2012; Levine, 1996; Orser, 2001). This helps secure the quality of output, which eases measuring improved employee competence and hereby contributes to meeting the objective of SOJT. Lastly, management support is fundamental to the effectiveness of SOJT as it likely increases the return of investment (Choi et al., 2015; De Jong & Versloot, 1999; Levine, 1996; Molnar & Watts, 2002; Van Der Klink & Streumer, 2002).

3.2 What is qualification and what are its objectives?

3.2.1 Definition of Qualification

3.2.1.1 Qualification

Qualification is defined by Ellström (1997, p. 267) as the set of competences that are required by the work task or prescribed by the employer, and implies that qualification includes competence. This definition aligns with how the concept of qualification is usually applied in research focused on the labour market (Hövels, 1998), like this research.

In a qualification process, qualification can be established through assessment. Here, an individual will be assessed on his or her possession of the competences that are required for the qualification. One thing to keep in mind, is that a qualification process is always under the influence of human error. This makes it possible to have 'false positives', meaning that FSEs can become qualified after assessment, even though he or she does not yet possess the competences that are required. To minimize the chances of 'false positives', it is important to employ assessment that is thorough and standardized.

3.2.1.2 Occupational Competence

Occupational competence is defined by Ellström (1994, as cited in Ellström, 1997, p. 267) as "the potential capacity of an individual to successfully handle certain situations or complete a certain task or job". This capacity is focused on hard skills and soft skills. The hard skills for the FSEs of ASML include having knowledge of the hardware and software of the lithography machine and knowing how to work on the machine. Hence, the hard skills consist of cognitive factors and motor skills. The soft skills include affective factors, personality traits, and social skills (Ellström, 1997).

3.2.1.3 Rationale for using the definitions

The concepts of occupational competence and qualification are often conceptually and terminologically confused with each other. Additionally, their definitions in literature are often unclear and a general consensus on the definitions seems to be missing (Ellström, 1997; Ellström & Kock, 2008; Hövels, 1998; Stoof et al., 2002).

The way Ellström's definitions qualification and occupational competence relate to each other fit the objective and setting of this research. Therefore, his definitions will be used in this research. It is important to employ a clear definition of occupational competence, because this will form the fundament to determine the standards for the qualification of the FSEs (Jessup, 1994). These standards are not only crucial to the success of SOJT (Rothwell & Kazanas, 2004), but to the desired qualification process as well. Because without these standards, the FSEs cannot be assessed in a reliable way (Van Der Vleuten, 1996).

3.2.1.4 Hard skills and soft skills

When it comes to training, SOJT in this case, it is essential to investigate which skills can and cannot be taught (Stoof et al., 2002); and therefore, on which skills employees can be assessed and qualified. The competences embodied in a qualification generally are hard skills (Balcar, 2016), as these are easier to teach, measure, and assess.

Soft skills are not as commonly represented in qualifications compared to hard skills. A number of reasons for this is mentioned in literature, such as that soft skills are more difficult to teach and assess as opposed to hard skills (Balcar, 2016; Colman & Willmot, 2016; Murti, 2014; Pulko & Parikh, 2003). However, the most significant reasons for the poor representation of soft skills in qualifications are that soft skills are constituted and evolve through relationships, and that an objective approach to assessing soft skills is difficult through relationships (Balcar, 2016; Murti, 2014), because of the personal connection the assessor has to the employee being assessed. Though observation could be fitting as an assessment method, it is too expensive to apply on larger groups of employees (Balcar, 2016). Parry (1996, as cited in Stoof et al., 2002) decided to leave soft skills out of his definition of competence, even though he acknowledged that soft skills affect performance. His rationale for this decision is that he did "not see them as competences to be developed through training" (p. 50).

However, in the case of SOJT, it would be useful to keep soft skills included in the definition of occupational competence. And to assess employees on soft skills, too. This would mean the competences embodied in the qualification are both hard skills and soft skills. The rationale for this is that hard skills and soft skills are complementary, and both cause significant increments to an employee's productivity. It is even suggested that productivity is only increased when hard skills and soft skills are used together (Balcar, 2016). As nowadays employers are looking for engineers that have both well-developed hard skills and soft skills (Bancino & Zevalkink, 2007; Mohd Kamaruzaman et al., 2019; Robles, 2012), they are considered to be equally important (Nguyen, 1998).

Additionally, in the case of SOJT, assessment of soft skills by observation is possible as it occurs in a one-on-one situation (Ahadi & Jacobs, 2017; Choi et al., 2015). Moreover, soft skills can be learned by applying methods and tools, and some soft skills are even related to cognitive factors (Balcar, 2016). Hence, the definition of competence by Ellström (1994, as cited in Ellström, 1997), which includes both soft and hard skills, will be used in this research.

3.2.2 Objectives of Qualification

Qualifications are used to set standards, to ensure that employees possess the minimal number of competences required to perform the job at hand. Hence, they are used to prove competence. Qualifications are linked with certificates and diplomas (Stoof et al., 2002), which can serve as physical proof of qualification and hence competence (Dufaux, 2012). The example in Text Box 1 in section 1.2 illustrates how the concepts of qualification, occupational competence, and certification relate to one another.

Text Box 4

Answer to research question 3: What is qualification and what are its objectives?

Qualification is defined as the set of competences that are required by the work task or prescribed by the employer (Ellström, 1997, p. 267). Since this research concerns service personnel, competence refers to occupational competence. This is defined as "the potential capacity of an individual to successfully handle certain situations or complete a certain task or job" (Ellström, 1994, as cited in Ellström, 1997, p. 267). This capacity is focused on hard and soft skills. The objective of qualification is to set standards and to prove competence.

3.3 Which assessment method is most suitable to establish qualification of FSEs within SOJT?

In this section, the findings from literature on assessment methods are summarised to conclude what the best suitable assessment method is to establish qualification of FSEs within SOJT. According to Jacobs (2003) "an orderly process is needed for the design, delivery, and evaluation of SOJT" (p. 35). Naturally, this process should be suitable for the qualification of FSEs within SOJT. Considering the objective of SOJT is to improve employee competence, and the objective of qualification is to set standards on the competences required, it has been concluded that a combination of formative and summative assessment methods is best fitting for the qualification of employees participating in SOJT. This is because formative assessment is used to determine learning needs and shape further learning (Harlen, 2006; Looney, 2011; OECD, 2005). Hence, this connects to SOJT's objective of improving employee competence. Summative assessment is used to document achievements (Harlen, 2006), so that is helpful in attaining the objective of qualification, which is to prove competence. Additionally, research shows that combining results from different assessment methods allows better generalising of those results and can consequently lead to more meaningful conclusions (Schuwirth & van der Vleuten, 2019).

Watkins et al. (2001, p. 2) mention that "the distinction between learning and performance is key." They opt for a "performance orientation" that is focused on proving competence, and a "learning orientation" that focuses on improving competence. Hence, in every educational situation, one should ask the question: 'Is this learning activity about proving or improving competence?' To answer this question in the view of the qualification of FSEs within SOJT, the answer is that both are relevant. Qualification is about proving competence, and SOJT is about improving competence. According to literature this can be feasible in practice by combining formative and summative assessment.

In the following subsections, the concepts for formative and summative assessment will be explored further. The reliability and validity of these concepts will be discussed too, because the quality of any form of assessment is contingent upon these. And as formative and summative assessment can be quite challenging to distinguish, they are summarized in Table 5.

Table 5

The main differences between formative and summative assessment

	Formative assessment	*Summative assessment*
Definition	Recurrent, interactive assessment of FSEs' skills and understanding during their regular work activities	The summary of FSEs' performance by means of for example testing and examining apart from regular work activities
Objective	Determine learning needs and shape training	Document achievements of FSEs
Examiner	Mentor and FSE	Mentor and/or external marker
Actions of mentor	Observe, support, and provide feedback	Conduct assessment
Actions of employee	Self-assessment	Participate in assessment
Reliable when	Individual-referenced	Results stay alike when the assessment is repeated in a comparable situation
Valid when	It leads to further learning	It measures what it is intended to measure

3.3.1 Formative assessment

3.3.1.1 Definition of formative assessment

Concerning SOJT, formative assessment can be defined as recurrent, interactive assessment of FSEs' skills and understanding during their regular work activities, to determine learning needs and shape training (Harlen, 2006; Looney, 2011; OECD, 2005). Formative assessment can be seen as assessment *for* learning (Harlen, 2006; Looney, 2011), as the objective is to determine where the FSEs are in their training process, where they have to go to reach the required level, and how to best go about this (ARG, 2002; Harlen, 2006). These formative assessment activities can be performed by both the mentor and the FSE (ARG, 2002), hence the interactive element in the definition. To illustrate, the mentor may observe the FSE and suggest suitable activities and goals to work on. The FSE can apply self-assessment (Kibble, 2017). Logically, the mentor should also encourage the FSE to self-assess (Black & Wiliam, 2006a; Sadler, 1989).

When it comes to responsibility in conducting formative assessment, the mentor delivering SOJT and the FSE receiving SOJT can be regarded as examiners (Harlen, 2006). This implies that both the mentor and the FSE should take responsibility in determining whether the objective of formative assessment will be and has been met. However, to be successful examiners, the mentor and FSE should have some knowledge of formative assessment, or have access to outside consultants (Jacobs, 2003). Otherwise this could lead to misconstruction of the assessment method, which poses a threat to reliability, and in turn validity of formative assessment. Since measurable performance standards should be established for SOJT (Rothwell & Kazanas, 2004), this means the assessment of the FSEs will be highly criterion-related. As reported by Stobart (2006), this has repercussions for the mentor's role. Namely, as formative assessment involves determining what is needed to meet the required level, a dilemma for mentors is "how to play the roles of both facilitator and examiner" (p. 140). Hence, the mentors should be aware of and able to set their personal bias aside.

Another option is to have a third party involved that assesses the FSE. This would ensure an independent judgment of the FSE's ability to perform the tasks and procedures (Jacobs, 2003). Although this is beneficial to the quality of summative assessment, this is not the case for formative assessment. Not only would a third party cause great expenses for the organisation because formative assessment occurs more frequently (Harlen, 2006; Looney, 2011; OECD, 2005), it would also not be beneficial to the progress of the FSE. This is because the mentor delivering SOJT will have a more fundamental relationship with the employee (Jacobs, 2003), which is a crucial element of formative assessment (Black & Wiliam, 2006a). This makes it more likely that productive feedback that actually informs next steps in learning is provided.

3.3.1.2 Reliability of formative assessment

In formative assessment judgments are considered reliable provided they are individual-referenced, meaning they are adapted to what the FSE needs in their learning. It is a weakness if the same feedback is given to different FSEs consistently, because each FSE might need different feedback to progress in their learning (Stobart, 2006).

A threat to the reliability of formative assessment is that the mentor misconstrues the competences to be assessed. This can lead to the mentor providing feedback that is unproductive to progress learning (Stobart, 2006). Logically, this applies to the FSE engaging in self-assessment as well.

3.3.1.3 Validity of formative assessment

As formative assessment is assessment *for* learning, it should lead to further learning to be valid (Stobart, 2006). This seems quite straightforward. However, according to Stobart (2006) the trustworthiness of the conclusions drawn from the assessment results are subject to the reliability of the assessment. Because "if the results are unreliable, then the inferences drawn from them will lack validity" (p. 133).

Two crucial elements that can strengthen validity of formative assessment, and hence lead to further learning, are a supportive learning context and productive feedback to the FSE (Stobart, 2006). Firstly, the learning context is crucial to the success of formative assessment, but it is also very complex. To clarify this, think of social and cultural aspects influencing the way of working and learning, consequently influencing the effectiveness of formative assessment. For example, people from east Asian countries generally prefer to provide negative feedback in an indirect and implicit manner. Whereas Americans, who also prefer to provide negative feedback indirectly, tend to do this in a more explicit manner (Meyer, 2014). Besides these overarching aspects, a supportive learning context also signifies a safe and productive working and learning climate, clarity of learning goals, and a possible connection of formative assessment to summative assessment (Crooks, 2001; Stobart, 2006).

Secondly, the provision of productive feedback can strengthen the validity of formative assessment, but at the same time it is a highly complicated process. Furthermore, it is possible that feedback provided in formative assessment is not valid. The issue is that the feedback should lead to further learning, not to greater motivation or enhanced confidence, for instance. These two latter aspects are a bonus to the outcome of formative assessment, yet they are not what formative assessment entails. According to Stobart (2006), for feedback to be productive in formative assessment, it should be:

- Well connected to the competence(s) assessed;
- Clear that the individuals involved understand the criteria of the competence(s) assessed;
- Provided at an appropriate level. The levels distinguished are self-regulatory, process, and task. Important to note is that only the levels addressed in feedback are likely to be acted on (Kluger & DeNisi, 1996; Stobart, 2006);
- Aimed at the task instead of the individual;
- Challenging yet achievable, hence actionable

3.3.2 Summative assessment

3.3.2.1 Definition of summative assessment

With regard to SOJT, summative assessment can be defined as the summary of FSEs' performance, for example by testing and examining independently from regular work activities (Harlen, 2006; Looney, 2011; OECD, 2005). Summative assessment can be seen as assessment *of* learning (Harlen, 2006; Looney, 2011), where the objective is to document achievements of FSEs (Harlen, 2006).

To ensure high quality summative assessment both the reliability and validity of the assessment should be attentively appraised (Black & Wiliam, 2006b). This is important, because based on summative assessment important choices can be made that may have considerable consequences for both the FSE and the organisation. For example, summative assessment could be used after a training period to decide whether or not FSEs are able to perform their job tasks.

According to Harlen (2006) both the mentor and an external marker are suitable options when it comes to who can best be responsible for examining summative assessment.

3.3.2.2 Reliability of summative assessment

Concerning summative assessment, the primary causes of error that threaten the reliability are: dissimilarities in performance depending on the specific content included in the assessment, dissimilarities in the FSE's day-to-day performance, and examiners appraising the same FSE differently (Black & Wiliam, 2006b). According to Black and Wiliam (Black & Wiliam, 2006b), this so-called 'marker error' can be partly handled by carefully choosing and training examiners, partly by establishing strict procedures examiners have to adhere to, and partly by studiously controlling samples of conducted examinations. Even though it is a significant threat to the reliability of summative assessment, Black and Wiliam point out that compared to the effects of the other two threats just mentioned, the amount of error due to marker error generally is likely to be limited. However, it should not be neglected because of this. Summative assessment is used for qualification. Hence, the standards set should lead to a clear boundary for passing and failing, and the examiners should adhere to this boundary.

A way to strengthen the reliability of summative assessment, is to conduct multiple assessments spread over a set time period (Van Der Vleuten, 1996). Another approach to strengthen the reliability, is to use different assessment methods next to each other (Hays et al., 1995; Van Der Vleuten, 1996).

3.3.2.3 Validity of summative assessment

According to Stobart (2006), there are two main threats to validity of summative assessment. The first is that in the process of constructing a highly reliable assessment, the pitfall is to only assess elements of tasks or procedures that are easier and more reliable to assess. Consequently, the assessment could be less valid as the conclusions drawn from it may not be representative of the tasks or procedures required for the job. The second threat to validity is that an assessment can measure something differently than it is intended to measure, an example of this is shown in Text Box 5.

Above all, it is crucial to the validity of summative assessment that what is measured is not only intended, but relevant as well. A way to establish this is to set up a review process (Van Der Vleuten, 1996). This review could be completed by a panel existing of multiple people fit for the task, but having a single colleague reviewing can also already be helpful to strengthen the validity (Kibble, 2017).

Text Box 5

Example of invalid assessment

In his final qualification exam, where he will be qualified within SOJT, FSE Kevin is asked to perform a mechanical replacement. Hence, in this situation the intention is the measure the application of cognitive factors and motor skills. According to the examiner, Kevin fails because he consulted a resource.
This is an invalid assessment, as the intention of the assessment was to measure the ability to perform a procedure, not the ability to memorize it.

Text Box 6

Answer to research question 4: Which assessment method is most suitable to establish qualification of FSEs within SOJT?

A combination of formative and summative assessment is best fitting for the qualification of FSEs participating in SOJT. Formative assessment can support establishment of qualification within SOJT, as it is used to determine learning needs and shape further learning (Harlen, 2006; Looney, 2011; OECD, 2005). This connects to SOJT's objective of improving employee competence.
Summative assessment can support the establishment of qualification within SOJT, as it is used to document achievements (Harlen, 2006). This is useful in attaining the objective of qualification, which is to prove competence.
Hence, these two assessment methods are most suitable to establish qualification of FSEs within SOJT; combining them empowers meeting the objectives of both SOJT and qualification. Furthermore, combining assessment methods to establish qualification of FSEs within SOJT can lead to more meaningful conclusions as the results can be better generalised (Schuwirth & van der Vleuten, 2019).

4. Interviews

As described in section 2.3, exploratory semi-structured interviews were conducted to explore the creation of a qualification process and possible design requirements for the solution design. This chapter presents the results of the interviews. The codes that were applied in the open and axial coding phases and a selection of the themes that were derived during the selective coding phase are included in their respective appendices: Appendix F and Appendix G.

The interviewees' behaviour during the interviews is perceived as open and honest by the interviewer. The researcher is under no impression that the interviewees have kept information to themselves, this is also apparent from the statements they made. The following comment illustrates this:

"You are recording this, but I am going to say it anyway. Once I even heard a manager say, 'Why should I talk to my engineers'. Right. So if they say that, then I think like, wow, wait a minute." – Program owner SOJT

In this chapter, the results from the interviews that were conducted are presented by describing the relevant themes, concepts, and relationships that were discovered in the selective coding phase. This is done according to the curriculum spider web of Van den Akker (2007) to provide structure and consistency, as this framework has been used to describe the SOJT-system in Chapter 3 of this report. Additionally, results regarding the current and desired situations will be described separately. After the results have been described, the answers to the three sub-questions that are answered via interviews are displayed. Lastly, there is additional relevant situation on the current and desired SOJT ecosystem available. However, as this information is not directly related to the research questions, it is displayed in Appendix K.

4.1 How are SOJT and its fundamental elements currently put into practice, and what are the desires on this for the future qualification of FSEs within SOJT?

4.1.1 Rationale

Current situation

Most interviewees argue that the FSEs currently learn via SOJT as it is crucial for them to get hands-on experience. Some even find SOJT to be better than formal training.

"And I feel like if anything, it gave me the tools that I needed to support the team. But also it forced me to think outside of the box and to take my learning into my own hands." – Engineer

More illustrative quotes on the opinions on SOJT are displayed in Appendix J, this goes for all following sub-sections containing interview results.

Desired situation

Higher management aims to standardize the SOJT process, so all FSEs would learn in the same way within SOJT worldwide. Looking back at the results from the interviews with the CS VPs (see section 1.3), higher management wants FSEs to learn like this because it would enable higher management to manage service capability per site, region, and globally; demonstrate service capability and quality to customers consistently; and because it can motivate engineers. Hence, it would enable qualification. Appendix J contains quotes that illustrate the aim for standardization and interviewees' opinions on qualification.

4.1.2 Aims and Objectives

Current situation

Considering the aims and objectives of SOJT that were mentioned in Chapter 3, the main objective for the FSEs to reach is to be able to independently maintain and repair the machines of ASML at the customer site. FSEs are allowed to work independently, and hence considered to be qualified, when they meet certain qualification criteria and job performance standards.

Currently there are site-to-site differences in the qualification criteria that are adopted. At some sites, you are considered to be a qualified FSE when you have completed a half of your Skill Management Tool (SMT, see Appendix J for explanation) list, whereas at other sites you are considered to be qualified when you have completed 100% of your SMT list. At one site you are even already considered to be qualified after having finished instructor-led training, which takes place before SOJT starts. The same applies to the current job performance standards; there are no job performance standards that are valid for all FSEs of ASML. This can be explained by the finding that although the SOJT SMT list is general, it is currently not being used in the same way due to the difference in qualification criteria.

However, what is currently mainly happening, is that the assessment is related to the periodic maintenance actions. Hence, those can be seen as the most important job performance standards. Some local sites also develop an additional site-specific set of job performance

standards to provide to their FSEs. Appendix J contains quotes illustrating the current situation on job performance standards more clearly.

Desired situation

In the future, being able to work independently on the machine of ASML means the FSEs have to become qualified. Regarding desired qualification criteria, the general opinion that was found in the data is that FSEs need to meet at least 80% of the performance standards to pass their qualification. For more information regarding desired job performance standards, please refer to section 4.1.4. Additionally, interviewees find that mistakes should be allowed, and that FSEs should have the opportunity to recover their mistakes. Some interviewees even argued there is no fail:

"My view is that there is no fail in the process. It's how long does it take you to get to the end. In essence you're outlining the steps. From here to there, that's what it takes to be qualified. And some engineers may do it fast, and some engineer may take longer. There is no fail unless they're not competent to perform the job, and then you start to bring in HR. so, in essence everyone should be able to reach that level, it's just a question of: 'Are we willing as a company to provide that timeframe, or are we not?'" – KM

4.1.3 Trainer role

Current situation

Mentor responsibilities

The mentor mainly facilitates SOJT by teaching the FSEs. (S)he does this by demonstrating the procedure to be learned. After having seen the procedure a couple of times, the FSE gets to perform the action. The mentor then observes the FSE and provides feedback along the way. In order to establish qualification a check is required, a form of assessment. This is another responsibility the mentors currently have; to regulate the SOJT process by assessing and monitoring the FSEs' progress.

Mentoring structure

The experienced employees functioning as mentor are mostly senior engineers, in some cases the mentor is a shift lead or a technical support engineer (who works in the office). There are currently no assigned mentors, and one FSE often has multiple mentors. This has three reasons:

- There are different senior engineers for different modules of the system, hence each senior engineer has different experience levels for each module;
- Within SOJT the FSE performs different actions on different modules, and;
- The FSE always performs actions together with a mentor (senior engineer)

The mentors changing and an FSE having multiple mentors was not introduced when the process transitioned from OJT to SOJT, it has been like this in the past as well. And, although the mentoring happens based on experience levels, interviewees also mentioned that they think not everyone can be a mentor:

"So I think when it comes to the shift lead, it would be just identifying the correct person to be the trainer. So I think that is an important step. Because you can be knowledgeable in a certain subject or a certain part of the system. It's a different story to pass that knowledge to somebody else." – Engineer

Mentor training

As far as the development of mentoring skills goes, there is not much happening currently. Engineers that mentor do invest in developing their own hard and soft skills, however this is not related to mentoring. Right now, there is no specific mentor training. They also do not share mentoring experiences such as best practices or lessons learned. The only preparation that currently takes place, is solely related to management preparing the mentor. However, it should be noted that this means management informs the mentor someone new is joining. Management does not prepare the mentor by facilitating training in mentoring skills, for example. Again, quotes supporting the findings reported here are displayed in Appendix J.

Desired situation

In the future the interviewees want the mentors to have the same responsibilities as they currently have, including deciding on FSEs' readiness to qualify. The mentor is frequently mentioned as the desired individual to perform assessments within the qualification process. However, there are opinions contradicting this as well. More information regarding this subject is discussed in section 4.1.8. To better fulfil their responsibilities as a mentor, some senior engineers argued they would like to have more opportunities to explain certain procedures and tools to FSEs as they are currently lacking time to do that sufficiently.

4.1.4 Content

Current situation

The current job performance standards were already mentioned in section 4.1.2. As learning content is related to job performance standards, this means that the current content within SOJT is mainly about periodic maintenance actions and any additional site-specific content.

Desired situation

In section 3.2 the definition of qualification used in this research was explained. It mentioned that qualification included competence, which can be categorized into hard skills and soft skills. Hence, when talking about the desired qualification process to take place within SOJT, the interviewees were asked about what, in their opinion, the ratio between hard skills and soft skills should be within the qualification.

The general opinion that arose from the data is that both hard skills and soft skills should be part of the qualification. The most important soft skills as perceived by the interviewees are communication skills and customer-facing skills. The hard skills that were mentioned most often are the periodic maintenance actions, followed by troubleshooting. Multiple arguments were given as to why the periodic maintenance are the most important hard skill: the periodic maintenance actions are mostly standardized; they happen often, and; FSEs often have the chance to see these actions in their SOJT.

Although the interviewees generally share the opinion of including both hard and soft skills in the qualification, they had some comments as to how they would go about this. They argue that although soft skills are needed, hard skills are most important within the qualification for the engineers. The reason for this is that hard skills are more frequently used by the engineers. Some interviewees argue they would like to include soft skills in the qualification but not in an exam, as they find soft skills take more time to develop. Lastly, multiple interviewees mentioned that, in their opinion, soft skills are very hard to qualify due to the circumstances in which SOJT takes place and the opportunities that arise. Appendix J contains quotes illustrating the desired ratio between soft skills and hard skills within the qualification.

4.1.5 Learning activities

Current situation

FSE responsibilities

FSEs are responsible for two things: developing their competences and reporting on their progress. To develop their competences, the FSEs engage in three main activities: shadowing their mentor when (s)he performs an action; asking questions; and taking initiative (e.g. asking to perform a certain procedure instead of waiting to be asked for it). To report on their progress, all FSEs have to update SMT. Some engineers also have to send weekly progress reports to their direct manager. The following comment made by a senior engineer illustrates what a SOJT process looks like for the FSEs:

"So typically I start with showing them how to do it. And then, I will have them do it under my supervision. And then once I am comfortable with that, I can advise them, oh yeah, you are good to go, you can do this by yourself now."

This example implies that the senior engineer that mentors decides when an FSE is ready to work independently. However, depending on their location and their mentors, the FSEs can also take initiative in showing their readiness themselves. Please refer to Appendix J for a quote illustrating this.

Lack of feedback

Although the engineers can indicate their perceived readiness for qualification, some engineers reported that they did not receive any feedback on their hands-on skills during SOJT. This made it harder for them to reflect and report on their progress. The reason for the lack of feedback is time pressure; the mentors are too busy. Interviewees mentioned that in the past, mentors had more time. They were able to provide feedback and also to take time to prepare the FSE before going into the fabrication plant. Now, there is not enough time for such things. Management does prepare the FSEs and provides feedback. However, this feedback is not as concrete, as they are not directly involved with the SOJT-process. Please refer to Appendix J for a quote illustrating FSE preparation by management.

Desired situation

Within the desired qualification process, there are expectations for the FSEs in terms of characteristics and behaviour. Namely, the interviewees want the FSEs to have a proactive mindset; meaning they want the FSEs to take initiative, demonstrate their capabilities, and ask questions.

4.1.6 Location, Materials, and Resources

Current situation

As mentioned in section 3.1.2.6, SOJT takes place in the actual work setting. For the FSEs of ASML this means that they work at the customer sites, on the machines of ASML, and with the actual tools and resources all other engineers use. Examples of resources are Coach, which is the global manual of procedures, and OneNotes, which contain various sources of information that are saved locally. Many interviewees perceive SOJT to take place in a challenging environment. Three current challenges were found that illustrate this:

- SOJT is opportunity-based;
- SOJT needs more structure;
- SOJT takes place in a time-pressured environment

SOJT is opportunity-based

The main challenge brought forward by interviewees from all locations is that SOJT is opportunity-based. This was mentioned twenty-two times in total. What is meant by opportunity-based, was explained by the program owner:

"Look, very often it's the case that SOJT is opportunity-based, right. So you don't know when everything happens. We have an increasing number of people in the shifts, an increasing number of machines, too. But, you don't know what happens when. You have to be a little lucky to have the right things happening on your machine. Or in your shift. So you can't quite steer it, that timing." – Program owner SOJT

To illustrate, the opportunity-based character of SOJT was mentioned by all engineers, four out of five KMs, and one out of two shift leads that were interviewed. Hence, this opportunity-based way of working for the FSEs seems to be present at many customer sites. KMs and shift leads mention that this is challenging for the continuity of the engineers' development, and engineers mention that sometimes it frustrates them. Appendix J contains quotes illustrating these comments. A couple of consequences the opportunity-based way of working has are mentioned in these quotes:

- Engineers are not able to see a whole action, as some take longer than shift time;
- Bigger sites have more learning opportunities;
- Engineers are not able to practice all actions in SOJT, as they might not have had the opportunity to see an action

SOJT needs more structure

The second main challenge that was found is that SOJT needs more structure. Part of the desire to have more structure to SOJT relates to the opportunity-based character it has:

"There would be no necessary structure, I think what you learn would be mainly focused on what actually happens. Because obviously service actions happen at different times unexpectedly. And you just join them and learn." – KM

However, other comments made about SOJT needing more structure relate to the fact that currently there is no process owner for SOJT; there are no assigned mentors, which leads to differences in mentoring and dissatisfaction; and differences in the amount of feedback being provided. This can in turn be explained by the fact that SOJT is fairly new at ASML, in the past it was unstructured OJT. Please refer to Appendix J and Appendix K for illustrative quotes.

SOJT takes place in a time-pressured environment

The third main challenge that was found is that SOJT takes place in a time-pressured environment. As mentioned in section 2.3.3 the engineers' priority lies with the customer, hence there is a constant struggle to have sufficient learning opportunities for the engineers while also delivering the machine back to the customer as quickly as possible. Consequentially, FSEs receive less training and reflect less on their learning due to the time-pressure they experience themselves; and the time pressure their mentors experience. Appendix J contains quotes illustrating this.

Desired situation

The interviewees mentioned that the challenging environment cannot be entirely changed, so they partly have to cope with it. However, interviewees would like management to allocate more time to SOJT and aligning planning. This would enable FSEs to have more learning opportunities, and mentors to better fulfil their responsibilities. Additionally, the aim of higher management for more standardization (see section 4.1.1) may add structure to the SOJT process.

4.1.7 Grouping and Time

Current situation

As mentioned before, the mentor-mentee relationship is fundamental to SOJT as it happens in a one-on-one situation . However, it was also mentioned in section 4.1.3 that an FSE often has multiple mentors. This could mean that FSEs currently have less fundamental relationships with their mentors, as they alternate between multiple mentors during their SOJT.

Timewise, management currently facilitates time for learning. It has previously not been like this, as is shown in Appendix J. Another way in which management supports SOJT, is by aligning planning.

Desired situation

The interviewees made no mention about changing the way the mentoring is currently structured. Regarding planning, interviewees want higher management to facilitate more learning opportunities, and local management to feed them to the FSEs by for example making sure plannings are better aligned.

4.1.8 Assessment

Current situation

Assessment methods

The assessments that are currently being performed are developed locally, which means there is not one single way of assessment or qualification for all FSEs of ASML. The current way of qualifying varies from observation of hands-on skills to no hands-on assessment, and from qualification by questioning to qualification by discussing. SMT is also being used as an assessment method. Qualification by observation happens most often, followed by qualification by discussing and using the SMT list.

However, many interviewees (10) from all locations perceive the use of SMT for assessment as a challenge. This is because SMT results are based on self-assessment by the FSEs. The fact that self-assessment is currently being used as a way to qualify is perceived by management as a weakness, and it is one of their concerns. This concern from management seems valid; engineers mentioned they update actions to ‘can’ in SMT when they have never performed them. Hence, SMT currently does not always portray a trustworthy image of the engineer. Appendix J provides more context on this matter.

A solution to the subjectiveness of self-assessment that has been implemented at some locations, is score validation by the mentor or a manager. This means the FSE can only update an item in SMT after the mentor or manager has confirmed (s)he is capable of performing the action. Another concern management has, is that SMT only measures hard skills. However, multiple interviewees that work directly in the field explained that it is supposed to be that way: the SOJT SMT list is used at the customer sites, where the engineers are currently only taught hard skills deliberately. For soft skills, the engineers attend soft skill trainings facilitated by HR.

Examiner

There are differences in who currently performs the assessments. Mostly it is the mentor who performs assessments, but on a few occasions it is the KM or a local manager who performs assessments. However, the current way of assessing seems to be more structured compared to the past. Section 4.1.8 in Appendix J contains a quote illustrating this.

As mentioned in section 4.1.5 the FSEs report on their progress by updating SMT. With SMT engineers track whether they 'can' or 'cannot' perform a certain task or procedure based on self-assessment. Hence, FSEs also perform assessments themselves. At the same time, SMT is the tracking system ASML uses to track FSEs' progress. SMT does not only enable tracking of an engineer's development, it also guides the engineers and allows them to drive their own development. Only engineers can update their SMT, others can monitor engineers' statuses. More information on SMT is provided in Appendix J.

Desired situation

Assessment methods

The interviewees' preferred assessment method to qualify FSEs within SOJT seems to be observation: this was mentioned twenty-six times by interviewees from all roles and locations in the interview sample. Nine interviewees mentioned that to support the examiner and make the assessment process more fair, they would provide examiners with a checklist on what to look for. Appendix J contains quotes illustrating what using observation and checklists for assessment can look like in practice.

Along with the use of observation and a checklist for assessment, multiple interviewees (7) expressed the desire to use process data for assessment purposes. With this, the interviewees intend to make every observation count, regardless of whether it is an observation performed during an exam or during the training and learning process. Some interviewees even mentioned they think that using process data for assessment purposes makes an exam unnecessary. The following comment made by a KM illustrates this:

"I think if the engineers they do some scheduled activity, and then this kind of data is recorded in ASML system. So if the data can be interacted with our SMT, then I think we can use that kind of data as assessment. We don't need to do additional assessment process. And then just rely on their own, their actual daily work activity data." – KM

This quote by the KM mentions the use of SMT as assessment for qualification. When asked whether interviewees would like to use SMT for assessment or not, contradicting answers

were given. Although the interviewees that elaborated on this topic are generally in favour of using SMT (mentioned by 7 interviewees), there also is a group that does not support this (3 interviewees). Appendix J illustrates some of the views interviewees shared on the matter.

The arguments the interviewees used to support their desire to use SMT are that SMT is a quantifiable tool, and that SOJT validation has been implemented in SMT. The arguments used to support the desire to not use SMT are that SMT is based on self-assessment, and that because of that, the assessment would be unreliable. Because of this, a desire to implement SMT validation was expressed. It is striking that interviewees in favour of using SMT mention that one of their reasons for this is that validation has been implemented, whereas interviewees against the use of SMT for assessment purposes mention that SMT is unreliable and needs validation. This implies that the SMT validation might not have been implemented at all customer locations yet. The program owner confirmed this:

"We have implemented SOJT validation in SMT. The validation is still somewhat neglected or unknown, but it is very important. We have built into SMT that when an engineer updates their skills, they get assigned to a curriculum in our learning management system. When an engineer thinks he or she is finished (s)he signs off, but before he can really be finished with the curriculum, a manager has to give approval." – Program owner SOJT

Lastly, another desire the interviewees have is to provide feedback to the FSEs, so they have the chance to improve after assessment took place (mentioned 10 times).

Examiner

The interviewees mentioned many options as to who should assess the FSEs. All of their desires can be divided into two groups that offer several alternatives: a local examiner or a non-local examiner. Local refers to the local customer sites.

The most frequently mentioned alternatives within the local examiner group, are: a senior engineer (18 times); a mentor (14 times). These are the preferred options by people from all locations and roles, but mainly by engineers. Table 6 displays the arguments the interviewees gave for their preferred options. Along with this, Appendix J contains quotes that add depth to the opinions displayed in Table 6.

There are contradicting opinions regarding the desire to have the mentor assess. Although there are fourteen mentions of a desire to have the mentor assess, there are also four mentions of the desire to not have the mentor assess. The reasons mentioned to not let the mentor assess are based on rater bias and subjectivity due to the personal relationship the mentor

has with the engineer. Please refer to Appendix J once more for a quote providing more depth on the matter.

The most frequently mentioned alternatives within the non-local examiner group, are: an experienced trainer (7 times) and an independent examiner (5 times). Again, the arguments for their choices are displayed in Table 6 and supported with quotes in Appendix J. Although interviewees were hesitant whether this task would fit within trainers' bandwidth, they thought it is a good alternative as the trainer knows what to look for. An independent examiner is desired as this person can minimize the rater bias. There was no mention of who should fulfil this role. The interviewees all referred to the independent examiner as 'a third party' coming in. Lastly, two senior engineers went a little outside of the box in their thinking and did not think in terms of 'examiner', but in terms of 'examiners'. They argued they would have not one, but two examiners to assess the FSEs:

"Yeah. We like both. We like the mentor to make sure they're really ready, but then also have another mentor or engineer to watch them at the same time or a different opportunity. Just to help with bias." – Engineers

Table 6

Interviewees' preferred examiner choices and their arguments for this

Examiner group	*Desired job role to assess the FSEs*	*Given arguments*
Local	Senior engineer	A senior engineer has more experience in the fab
		A senior engineer has a lot of experience in the field
	Mentor	A mentor knows the engineer and his/her capabilities best
Non-local	Experienced trainer	An experienced trainer knows what to look for
	Independent examiner	An independent examiner can minimize the rater bias

Process characteristics

The interviewees have a general preference for a stepwise qualification process (mentioned 10 times) that is flexible (mentioned 8 times) and is hence spread out over multiple assessment moments (mentioned 10 times). Flexibility in a qualification process can be interpreted in multiple ways. In the interviews, interviewees used the term flexible to refer to the timing of a qualification exam. Appendix J contains quotes illustrating what is meant by a

stepwise and flexible qualification process. For the desire to have multiple assessment moments the interviewees have three drivers, namely:

- Some actions take longer than shift time;
- It is expected to be less stressful for the FSE;
- The local site saves resources as there is higher availability at the customer site

These drivers are related to the desire to have a stepwise and flexible qualification process, as multiple assessment moments are required when actions take longer than shift time. This requires flexibility from the people involved in the qualification process: you don't always know when a certain action happens, hence, you don't always know when you will have to assess or be assessed.

4.1.9 Accountability

Originally, accountability is not part of the curriculum spider web of Van den Akker (2007). It was decided to add this component as it is important for the implementation of the qualification process.

Current situation

Currently, there is no responsible party with regard to assessment and qualification. This has led to assessment and qualification being performed and established in diverse and self-developed ways. There is no global quality control on this.

Desired situation

In the future, interviewees want responsibility to be carried for the qualification process. This also connects to the aim of higher management to standardize the SOJT process. There is a contradiction in the data when it comes to whether or not the qualification process should be managed by local management or not. The interviewees are divided on this topic. Some find the qualification should be managed locally because that way it is easier to apply the process the same across all shifts. They think it is harder to achieve commonality amongst different countries. Whereas the other group argued they would never want a qualification process that can be managed locally, as they find there can be 'shortcuts'. With this, the group meant that sites could possibly qualify FSEs before they are ready to, in order to save costs. In their opinion, that would make the qualification meaningless.

Text Box 7

Answer to research question 5: How is SOJT currently put into practice?

SOJT is fairly new at ASML, in the past it was unstructured OJT. It is seen by interviewees as crucial to get hands-on experience. This is because SOJT takes place in the actual work setting at the customer site, where the FSEs are trained on the actual machines of ASML with the same tools and resources other engineers use.

SOJT takes place in a challenging environment. This is due to SOJT being opportunity-based, needing more structure, and being subject to time-pressure. There currently are site-to-site differences in the way SOJT is being put to practice. These differences are related to qualification criteria, job performance standards, mentoring, content, assessments, and examiners. These differences may be explained by the fact that there is currently no responsible party for SOJT, which may explain the challenging environment and the need for more structure.

Text Box 8

Answer to research question 6: How and to what extent are the fundamental elements currently present within SOJT?

As mentioned in the literature review, SOJT has six fundamental elements: the mentor, the FSE, assessment, measurable job performance standards, tracking systems, and management support. For each element it will now be described how and to what extent these are currently present within SOJT at ASML. Firstly, the mentor facilitates the FSE's development by teaching. More concretely, they demonstrate a procedure, then observe the FSE and provide feedback. However, the FSEs indicated they currently experience a lack of feedback. Besides a facilitative role, the mentor also has a regulative role because (s)he assesses and monitors the FSE's progress. This is partly to decide when an FSE is ready to work independently. Most often the employee mentoring is a senior engineer. The mentors change depending on the system module, meaning that an FSE often has multiple mentors. A theme that arose in the data is that not everyone can be a mentor. However, currently there is are no assigned mentors and there is no mentor training.
The FSE has two responsibilities within the SOJT process. The first one is to develop his/her competences by shadowing the mentor, asking questions, and taking initiative. The second one is to report on his/her progress by updating SMT, which is the tracking system the FSEs use. Some FSEs also have to send weekly progress reports to their direct manager. FSEs can not only take initiative in steering their learning progress, they can also take initiative in showing readiness to work independently.
The assessments for qualification that are currently happening differ from site to site in three ways. Namely, in how they assess, who performs the assessments, and the qualification criteria that are adopted. Overall, the assessments happening now are more structured compared to the past. Because of the different qualification criteria, the job performance standards differ as well. Most job performance standards relate to the periodic maintenance actions. Some sites have developed additional site-specific performance standards.
To support the whole SOJT process, management fulfils a facilitative role. Management currently support the SOJT process by facilitating time for learning.

Text Box 9

Answer to research question 7: Which fundamental elements are needed to establish qualification of FSEs within SOJT, and how should they be represented?

For each fundamental element of SOJT it will now be described how they are needed and how they should be represented in order to establish qualification, according to the interviewees. Firstly, the mentor should have the same responsibilities as (s)he currently has. However, the interviewees want mentors to have more opportunities to explain procedures and tools, as they currently lack time to do so.
The expectation set for the FSE is to have a proactive mindset. With this, the interviewees intend the FSEs should take initiative, demonstrate capabilities, and ask questions.
The interviewees want the assessments for qualification to be performed by observing the FSE with a checklist containing information on what to look for. Additionally, they want to use process data for assessment purposes. Moreover, the interviewees find the provision of feedback to be important, as they argue the FSEs should have the chance to improve after assessment took place.
Regarding who should be the examiner, there are two options: a local examiner or a non-local examiner. A local examiner is preferred. For a local examiner a senior engineer or a mentor are preferred, although there are contradicting opinions on whether a mentor should also examine. For a non-local examiner this is an experienced trainer or an independent examiner. Additionally, there is a desire to have two examiners; to help reduce rater bias.
For qualification criteria, regarding when FSEs are considered qualified, interviewees argue they want FSEs to meet at least 80% of the job performance standards. This means mistakes are allowed.
For job performance standards, the interviewees want to include both hard skills and soft skills. However, they wish to emphasize hard skills as these are more frequently used by the FSEs. Moreover, they argue soft skills should be excluded from an exam as they take more time to develop and are hard to quantify. The hard skills interviewees consider to be most important are the periodic maintenance actions and troubleshooting. The soft skills interviewees consider to be most important are communication skills and customer-facing skills.
Regarding SMT there are contradicting opinions on whether it should be merely be used to track and monitor progress, or whether it should also be used for assessment purposes.
The interviewees argue the challenging environment of SOJT cannot be entirely changed. Therefore they want the qualification process to be stepwise, flexible, and consisting of multiple assessment moments.
Regarding management support the interviewees want higher management to facilitate more learning opportunities, and local management to feed them to FSEs by aligning planning. Hence, they want management to allocate more time to SOJT and to align planning. Additionally, higher management aims to standardize the SOJT process further.
Lastly, interviewees want responsibility to be carried for the qualification process. However, there is disagreement on whether the process should be locally managed or not.

4.2 Interim conclusion

This interim conclusion focuses on two main aspects that were discussed in the interviews: the current situation and the desired situation, and what could be needed to bridge that. What can be concluded is that although an official qualification process does currently not exist, assessment and qualification are locally happening in self-developed ways.

It is striking that when asked what the desired qualification process within SOJT should look like, the interviewees often mentioned factors that relate to the SOJT process instead of only mentioning factors that relate to a qualification process. This can be explained by the fact that in order to successfully qualify FSEs within SOJT, it is essential for SOJT to take place within the right conditions. Namely, without these, it will be harder for FSEs to reach a certain competence level and be qualified.

Several findings lead to an overarching point of improvement in order to qualify FSEs within SOJT, which is to structure the SOJT process further. The fact that SOJT is still fairly new at ASML can be a possible reason for the local differences in structure, assessment methods, and qualification, as the development of the SOJT-system has not yet reached this stage. Another reason could be the fact that there is currently no global process owner for SOJT and/or qualification.

In the future, the interviewees also desire to have better quality mentoring. Currently there is no mentor training, which leads to differences in the quality of mentoring and dissatisfaction amongst interviewees. To minimize the difference in quality of mentoring that is currently visible, it is recommended to implement a mentor training program. However, it should be noted that the interviewees also think that not everyone can be a mentor. Hence, it can be concluded that not everyone should be eligible to participate in the mentor training program.

The interviewees mentioned that one of the main challenges for qualification within SOJT is the opportunity-based character it has. Therefore, the interviewees find that the qualification process should be stepwise, flexible timewise, and consist of multiple assessment moments. They find this to be especially important, as the opportunity-based character can cause the FSE to take more or less time to be able to learn certain actions or procedures.

Another main challenge that is currently present, is the balance that has to be found between providing learning opportunities whilst also achieving less machine downtime, which results in SOJT taking place in a time-pressured environment. Currently there is a lack of time

to sufficiently teach the FSEs due to priorities that lie with the customer. This leads to less training and reflection. Interviewees mentioned they need more time as the current environment slows the improvement of competence, this desire is related to creating the right conditions for SOJT to take place in. Eventually, this can lead to qualifications by proving competence being delayed.

At locations where assessment is already taking place, it is mainly a responsibility of the mentor to perform this. The mentor decides on an FSE's readiness, but also qualifies the FSE. In some occurrences, the FSE can also take initiative in indicating readiness. Hence, currently the mentor is responsible for assessment. In the desired situation the examiner is a local employee as well. A senior engineer and a mentor are preferred the most, with the senior engineer being most desired. Having the mentor to examine is not preferred by all interviewees, this is mostly due to rater bias. However, the mentor is regarded as a suitable option by others as (s)he knows the FSE and his/her capabilities best. The main reason to not opt for a non-local examiner according to multiple interviewees, is because an examiner should be independent. Lastly, rater bias could be minimized by having multiple examiners, which was suggested by a couple of interviewees. Hence, in the desired situation the examiner should still be locally based, however it is of importance to make sure he/she is also independent from the FSE. The fact that this desired is widely shared by interviewees from all locations and roles – especially by engineers – is valuable, as it implies that both the managing party, performing party, and receiving party align on this matter.

The assessment methods that are currently used most often are: observation, discussing, and using SMT. This is not too different from the desired assessment methods, but there are some footnotes to be discussed here. The interviewees find observation to be the most suitable assessment method, however they also want to make use of process data. To support the observations, they opt for checklist usage. Additionally, they highly value the provision of feedback after assessments have taken place. There is disagreement amongst interviewees when it comes to using SMT for assessment purposes. This is perceived as a challenge, as the data are based on self-assessments performed by the FSEs. However, the recent introduction of score validation in SMT can change the unreliable character the tool currently possesses. Additionally, one engineer mentioned that he thinks qualification can push the engineer to look for opportunity. SMT can support in doing so, as SMT allows engineers to track their progress and enables them to take initiative and drive their own development on what next steps in learning could be. Hence, the use of SMT for assessment seems to be a suitable option, as it

tracks process data, validation has been implemented, and it supports the engineer in taking initiative, which is something that is expected from them.

Also leading back to the desire for more structure, are the diverse qualification criteria that are currently adopted. It seems like each location runs their own show, there is no standard as to when an FSE is qualified or not. Also, the performance standards currently also vary across locations, which does not make them standard anymore. Luckily, when looking at the interviewees' desired qualification criteria for the future there is a higher level of commonality: interviewees want the FSEs to pass the qualification when they prove to have mastered at least 80% of the performance standards. The performance standards that are most desired for the hard skills relate to the periodic maintenance actions and troubleshooting. For the soft skills, they related to communication skills and customer-facing skills.

The desire is to include both hard and soft skills in the qualification, but to put emphasis on the hard skills. Some interviewees argue to include soft skills in the qualification, but exclude them from an exam. This seems like a solid option, since the FSEs attend soft skill trainings facilitated by HR that are separate from SOJT, and the focus within SOJT is on hard skills. That is also why SMT only tracks hard skills. However, there are some concerns about including soft skills in the qualification. Interviewees find soft skills to take more time to develop in general, and their development is also subject to the opportunities that arise within SOJT.

One last point of discussion, is whether the qualification process should be locally managed or not. Interviewees in favour of this argue that managing the process locally makes it easier to apply. Interviewees against this argue that there can be shortcuts. Seeing that there are currently big differences between sites and the aim of higher management to standardize, it seems the better alternative is to not have the qualification process managed locally.

It is a positive observation that for each of the aspects related to qualification within SOJT, the desires for the future seem to be more similar than the current diverse situations. This is positive because the interviewees find that qualification enables standardization (see Appendix J). And as management currently aims to standardize the SOJT process, qualification within SOJT could be very beneficial in this development.

5. Design Requirements and Design Propositions

This chapter encompasses the design requirements and design propositions used to create the solution design. Design requirements encompass what criteria the solution design shall adhere to in order for it to be feasible, accepted and effective. Design propositions are a means to an end; they provide guidance and structure in the process of creating the solution design by giving context to the solution (Van Aken & Berends, 2018). Design propositions illustrate how the design requirements can be put to practice.

5.1 Design requirements

Multiple design requirements were formulated, divided over four categories of requirements (Van Aken & Berends, 2018):

- Functional requirements, which describe the performance demands of the design;
- User requirements, which describe the specific requirements from the viewpoint of the user;
- Boundary conditions, which describe the requirements that are to be met unconditionally;
- Design restrictions, which describe the design as preferred by the VPs

The difference between boundary conditions and design restrictions is that design restrictions can be negotiable, whereas boundary conditions are non-negotiable. The design requirements are established through findings from literature, interviews, and input provided by the VPs. They are displayed Table 7.

Table 7

Design requirements

Category	*Description*
Functional requirements	The solution design shall improve the competence level of FSEs at ASML
	The solution design shall fit with the opportunity-based character of SOJT
	The solution design shall induce more standardization between locations
	The solution design shall include formative and summative assessment
	The solution design shall include measurement of hard skills
	The solution design shall include measurement of soft skills
	The solution design shall be accountable
User requirements	The solution design shall emphasise measurement of hard skills
	The solution design shall exclude soft skills from summative assessment
	The solution design shall include a local examiner
	The solution design shall include a knowledgeable examiner
Boundary conditions	The solution design shall not interrupt regular business for the customer of ASML
	The solution design shall enable FSEs to be qualified within SOJT
	The solution design shall produce valid assessments
	The solution design shall produce reliable assessments
Design restrictions	The solution design shall be free of biases
	The solution design shall include clearly defined pass/fail criteria
	The solution design shall operate under guidance of a central governing body

5.2 Design propositions

As mentioned previously, design propositions illustrate how the design requirements can be put to practice. In this research this will be done according to the CIMO-logic as used by Denyer et al. (2008). Design propositions created using this logic provide information on "what to do, in which situations, to produce what effect, and offer some understanding of why this happens" (p. 396). Table 8 displays an adapted explanation of each component of the CIMO-logic from Denyer et al. (2008). Table 9 displays the design propositions that guide the creation of the solution design in this research.

Table 8

Explanation of the individual CIMO-logic components

Component	*Description*
Context (C)	The surrounding factors (external and internal environment) and the nature of the human actors that influence behavioural change.
Interventions (I)	The interventions managers have at their disposal to influence behaviour, and how they are implemented.
Mechanisms (M)	The mechanism that is triggered by the intervention
Outcome (O)	The outcome of the intervention

Table 9

Design propositions

	Design propositions
1	In SOJT (C), formative assessment is performed (I), which stimulates a focus on learning by assessing, evaluating, and providing feedback (M), leading to improvement of competence (O).
2	In SOJT (C), multiple flexible and stepwise assessments are performed (I), making the assessments align with training schedules (M), which enables qualification within the opportunity-based character of SOJT (O).
3	In SOJT (C), inter-locational agreement on performance standards, qualification criteria, checklist usage, and mentor training (I), leads to more similarities in training and assessment (M), resulting in more standardization (O).
4	In SOJT (C), summative assessment is performed (I), which leads to summaries of performances and documentation of achievements (M), enabling qualification within SOJT (O).
5	In SOJT (C), periodic maintenance actions and troubleshooting actions are measured (I), which provides insight on performance levels (M), enabling assessment of hard skills (O).
6	In SOJT (C), communication skills and customer-facing skills are measured (I), which provides insight on performance levels (M), enabling assessment of soft skills (O).
7	In SOJT (C), SMT is used by FSEs and mentors (I), enabling stakeholders to track the progress made (M), which leads to an accountable training and qualification process (O).
8	In SOJT (C), a mentor or a senior engineer assesses the FSE (I), which enables formative and summative assessment (M), resulting in assessment being performed by a local examiner (O).
9	In SOJT (C), a mentoring program or examiner program is implemented (I), which improves training, mentoring, assessment, and evaluation skills (M), resulting in a knowledgeable examiner (O).
10	In SOJT (C), assessments are not bound to specific timing (I), leading to a flexible assessment process (M), resulting in business continuity for customer of ASML (O).
11	In SOJT (C), assessment is performed with the right measurements in place whilst also providing feedback (I), which stimulates further learning and a supportive learning context (M), resulting in valid assessments (O).
12	In SOJT (C), multiple individual-referenced assessments are performed whilst diversifying with observation and using process data as assessment methods (I), which stimulates similar assessment results when assessment is repeated in comparable situations (M), resulting in reliable assessments (O).
13	In SOJT (C), multiple and independent examiners use checklists when performing assessments (I), which enhances consistency and reliability (M), minimizing the level of bias present in assessments (O).
14	In SOJT (C), qualification is managed by a central governing body (I), which enhances consistency (M), and so enables retainment of standardization (O).

6. Solution Design

In this chapter, the solution design of this research is presented. The main purpose of the solution design, is that it will result in the realization of the opportunity. In this research, it is a process through which the FSEs of ASML can be qualified within SOJT. Van Aken and Berends (2018, p. 99) mention: "The solution design is not an end, but a means to create performance improvement." They also mention that the relationship between the new situation and the current situation should become visible with the solution design. That is why in this chapter the solution design will also be validated on feasibility, acceptance, and educational impact, amongst others.

Idealized design is the method that was chosen for the creation of the solution design. With idealized design, an 'ideal' solution is designed whilst keeping technical, economical, and social viewpoints in mind. Hence, 'ideal' refers to the ideal situation without taking change management problems into account, for example (Van Aken & Berends, 2018). Idealized design fits the character of this research, as it focuses on a desired situation that does not exist yet; an opportunity. Once the ideal design has been finalized, the next step is investigating to what extent it can be implemented in the current situation. The outcome of this investigation is described as the validation of the solution design in this chapter.

6.1 Qualification process

A process has been developed through which the FSEs of ASML can be qualified within SOJT. It has been designed according to the design requirements and design propositions, which resulted in a process that is grounded in literature and based on findings from the interviews. The process consists of three phases, and its distinctive elements are described according to the curriculum spider web (Van den Akker, 2007) in this section. A visualization of the process is displayed in Figure 6, and a summary of the process is displayed in Table 10.

6.1.1 Rationale

The qualification process exists to enable qualification within SOJT. Higher management wants all FSEs to learn in the same way within SOJT worldwide. Qualification within SOJT requires standardization, thus qualification within SOJT makes it possible to meet higher management's aim for standardization.

Furthermore, the qualification process meets the three drivers mentioned by the VPs. These are to manage service capability per site, region, and globally; to motivate engineers to

develop, grow, and be the best they can be; and to demonstrate service capability and quality towards customers consistently.

6.1.2 Aims and Objectives

Qualification within SOJT means the FSEs are learning towards two goals: improving competence on the one hand, and proving competence on the other hand. This is because the objectives of SOJT and qualification. The objective of SOJT is to improve competence, and this can be done by determining learning needs and shaping further learning (formative assessment) (ARG, 2002; Harlen, 2006; Looney, 2011; OECD, 2005).

The objective of qualification is to prove competence, this can be done by documenting achievements (summative assessment) (Harlen, 2006). Documenting achievements is necessary to verify if the FSE meets the requirements for qualification; the qualification criteria and the performance standards. The interviewees have disclosed a qualification criterium they highly value, which is for FSEs to have mastered at least 80% of the performance standards in order to be qualified. The desired performance standards to be included in the qualification process are described in section 6.1.3.

6.1.3 Content

It is essential that the job performance standards included in the qualification process include both hard skills and soft skills, as they are complementary and both cause significantly increased productivity (Balcar, 2016) and they are considered to be equally important (Nguyen, 1998).

The interviewees also wish to include hard skills and soft skills, but they do have some desires about how to go about this. They want to emphasise the importance of hard skills by measuring them through both formative and summative assessment. Hence, within the qualification process hard skills are measured through both assessment methods. The hard skill performance standards they find most important to include in the qualification are periodic maintenance actions and troubleshooting.

The interviewees want to exclude soft skills from summative assessment. This has multiple reasons. Firstly, summative assessment focuses on hard skills as they are easier to measure and assess (Balcar, 2016). Secondly, soft skills are difficult to measure through summative assessment as they evolve through relationships (Balcar, 2016; Murti, 2014) and take longer to develop. This makes them difficult to assess in a final exam as this is a single point in time. Hence, within the qualification process soft skills are only measured through

formative assessment. The soft skill performance standards the interviewees find most important to include in the qualification are communication skills and customer-facing skills.

6.1.4 Learning activities

Within the qualification process FSEs should take responsibility for their own learning process in order to be qualified. By engaging in self-assessment (Kibble, 2017) via SMT, the FSE can critically reflect on his/her process and progress made (Choi et al., 2015) and take initiative on what next steps in learning should be together with the mentor. Furthermore, the FSE can take initiative by indicating his/her readiness to qualify to the mentor. Having the opportunity to steer their learning process may motivate FSEs to take more initiative.

6.1.5 Trainer role

Within the qualification process the mentor is responsible for formative assessment, which means s/he is responsible for the assessments that take place during the learning process (Harlen, 2006; Looney, 2011; OECD, 2005). The mentor is the right person to examine in this specific part of the qualification process, as (s)he has a fundamental relationship with the FSE (Jacobs, 2003). This allows the mentor to improve the FSE's competence by assessing the FSE's current position, determining next steps in learning, and providing productive feedback.

However, the importance of providing feedback has become bigger as now the aim is not only to improve competence, but to prove it as well. It is of utmost importance that productive feedback is provided so the FSE knows which competences should be improved in what way, to successfully prove competence and be qualified in the future. Provision of feedback is relevant for both formative and summative assessment, however the mentor is not responsible for summative assessment. More information on feedback after summative assessment is provided in section 6.1.8.

6.1.6 Location, Materials and Resources

The qualification process focuses on qualification within SOJT. Hence it will take place at the customer site, on the machines of ASML and in the real work context. This means the tools and resources used by the FSE during assessment are the same ones s/he will use once s/he is qualified, and that the challenging environment in which SOJT takes place will not be altered.

Of course SMT, the tracking system, will also be used as an additional resource to guide the mentor and the FSE during the SOJT and qualification process (Ahadi & Jacobs, 2017; Jacobs & Bu-Rahmah, 2012; Levine, 1996; Orser, 2001). Please refer to section 6.1.4 to learn

how. Materials used by the examiners during assessments are standardized checklists. Please refer to section 6.1.8 and 6.1.9 for more information on standardized checklist usage.

6.1.7 Grouping and Time

As mentioned previously, the mentor-mentee relationship is fundamental (Jacobs, 2003) because it takes place in a one-on-one situation (Ahadi & Jacobs, 2017; Choi et al., 2015). However, seeing the FSEs of ASML have multiple mentors and the fact that this cannot be easily changed, this is something that must be taken into account in the qualification process. Therefore, each mentor should perform formative assessments and the results from formative assessment should be handled in the same way to assure consistency. Please refer to section 6.1.9 for more information on this matter.

Sequence and timing

Timewise, the qualification process needs to be flexible and stepwise and consist of multiple assessments to match the opportunity-based character of SOJT at ASML. Earlier it was stated that summative assessment should only focus on measuring hard skills. Yet, not every hard skill can be assessed in a final exam (summative assessment) due to the opportunity-based character. Hence, continuous formative assessments are not only needed to shape further learning and improve FSEs' competence levels, but to document achievements and qualify FSEs as well. This can be done by using the data gathered in formative assessments for summative purposes (Crooks, 2001; Stobart, 2006). Therefore, a standardized way for handling the data from formative assessments should be implemented, as was just mentioned. Using process data requires summarizing and objectively judging data. Harlen (2006) justly argues that the reliability of formative data should be assured. The reliability of the data is partly assured through the standardized checklists, but the examiners should have a standardized way for handling the data from formative assessment as well.

Before being able to go to the final exam and be summatively assessed, the FSE needs to receive the mentor's approval. Hence, it is up to the SOJT mentor to decide when the FSE is ready for the next step in the qualification process. The mentor informs this decision by using the data gathered through formative assessment. During the training process, the mentor and the FSE approach the qualification criteria and performance standards in a process-based way by means of continuous formative assessments. When the mentor believes the FSE sufficiently meets the qualification criteria and performance standards, the FSE can take part in the final exam. As mentioned in section 6.1.4 the FSE can take initiative in and responsibility for their own learning process by for example indicating their readiness to qualify. However, the mentor

should always approve of this. In case the mentor does not give the FSE approval yet, SOJT continues until the mentor perceives the FSE to be ready for qualification. The same applies to the final exam; in case the FSE fails to prove competence in the final exam, (s)he will continue SOJT to further improve competence.

After the FSE has completed SOJT and attended his/her final exam, there will be an abundance of data available. Therefore, the results from formative assessment (process data) and the results from summative assessment (the final exam) should be taken together to evaluate if the FSE meets the qualification criteria and performance standards and if nothing has been missed. Namely, this might happen because of the challenging environment in which SOJT takes place. Therefore, this final check should take place. If the FSE meets all requirements, (s)he will be qualified, if the FSE does not yet, (s)he will continue SOJT to further improve his/her competence. Note the importance of feedback here. Interviewees made no comments on who should do the final check. However, seeing the aim is to standardize an independent party seems to be the best fit.

6.1.8 Assessment

Assessment method

Within the qualification process both the formative and summative assessments are performed by observation supported by standardized checklists (Ahadi & Jacobs, 2017; Levine, 1996; Molnar & Watts, 2002). The checklists must be standardized in order to ensure consistent data gathering and the qualification's reliability.

Examiners

As mentioned in section 6.1.5 the mentor will be the examiner during the whole process of conducting formative assessments. The final exam (summative assessment) will be examined by a senior engineer working at the same location as the FSE to be assessed, but who is also independent from him/her. This has two reasons: firstly, having two examiners increases the reliability of the qualification process (Van Der Vleuten, 1996). Secondly, a second examiner can release pressure from the SOJT mentor, since a dilemma for mentors is "how to play the roles of both facilitator and examiner" (Stobart, 2006, p. 140). Knowing they do not have the final say in the qualification process might support mentors in providing feedback and being a supportive trainer, which are crucial aspects in strengthening the validity of formative assessment (Stobart, 2006).

Feedback

In section 6.1.5 the importance of providing feedback after assessment was discussed, so FSEs know how to improve to become qualified in the future. However, in case an FSE successfully proves competences and becomes qualified after summative assessment, productive feedback is important as well. The provision of productive feedback after summative assessment can be considered as the formative element of summative assessment, and this feedback should be provided by the examining senior engineer accordingly. This shows that formative and summative assessment reinforce each other and are sometimes intertwined. This is in line with the remark Harlen (2006) made, saying that the same assessment can be both formative and summative, because it all depends on how the data is used.

6.1.9 Accountability

Global process owner

By appointing a global process owner to manage the qualification process, more structure can be brought to both SOJT and the qualification process, whilst also standardizing the processes and assuring quality of training and assessment. To achieve this, the global process owner should:

- Implement a standardized way of working within both processes;
- Make sure all locations adhere to these processes in the same way;
- Make sure all locations use the same qualification criteria and performance standards;
- Implement mentor training to improve the quality of mentoring;
- Implement examiner training to ensure assessments are being performed in the same way;
- Monitor the qualification process on its reliability and validity and implement changes if necessary

Reliability and validity

The last bullet is important since reliability and validity form the basis of an assessment's quality. Hence, they are essential to the quality of the qualification process as well. The reliability of the qualification process has been ensured in multiple ways when designing the solution design:

- Combining formative and summative assessment increases the reliability of the overall qualification process, as assessment results are not affected by fluctuating day-to-day performance and specific content assessed in the final exam;

- Combining formative and summative assessment allows better generalising and can lead to more meaningful conclusions (Black & Wiliam, 2006b; Hays et al., 1995; Schuwirth & van der Vleuten, 2019; Van Der Vleuten, 1996);
- As qualification process is flexible and contains multiple assessments it can adapt to each FSEs' individual needs (Black & Wiliam, 2006b);
- Implementing mentor and examiner training and using standardized checklists enhances reliability, as it makes attendees and examiners learn to train and assess alike and as intended (Stobart, 2006);
- Implementing a standard way of working within the qualification process enhances reliability (Black & Wiliam, 2006b)

Validity is attained as the qualification process is aimed at both proving and improving competence by conducting on-job formative assessments that aim to take place in a supportive learning context where productive feedback is provided (Hassanein et al., 2021). Hereby, the qualification process aims at leading to further learning, which is the main validity argument of formative assessment (Stobart, 2006). Validity of summative assessment is attained as the assessments will be performed on the job within SOJT, meaning the competences assessed will be relevant and assessed correctly, as they are part of the daily work of FSEs (Stobart, 2006) and examiner training is to be implemented.

Accountability and consistency

As mentioned in Chapter 3, accountability and consistency are important to assure quality of training and qualification within SOJT. In the qualification process accountability is attained by having both mentors and FSEs use the tracking system SMT (Ahadi & Jacobs, 2017; Jacobs & Bu-Rahmah, 2012; Levine, 1996; Orser, 2001).

Within the qualification process consistency is attained by implementing mentor training and examiner training, the periodic maintenance actions being mostly standardized, the documentation of the qualification process through this research, and the use of standardized checklists, and documenting achievements in a standardized way (Ahadi & Jacobs, 2017; Choi et al., 2015; Levine, 1996; Molnar & Watts, 2002).

This is especially important, because in order to use results from the training process (formative assessment) for assessment purposes the data must be accountably and consistently gathered. Moreover, accountable and consistent data gathering may lead to higher quality training and assessment.

Figure 6

Qualification process for qualification of FSEs within SOJT

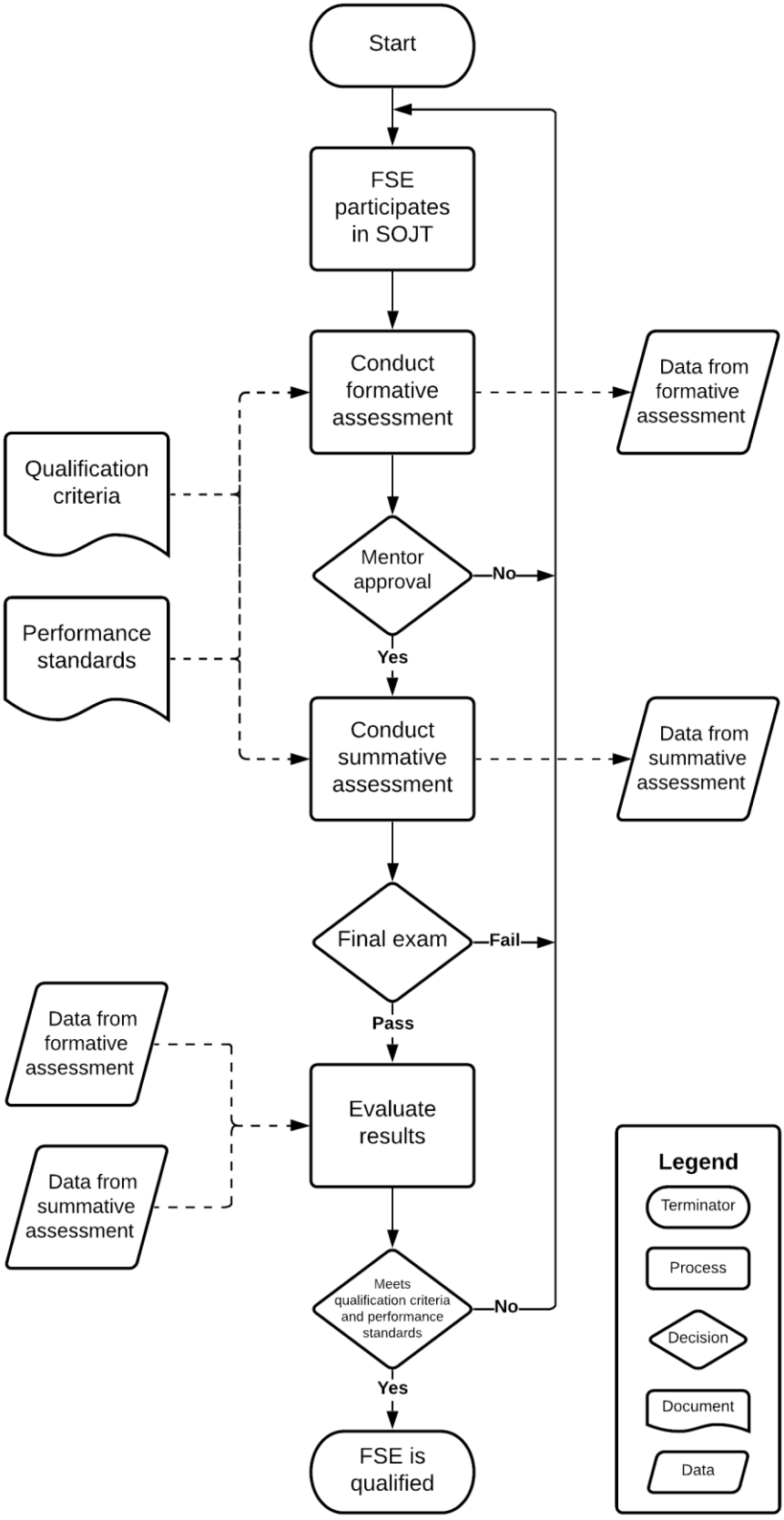


Table 10

Summary of qualification process

Phase	*Aims and Objectives*	*Content*	*Learning activities*	*Examiner*	*Assessment method*	*Location*	*Materials and Resources*
Formative assessment	Improve competence	**Hard skills** • Periodic maintenance actions • Troubleshooting **Soft skills** • Communication skills • Customer-facing skills	• Learn • Self-assessment • Reflect • Take initiative	**Mentor(s)** • Conduct assessments • Provide feedback • Give approval	Observation supported by standardized checklist	Local customer site	• Machine of ASML • Required tools and resources to perform action/procedure • SMT
Summative assessment	Prove competence	**Hard skills** • Periodic maintenance actions • Troubleshooting	• Demonstrate competence • Reflect	**Independent senior engineer** • Conduct assessments • Provide feedback	Observation supported by standardized checklist	Local customer site	• Machine of ASML • Required tools and resources to perform action/procedure • SMT
Evaluation of results	Final check to see if 80% of all qualification criteria and performance standards have been met	**Hard skills** • Periodic maintenance actions • Troubleshooting **Soft skills** • Communication skills • Customer-facing skills	N/A	Independent party	N/A	N/A	All data that was gathered during assessments

6.2 Validation of solution design

As this is a design research, validation means the design will be justified (Van Aken & Berends, 2018). In design research this is done by looking at the designed solution, and moving back to the design requirements to assess to what extent the design adheres to the design requirements. Validation was carried out by the manager of CS Learning, an engineer and a thesis supervisor from the organisation this research was performed at. These individuals were involved in the validation because they are all involved but have different perspectives and interests. Their opinion on the quality of the design is crucial, because as Van der Vleuten (1996, p. 55) argued: "A reliable, valid and feasible test will have a short life if it's accepted by no one". The process of justification was split up into three parts:

- A justification of the designed solution according to the elements of good assessment (Kibble, 2017; Norcini et al., 2011; Van Der Vleuten, 1996);
- A justification of the extent to which the design requirements are represented in the designed solution;
- A description of the process of analysis and design that has produced the designed solution

The designed solution revolves around assessment, hence it will be justified against the elements of good assessment. These elements are: reliability, validity, feasibility, cost effectiveness, acceptance, educational impact, equivalence, and catalytic effect (Kibble, 2017; Norcini et al., 2011; Van Der Vleuten, 1996). A brief explanation of these concepts is included in Table 11. It should be noted that perfect assessment is non-existent. Due to different factors affecting the interplay between the elements of assessment, certain elements will be more important than others (Norcini et al., 2011). Hence, there will always be a compromise between the certain elements of assessment (Black & Wiliam, 2006b; Van Der Vleuten, 1996).

Table 11

Elements of assessment

Concept	*Explanation*
Reliability	Assessment results stay alike if the assessment is repeated in a comparable situation.
Validity	The assessment measures what it is intended to measure.
Feasibility	How feasible an assessment is to conduct. Factors that influence the feasibility of an assessment in a specific context are how practical, realistic, and sensible it is.
Cost effectiveness	Asks the question of how much of an investment in time and money pays off.
Acceptance	The question if all stakeholders agree with the assessment process and results.
Educational impact	Whether the assessment motivates those who take it to prepare in a manner that profits education.
Equivalence	Assessment results will be alike when the assessment is conducted in assessment cycles or in different institutions.
Catalytic effect	Whether results and feedback from assessment prompt future learning.

Note. Adapted from Kibble (2017), Norcini et al. (2011), and Van Der Vleuten (1996).

6.2.1 Validation results

The results of the validation are summarised in this section, the complete results are included in Appendix H. In general, the validation panel would implement the qualification process as designed. In their opinion it brings structure and shows gaps in the current system: it can ‘make the S of SOJT bigger’. They find it contains exactly what is needed and shows that it is not solely the FSE who is responsible for learning.

6.2.1.1 Justification of meeting the elements of good assessment

According to the engineer, the ‘process has reliability at its heart’. Additionally, the validation panel finds the validity and feasibility to be good, as the process is very straightforward and all preconditions are aligned and present. There were some comments made about the reliability and validity, as they find the reliability to also depend on the preconditions (such as the complete set of qualification criteria and performance standards) of this process and other factors related to the process. The preconditions are yet to be developed and out of scope of this research.

Because the qualification process is straightforward and uses existing employees, the validation panel finds the process to be cost effective. They argued that the process initiates standardization, thereby enabling ASML to train FSEs in a global and standardized way. This

is expected to ease communication and sharing human resources and thereby creates ‘faster and better prepared engineers who can work independently and anywhere on the world’.

The validation panel finds that if executed well, the qualification process ‘will really be a step-up towards operational excellence preparations’. They expect it to make engineers more invested in their learning as it functions as an incentive to ‘be hungry for knowledge’. Hence, they believe the educational impact to be high. Next to this, they also believe the process to be equivalent globally as the consistency of quality is safeguarded. However, they do expect some site-to-site variations. Lastly, the panel finds the process itself to prompt future learning. However, it is expected that this will not influence the engineers’ attitude towards learning after being qualified. Therefore, they find the catalytic effect to be present within the process, but do not expect future learning to take place much.

6.2.1.2 Justification of meeting the design requirements

The validation panel finds that the qualification process meets the functional requirements, user requirements, and design restrictions well. There are some concerns about how the global process owner and qualification criteria are precisely present within the process, however, these are out of scope for this research. When it comes to the boundary conditions, there is one concern regarding the customer requirement: explanation about the process should take place. Additionally, it should be tested if extra time loss is acceptably low. However, it is expected this will be the case.

6.2.1.3 Justification of the design process

According to the validation panel the researcher has been very thorough and structured in conducting this research. They find that by stepping away from the typical research method used within the organisation, the researcher was able to get to the core and design a process that is fitting their needs and is accepted by stakeholders. Hereby, it can be concluded that this research has met the qualification criteria for problem-solving projects as described by Van Aken and Berends (2018, see section 2.4.4).

7. Conclusion and discussion

This is the final chapter of this thesis. Here the thesis is concluded; implications and limitations are discussed; and suggestions for further research are given.

7.1 Conclusion

The main purpose of this research was to investigate how the FSEs of ASML can be qualified within SOJT. To fulfil this purpose the design science research methodology by Van Aken and Berends (2018) was adopted, which led to two main research activities taking place: literature review and interviews. The seven sub-questions of this research were answered through these activities. Consequently, these induced the design of the qualification process, which forms the answer to the main research question: *How can the Field Service Engineers of ASML be qualified within Structured On the Job Training?* The key elements of the designed qualification process through which the FSEs of ASML can be qualified are described below.

Proving competence whilst improving competence

Since this research focused on qualification within SOJT, the qualification process had to comply with the objectives of both qualification and SOJT. This means the process focuses on proving competence whilst improving competence, which is put to practice through the combination of formative and summative assessment methods; the focus on learning through continuous SOJT; and the provision of feedback.

Established locally, managed globally

At the intake interviews for this research project, the VPs mentioned they want to be able to manage service capability per site, region, and globally. SOJT takes place at the customer sites, which means qualification within SOJT has to be established locally at the customer sites. In the qualification process this is put to practice by letting mentors and senior engineers examine the FSEs through observation supported by the use of standardized checklists and SMT. However, as qualification revolves around standards, the qualification process should be managed by a global process owner to ensure standardization. Because without standardization across the local customer sites worldwide, the VPs' desire to globally manage service capability cannot fulfilled.

FSEs as active participants

Another key element of the qualification process is the role the FSE has within it. Seeing the focus of the FSE should be to improve and prove his/her competence, (s)he should be

actively involved in the processes of SOJT and qualification. Additionally, the VPs wanted qualification to motivate the FSEs. Active involvement of FSEs and motivating factors in the qualification process become visible through the self-assessment FSEs perform during formative assessment; the room for initiative there is for FSEs to indicate readiness; and the use of process data in establishing qualification.

Consistently delivering quality

The final key element of the designed qualification process is aimed at consistent delivery of quality. This aim is twofold: on the one hand there is delivery of quality FSEs by qualification and on the other there is delivery of quality assessments for qualification. Delivery of quality FSEs is represented in the qualification process by using process data; performing multiple assessments; and assessing both hard and soft skills. Delivery of quality assessments is represented in the qualification process by implementing mentor and examiner trainings; standardized checklists; conducting multiple assessments with different methods; and using SMT as a tracking system. By taking these measures within the qualification process, quality can consistently be delivered to the customers of ASML. This was also one of the drivers for qualification mentioned by the VPs at the intake interviews of this research project.

The validation panel would implement the qualification process as defined. Hence, to conclude, the answer to the main research question of this research is satisfactory for the client organisation. The qualification process will be used in the development of the program aimed at qualification of FSEs within ASML.

7.2 Theoretical implications

This research provides a meaningful contribution to the literature on SOJT on three aspects. The first aspect relates to the combination of formative and summative assessment that has led to the current qualification process, enabling the FSEs of ASML to be qualified within SOJT. As Molnar and Watts (2002) have already pointed out, effective SOJT requires regular assessment of trainee progress. Additionally, Hassanein et al. (2021) found on-job skill assessment to be effective for competence development. In this research the possibility of expanding the purpose of on-job skill assessment from competence development to establishment of qualification was explored by investigating the concepts of formative and summative assessment. These concepts have been widely discussed in literature. However, combining these assessment methods has only been briefly discussed. Crooks (2001) and Stobart (2006) discussed a possible connection of formative to summative assessment. Other

than that, the two concepts are generally handled separately, as learning situations are often categorized as being either ‘learning oriented’ or ‘performance oriented’ (Watkins et al., 2001). That same categorization was made in this research, however, instead of handling the different orientations separately, they were taken together. Hence, the combination of formative and summative assessment in the qualification process contributes to the literature on SOJT as these concepts are combined instead of handled separately, as they generally are.

The second aspect relates to a lack of empirical evidence on evaluation of SOJT. To specify, only six percent of SOJT literature focuses on evaluation of SOJT (Ahadi & Jacobs, 2017). As the present research focuses on the qualification of employees within SOJT, it adds to the literature base regarding evaluation of SOJT by providing a process to qualify employees within SOJT.

The third and final aspect relates to other research areas on SOJT that are currently scarce, namely research on SOJT performed in educational and services work settings (Ahadi & Jacobs, 2017). As the present research focuses on the qualification of the FSEs of ASML within SOJT, it thereby focuses on SOJT performed in educational and services work settings.

7.3 Practical implications

The main deliverable presented in this research; the qualification process, provides the client organisation with a way to qualify their FSEs working on their machines within SOJT. Other organisations can use the process to engage in qualification via on-job assessments with a focus on competence improvement as well. Here, it should be noted that some adjustments might have to be made to fit the specifics of the organisation. For example, an individual in another job role than ‘senior engineer’ might examine the final exam.

There are some conditions to guarantee the effectiveness of the qualification process when implemented at ASML. Firstly, quality of mentoring is essential to the success of SOJT (Choi et al., 2015; Jacobs, 2003; Jacobs & Bu-Rahmah, 2012). Mentor training has been found to be effective by positively affecting mentors’ self-efficacy, competence and delivery of SOJT (Burkett, 2002; Cho, 2009). Therefore, mentor training should be implemented to improve the quality of mentoring.

Secondly, to have effective and successful qualification of FSEs within SOJT, the right conditions for SOJT need to be in place. Interviewees find there is a lack of time for training and reflection. Thus, management should allocate more time for SOJT.

Thirdly, standardized checklists should be developed to assure quality of observations (Ahadi & Jacobs, 2017; Levine, 1996; Molnar & Watts, 2002). The checklists should contain the performance standards and the way in which they should be met. A way to develop standardized checklists is by using the Delphi method (Linstone & Turoff, 2002).

Fourthly, the set of performance standards and the qualification criterium presented in this research is not yet substantial enough. Hence, ASML should investigate which performance standards and criteria they want to include in the qualification.

Fifthly, examiner training should be implemented for both the mentors and the engineers. In this training, the focus should be on explaining the concepts of formative and summative assessment; how to observe; and how to use the standardized checklist. Additionally, it may be valuable to guide the FSEs through their self-assessment. The rationale for this is that self-assessment is part of the formative assessments; both mentors and FSEs should have some knowledge about that (Jacobs, 2003). This guidance can be arranged by for example introducing explanatory texts or guiding questions that are embedded in the SMT-system, or by developing an e-learning.

Lastly, a global process owner should be appointed to standardize the SOJT and qualification processes in order to meet the aims and drivers of higher management and the CS VPs. Examples are appointing a party responsible for the ‘evaluation of results’ phase in the qualification process, bring more structure to the processes, and to assure the quality of the qualification process.

7.4 Limitations

During and after conducting the present research, both theoretical and practical limitations were established. Firstly, despite having performed search actions in multiple databases and attempting multiple search queries, the systematic literature search only yielded twelve articles that met the inclusion criteria. This can be explained by the lack of empirical research on SOJT mentioned previously. Therefore, the search results were revisited and it was decided to include literature reviews as well. These turned out to be highly informative, which partly compensates for the lack of empirical evidence. However, even after including literature reviews no information was found on tracking systems and job performance standards. Hence, there was insufficient information present on for example ways in which a tracking system should be used to optimize SOJT and qualification within SOJT, or certain categories of job

performance standards that can be applied. Having more (empirical) data available could have added more depth to the designed qualification process.

Secondly, there are some limitations and bias when it comes to the interview sample. The interviews had to be conducted via Microsoft Teams. This could have caused people to feel less safe or comfortable (Gubrium et al., 2012). Another limitation related to the interview sample is that the interview findings may not be generalisable (Gubrium et al., 2012). This is because the group of people interviewed in certain roles is relatively small compared to the amount of people working at (the customer sites of) ASML, meaning that for instance stakeholders from locations not included in the interview sample may have different opinions. However, this does not seem to be a major concern in this research, as the interview sample contains varying job roles and various locations between which people tend to agree and disagree similarly. This means that saturation has been achieved within the interview sample and leads to interview findings that are representative for the purpose of this research.

Thirdly, there are limitations to the interviews that were conducted. The engineers were interviewed in pairs due to their limited availability. This is a limitation, as it could have caused them to be less open or alter their answers as opposed to an individual interview (Gubrium et al., 2012; Van Aken & Berends, 2018). However, as Van Aken and Berends also point out, interviewing individuals together makes it more likely to receive more in-depth explanations; opinions that are really inter-subjectively shared; and insight into contrasts and analogies between individuals' opinions.

Lastly, there is the risk of interviewer bias, even though the interviewer prepared the interviews by creating the interview guides; discussing points of attention with the client organisation; and reading scientific and grey literature. Regardless, sharing personal viewpoints and asking leading questions may still have happened at times, which may have affected the answers that were given by the interviewees (Alsaawi, 2014; Boyce & Neale, 2006).

7.5 Future research

The qualification process that has been designed in this research provides ASML (and other organisations) with a way to qualify FSEs (employees) within SOJT. As mentioned in section 7.2, this research and the qualification process add to the literature on SOJT on three aspects. The qualification process is based on both theoretical and empirical findings. However, it has not been empirically tested yet. Thus, the present research can be a step-up to more empirical evidence regarding the three aspects mentioned in section 7.2. Therefore, it is

suggested to perform follow-up research by investigating the effectiveness of the qualification process presented in this research.

Naturally, the process can only be empirically tested if it has been put to practice. This is yet to be done. Hence, the strength of the process's effectiveness and its strong and weak point cannot be investigated yet. Therefore, the second suggestion for future research is ASML specific. As mentioned in the practical implications, there are prerequisites to guarantee the effectiveness of the qualification process when implementing it at ASML. Therefore, it is advisable for the organisation to conduct internal research on a number of aspects before implementing the qualification process. Because without these aspects in place, the qualification process may be less effective or even unsuccessful.

Based on the suggestions supplied in section 7.3 it is advised for ASML to start investigating how mentor training should be developed, designed, and implemented, as mentoring within SOJT is already taking place and highly relevant in the qualification process as well. In other words, starting with this may result in the highest direct impact. After mentor training has been implemented, simultaneously appointing the global process owner and reaching out to get the desired management support is desired, to start creating the right conditions for SOJT and qualification to take place in and to start enhancing the level of structure that is currently present. The third step to be taken towards implementing the qualification process should be to define the performance standards and qualification criteria, because without these assessment and qualification cannot take place. After that, the other suggestions supplied in section 7.3 will come.

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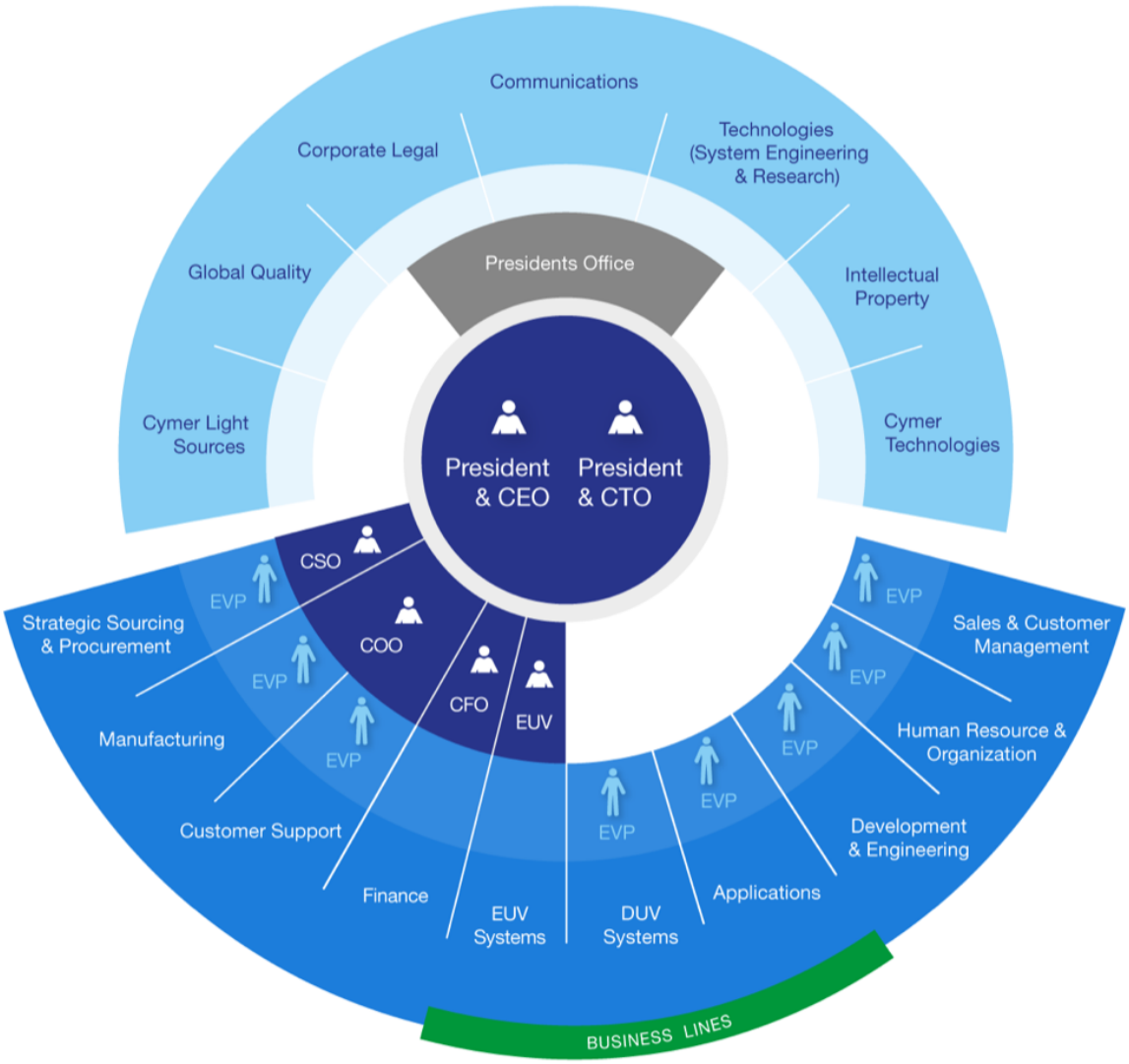
Appendices

Appendix A – ASML Organisational Structure



Appendix B – Interview guide

Questions with a bullet point in **bold**: questions to be asked
Questions in *italic*: guiding questions/follow-up questions
Checkboxes: to check whether all elements that are fundamental to SOJT are discussed

Interview guide for FSEs

Introduction

Thank you for your time. The aim of this research is to explore the possibility of creating a qualification process and possible design requirements. Before we start the interview, I want to ask your permission to record this interview, so I can transcribe it. This allows me to analyse the interview more thoroughly. All data will be handled anonymously and the recording will be deleted after the research project is finished. Do you give your permission to record?

[YES ↓ / NO →] Agree on taking notes or end interview.

Thank you. Now, please know that by agreeing to record, you are voluntarily participating in this interview. The interview will last about 30 minutes, you have the right to withdraw from participating at any time. I am interested in learning your opinions, there will be no right or wrong answers. So please, feel free to be open and honest in your answers.

RQ 5: How is SOJT currently put into practice? +

RQ 6: How and to what extent are the fundamental elements currently present within SOJT?

First, I would like to learn how SOJT is currently performed at your site or to your knowledge.

- **Did you attend SOJT already?**
- **Can you describe what a typical SOJT-day looks like for you? What do you do in a typical SOJT day?**

  Before training

  ☐ *Were the learning objectives clear to you before training?*

  During training

  ☐ *How is the mentoring structured? E.g. one or multiple mentors, assigned mentors or random colleagues, no mentoring yet.*
  ☐ *Which training materials are present for SOJT?*
  ☐ *How and how much is feedback provided to you?(also after training?)*

  After training

  ☐ *How do you and your mentor secure you have learned? E.g. use of observations, results, checklists, tracking/record system. How often? Which one(s)? What do you use them for?*
- **How does SOJT affect your performance?**

  How do you notice that? E.g. during training, during work.

- **How does management currently support SOJT? Please provide concrete examples.**

RQ 7: Which fundamental elements are needed to establish qualification of FSEs within SOJT, and how should they be represented?

- **What is needed for you to obtain a qualification (think of it as a diploma) as FSE during your SOJT?**
  - ☐ Mentor
    What should the role of the mentor look like in a qualification process for FSEs? Think of e.g. preparation for the examination, the examination itself.
  - ☐ FSE
    What should your role be in the qualification process? E.g. only participating, or carry responsibility as well?
  - ☐ Shift lead/knowledge manager
    What should the role of shift leads and knowledge managers be in the qualification process?
  - ☐ Assessment and tracking/record system
    What is needed to qualify FSEs during their regular work activities?
    How often should assessment take place?
    Who should examine FSEs?
    What resources are required? E.g. checklists, examiners, time, tracking system.
  - ☐ Job performance standards
    Job performance standards are essential for qualification, they are what the assessment and hence qualification is based on.
    How should these standards be communicated to FSEs?
    How should these standards be used for pass/fail? Where would you set the boundary for pass/fail?
    How would you say the ratio between hard and soft skills should be?
    Hard skills = cognitive factors and motor skills
    Soft skills = affective factors, personality traits, social skills

    Which hard skills are most important to qualify?

    Which soft skills are most important to qualify?
  - ☐ Management support
    What support would you as an FSE, being qualified within SOJT, need from management?

Completion of interview

We have now come to the end of our interview. Thank you very much for your time and answers. Your contribution really helps my research and increases the possibility of a feasible and complete design for a qualification process. In case any more information or ideas come to mind, please email me. Every contribution is valuable.

I will transcribe the interviews and send you those results as soon as possible.

Once again, thank you and enjoy the rest of you day!

Interview guide for shift leads and knowledge managers

Introduction

Thank you for your time. The aim of this research is to explore the possibility of creating a qualification process and possible design requirements. Before we start the interview, I want to ask your permission to record this interview, so I can transcribe it. This allows me to analyse the interview more thoroughly. All data will be handled anonymously and the recording will be deleted after the research project is finished. Do you give your permission to record?

[YES ↓ / NO →] Agree on taking notes or end interview.

Thank you. Now, please know that by agreeing to record, you are voluntarily participating in this interview. The interview will last about 30 minutes, you have the right to withdraw from participating at any time. I am interested in learning your opinions, there will be no right or wrong answers. So please, feel free to be open and honest in your answers.

RQ 5: How is SOJT currently put into practice? +

RQ 6: How and to what extent are the fundamental elements currently present within SOJT?

First, I would like to learn how SOJT is currently performed at your site or to your knowledge.

- **Shift lead: Can you describe what a typical SOJT-day looks like for you? What do you do in a typical SOJT day?**
- **Knowledge manager: Can you describe what your role in a typical SOJT-process looks like?**

Before training

- ☐ *Were the learning objectives clear to you before training?*

During training

- ☐ *Is there a mentor community?*
- ☐ *How is the mentoring structured? E.g. one or multiple mentors, assigned mentors or random colleagues, no mentoring yet.*
- ☐ *How is the SOJT process structured? What do you mean by structured, what specifically is structured.*
- ☐ *Which training materials are present for SOJT?*
- ☐ *How and how much is feedback provided to FSEs and mentors?(also after training?) Is there a train-the-trainer program?*

After training

- ☐ *How do you secure FSEs have learned? E.g. use of observations, results, checklists, tracking/record system. How often? Which one(s)? What do you use them for?*

- **How does SOJT affect FSE performance?**
  How do you notice that? E.g. during training, during work, in results.
- **How does management currently support SOJT? Please provide concrete examples.**

RQ 7: Which fundamental elements are needed to establish qualification of FSEs within SOJT, and how should they be represented?

- **What is needed for FSEs to obtain a qualification (think of it as a diploma) during SOJT?**
  - ☐ Mentor
    What should the role of the mentor look like in a qualification process for FSEs? Think of e.g. preparation for the examination, the examination itself.
  - ☐ FSE
    What should the role of FSEs be in the qualification process? E.g. only participating, or carry responsibility as well?
  - ☐ Shift lead/knowledge manager
    What should your role be in the qualification process?
    How important is qualification of FSEs within SOJT for you?
  - ☐ Assessment and tracking/record system
    What is needed to qualify FSEs during their regular work activities?
    How often should assessment take place?
    Who should examine FSEs?
    What resources are required? E.g. checklists, examiners, time, tracking system.
  - ☐ Job performance standards
    Job performance standards are essential for qualification, they are what the assessment and hence qualification is based on.
    How should these standards be communicated to FSEs?
    How should these standards be used for pass/fail? Where would you set the boundary for pass/fail?
    How would you say the ratio between hard and soft skills should be?
      Hard skills = cognitive factors and motor skills
      Soft skills = affective factors, personality traits, social skills
    Which hard skills are most important to qualify?
    Which soft skills are most important to qualify?
  - ☐ Management support
    What support would be needed from management to successfully qualify FSEs within SOJT?

Completion of interview

We have now come to the end of our interview. Thank you very much for your time and answers. Your contribution really helps my research and increases the possibility of a feasible and complete design for a qualification process. In case any more information or ideas come to mind, please email me. Every contribution is valuable.

I will transcribe the interviews and send you those results as soon as possible.

Once again, thank you and enjoy the rest of you day!

Interview guide for the CS VP and manager of CS learning

Introduction

Thank you for your time. The aim of this research is to explore the possibility of creating a qualification process and possible design requirements. Before we start the interview, I want to ask your permission to record this interview, so I can transcribe it. This allows me to analyse the interview more thoroughly. All data will be handled anonymously and the recording will be deleted after the research project is finished. Do you give your permission to record?

[YES ↓ / NO →] Agree on taking notes or end interview.

Thank you. Now, please know that by agreeing to record, you are voluntarily participating in this interview. The interview will last about 30 minutes, you have the right to withdraw from participating at any time. I am interested in learning your opinions, there will be no right or wrong answers. So please, feel free to be open and honest in your answers.

RQ 5: How is SOJT currently put into practice? +

RQ 6: How and to what extent are the fundamental elements currently present within SOJT?

First, I would like to learn how SOJT is currently performed at your site or to your knowledge.

- **How does SOJT affect performance?**
- **How does management support the SOJT process? Please provide concrete examples.**

RQ 7: Which fundamental elements are needed to establish qualification of FSEs within SOJT, and how should they be represented?

- **What is needed for FSEs to obtain a qualification (think of it as a diploma) during SOJT?**
  - ☐ Mentor
    What should the role of the mentor look like in a qualification process for FSEs? Think of e.g. preparation for the examination, the examination itself.
  - ☐ FSE
    What should the role of FSEs be in the qualification process? E.g. only participating, or carry responsibility as well?
  - ☐ Shift lead/knowledge manager
    What should the role of shift leads and knowledge managers be in the qualification process?
  - ☐ Assessment and tracking/record system
    What is needed to qualify FSEs during their regular work activities?
    How often should assessment take place?
    Who should examine FSEs?
    What resources are required? E.g. checklists, examiners, time, tracking system.
  - ☐ Job performance standards
    Job performance standards are essential for qualification, they are what the assessment and hence qualification is based on.

How should these standards be communicated to FSEs?
How should these standards be used for pass/fail? Where would you set the boundary for pass/fail?
How would you say the ratio between hard and soft skills should be?
Hard skills = cognitive factors and motor skills
Soft skills = affective factors, personality traits, social skills
Which hard skills are most important to qualify?
Which soft skills are most important to qualify?

- ☐ Management support
  How should you as part of management support the qualification of FSEs within SOJT? E.g. what resources should be provided, what support would FSEs need.

Completion of interview

We have now come to the end of our interview. Thank you very much for your time and answers. Your contribution really helps my research and increases the possibility of a feasible and complete design for a qualification process. In case any more information or ideas come to mind, please email me. Every contribution is valuable.

I will transcribe the interviews and send you those results as soon as possible.

Once again, thank you and enjoy the rest of you day!

Interview guide for the program owner of SOJT

Introduction

Thank you for your time. The aim of this research is to explore the possibility of creating a qualification process and possible design requirements. Before we start the interview, I want to ask your permission to record this interview, so I can transcribe it. This allows me to analyse the interview more thoroughly. All data will be handled anonymously and the recording will be deleted after the research project is finished. Do you give your permission to record?

[YES ↓ / NO →] Agree on taking notes or end interview.

Thank you. Now, please know that by agreeing to record, you are voluntarily participating in this interview. The interview will last about 30 minutes, you have the right to withdraw from participating at any time. I am interested in learning your opinions, there will be no right or wrong answers. So please, feel free to be open and honest in your answers.

RQ 5: How is SOJT currently put into practice? +

RQ 6: How and to what extent are the fundamental elements currently present within SOJT?

First, I would like to learn how SOJT is currently performed at your site or to your knowledge.

- **Can you describe what a typical SOJT process looks like?**

  Before training

  □ *Are the learning objectives clear for the FSEs before training?*

  During training

  □ *How is the mentoring structured? E.g. one or multiple mentors, assigned mentors or random colleagues, no mentoring yet.*
  □ *Which training materials are present for SOJT?*
  □ *How and how much is feedback provided to FSEs and mentors?(also after training?)*

  After training

  □ *How do you and your mentor secure you have learned? E.g. use of observations, results, checklists, tracking/record system. How often? Which one(s)? What do you use them for?*
- **How does SOJT affect performance?**
  How do you notice that? E.g. during training, during work.
- **How does management currently support SOJT? Please provide concrete examples.**

RQ 7: Which fundamental elements are needed to establish qualification of FSEs within SOJT, and how should they be represented?

- **What is needed for FSEs to obtain a qualification (think of it as a diploma) during SOJT?**
  □ Program owner SOJT

What should your role be in the qualification process?
How important is qualification of FSEs within SOJT for you?

- ☐ Mentor
  What should the role of the mentor look like in a qualification process for FSEs? Think of e.g. preparation for the examination, the examination itself.
- ☐ FSE
  What should the role of FSEs be in the qualification process? E.g. only participating, or carry responsibility as well?
- ☐ Shift lead/knowledge manager
  What should the role of shift leads and knowledge managers be in the qualification process?
- ☐ Assessment and tracking/record system
  What is needed to qualify FSEs during their regular work activities?
  How often should assessment take place?
  Who should examine FSEs?
  What resources are required? E.g. checklists, examiners, time, tracking system.
- ☐ Job performance standards
  Job performance standards are essential for qualification, they are what the assessment and hence qualification is based on.
  How should these standards be communicated to FSEs?
  How should these standards be used for pass/fail? Where would you set the boundary for pass/fail?
  How would you say the ratio between hard and soft skills should be?
    Hard skills = cognitive factors and motor skills
    Soft skills = affective factors, personality traits, social skills
  Which hard skills are most important to qualify?
  Which soft skills are most important to qualify?
- ☐ Management support
  What support would be needed from management to successfully qualify FSEs within SOJT?

Completion of interview

We have now come to the end of our interview. Thank you very much for your time and answers. Your contribution really helps my research and increases the possibility of a feasible and complete design for a qualification process. In case any more information or ideas come to mind, please email me. Every contribution is valuable.

I will transcribe the interviews and send you those results as soon as possible.

Once again, thank you and enjoy the rest of you day!

Appendix C – Justification and construct validity of interview questions

Justification of interview questions

Researcher's personal justification of interview questions

First of all, 4 separate interview guides were created, because there are six different job roles in the interview sample. Therefore, Van Aken and Berends' (2018) suggestion to create interview guides for each interview was followed. Some interview guides were combined, like those for both corporate management roles.

The aim of the interview is to ensure the solution design is empirically informed by mapping the current (RQ 5+6) and desired (RQ 7) situation. The idea behind this is that by having both situations mapped, a solution design can be designed that fits the desired situation, but is not too far away from the current situation.

Introduction/Completion of interview

In the introduction and completion paragraphs of the interview guide, the informed consent and procedure of the interview are mentioned to fully inform the interviewees about the aim of the interview and to inform them about what they can expect to happen during and after the interview.

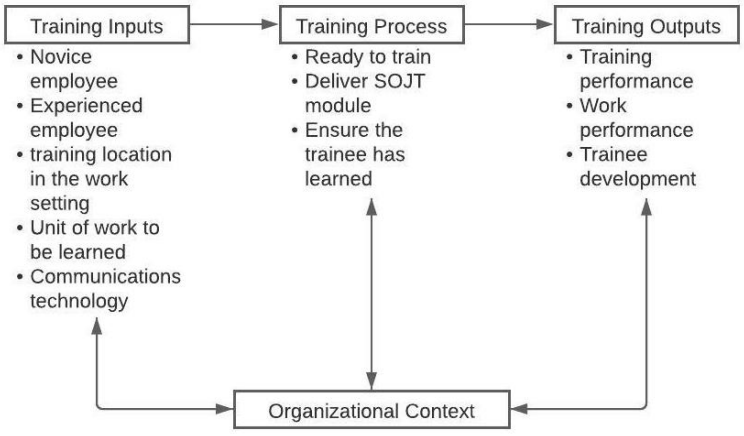
RQ 5: How is SOJT currently put into practice?

RQ 6: How and to what extent are the fundamental elements currently present within SOJT?

For the interview questions that are aimed at answering RQ 5+6, the literature of the SOJT-system (see Figure) was used, along with the findings on the fundamental elements of SOJT from literature. A distinction was made between the phases of the training process (input/process/output), and the characteristics of the distinctive phases and fundamental elements of SOJT that were found in literature have been included in these sections.

Figure *1*

The SOJT-system (Jacobs, 2003, 2014).



RQ 7: Which fundamental elements are needed to establish qualification of FSEs within SOJT, and how should they be represented?

As can be derived from the introductory part to the questions aiming to answer RQ7, the questions here are designed to derive design requirements. Therefore, all questions start with: 'How should', 'What should' or 'Which are' etcetera. This way, all interviewees will share their personal opinions, desires, or requirements. All input from the different perspectives is expected to be helpful in creation design requirements and eventually synthesizing the requirements and literature into a solution design.

Results of construct validity assessment by supervisory panel

University supervisor

		Strongly disagree	Disagree	Agree	Strongly agree
1	The interview questions aim to induce rich, specific, and relevant answers	☐	☐	☐	☒
	Comment:				
2	The interview questions are brief, but can lead to long answers	☐	☐	☐	☒
	Comment:				
3	The interview questions fully cover the SOJT-system	☐	☐	☐	☒
	Comment:				
4	The interview questions fully cover the elements that, according to literature, are fundamental to SOJT	☐	☐	☐	☒
	Comment:				
5	The interview questions aim to discover the required fundamental elements for the qualification of FSEs within SOJT	☐	☐	☐	☒
	Comment:				
6	The interview questions only have components that fit the meaning of the concepts mentioned in statements 3, 4, and 5	☐	☐	☐	☒
	Comment:				
7	The interview questions are open-ended	☐	☐	☐	☒
	Comment:				
8	The interview questions explore the creation of a qualification process from a range of different perspectives	☐	☐	☐	☒
	Comment:				

Organisation supervisors

		Strongly disagree	Disagree	Agree	Strongly agree
1	The interview questions aim to induce rich, specific, and relevant answers	☐	☐	☒	☐
	Comment:				
2	The interview questions are brief, but can lead to long answers	☐	☐	☒	☐
	Comment:				
3	The interview questions fully cover the SOJT-system	☐	☐	☒	☐
	Comment:				
4	The interview questions fully cover the elements that, according to literature, are fundamental to SOJT	☐	☐	☒	☐
	Comment:				
5	The interview questions aim to discover the required fundamental elements for the qualification of FSEs within SOJT	☐	☐	☐	☒
	Comment:				
6	The interview questions only have components that fit the meaning of the concepts mentioned in statements 3, 4, and 5	☐	☐	☒	☐
	Comment:				
7	The interview questions are open-ended	☐	☐	☒	☐
	Comment:				
8	The interview questions explore the creation of a qualification process from a range of different perspectives	☐	☐	☒	☐
	Comment:				

		Strongly disagree	Disagree	Agree	Strongly agree
1	The interview questions aim to induce rich, specific, and relevant answers	☐	☐	☐	☒
	Comment:				
2	The interview questions are brief, but can lead to long answers	☐	☐	☐	☒
	Comment:				
3	The interview questions fully cover the SOJT-system	☐	☐	☐	☒
	Comment:				
4	The interview questions fully cover the elements that, according to literature, are fundamental to SOJT	☐	☐	☐	☒
	Comment:				
5	The interview questions aim to discover the required fundamental elements for the qualification of FSEs within SOJT	☐	☐	☐	☒
	Comment:				
6	The interview questions only have components that fit the meaning of the concepts mentioned in statements 3, 4, and 5	☐	☐	☒	☐
	Comment: Because of questions 1, otherwise strongly agree				
7	The interview questions are open-ended	☐	☐	☒	☐
	Comment: only question 1 is not, did you attend SOJT, is a yes/no question				
8	The interview questions explore the creation of a qualification process from a range of different perspectives	☐	☐	☒	☐
	Comment:				

Appendix D – Role descriptions

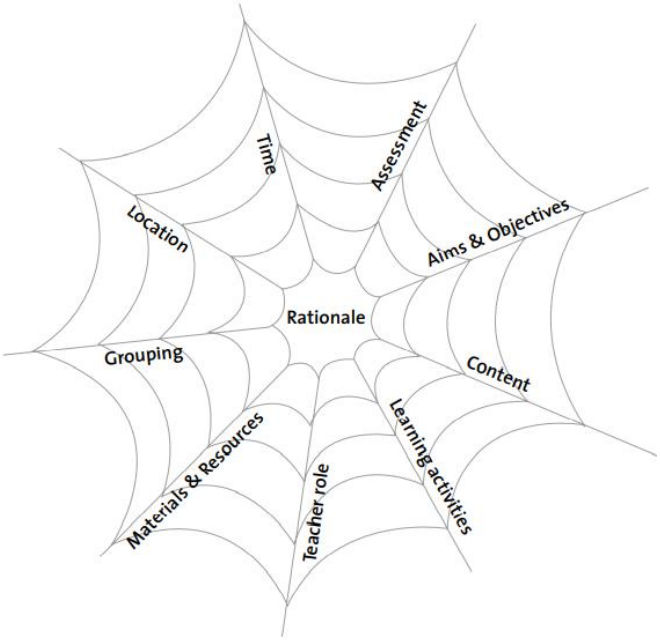
Role	*Description*
FSE	Field service engineers work in the field at the customer sites. Their main responsibility is to maintain and repair the machines
Shift lead	Shift leads work in the field at the customer sites. Their responsibility is to manage the day to day operations, contribute to skill up plans for each FSE, create the planning and assign the engineers in their shifts with tasks to work on, and contribute to the evaluation of practical skill measurement.
Knowledge manager	Knowledge managers work in the field, they have an office job. Their main responsibility is to develop the engineers by monitoring their progress and feeding them with learning opportunities (both formally and informally)
CS VP	A customer service vice president has an office job. Vice presidents are responsible for their region and work together with the other CS VPs to manage the Customer Support organisation and activities.
Manager CS learning	The manager of Customer Support Learning has an office job. He is responsible for the worldwide training centres and all learning provided to engineers in order to support the customers.
Program owner SOJT	The program owner of SOJT has an office job. He drives and coordinates the worldwide development of SOJT and its implementation in the field with the knowledge managers.

Appendix E – The Curriculum Spider Web

The curriculum spider web helps to increase the transparency and balance of curriculum analysis, development, and discussions. It does this by creating balance and consistency between the various components of a curriculum, which are displayed in the Figure and explained in the Table below.

Figure 1

The curriculum spider web (Van den Akker, 2007)



The reason the components are visualized in a spider web, is to illustrate the interconnections between them, but also its vulnerability. Each component is connected to and dependent upon the others in order for the curriculum design to be successful. Van den Akker (2007) relates the curriculum spider web to the saying ‘every chain is as strong as its weakest link’. This underlines the complexity of curriculum design.

This research focuses on qualification of FSEs within SOJT, hence on qualification that is established during the learning process. This means all aspects of the SOJT curriculum should be concrete in order to design a qualification process that is clear, concrete, and that suits the context. By applying the curriculum spider web to the SOJT-system, the interconnectedness between the elements of the SOJT-system can be made more concrete.

Table 1

Explanation of the curriculum components

Component	*Meaning*
Rationale	Why are they learning?
Aims & Objectives	Toward which goals are they learning?
Content	What are they learning?
Learning activities	How are they learning?
Teacher role	How is the teacher facilitating learning?
Materials & Resources	With what are they learning?
Grouping	With whom are they learning?
Location	Where are they learning?
Time	When are they learning?
Assessment	How to measure how far learning has progressed?

Appendix F – Applied codes

Category	*Code*	*Description*	*Example*
Current engineer activities	Current engineer behaviour inside fab	The observable actions the engineer undertakes while inside the cleanroom	*'We just attach the senior engineer and see what they're actually doing. So, actually, the senior engineer, they are performing their job. And they would teach us when they are performing their job.'*
	Current engineer behaviour outside fab	The observable actions the engineer undertakes while outside the cleanroom	*'I send SOJT progress report every week so my manager give me the feedback for the progress.'*
	Current engineer communication patterns	Interactions the engineer has with other individuals	*'We not have so much chance to interact with the knowledge management.'*
	Currently: other trainings engineers participate in than SOJT	Other trainings or training programs engineers participate in that are not SOJT	*'in the beginning we start our CBT and our FR1 and CSTO training. So the FR1 and CSTO is our first job training, but it's in our training centre.'*
Current KM activities	Currently: KM facilitates SOJT	Ways in which the KM enables learning in SOJT by creating suitable conditions	*'And that's basically what we typically do, is feed opportunities to, if we see opportunities we feed those to the line management. And they have the opportunity to displace amongst their engineers and send them to different activities or whatever's available.'*
	Currently: KM regulates SOJT	Ways in which the KM is responsible for the learning in SOJT. This can be related to the what, how, when and evidence of learning.	*'So we have a skill management tool, SMT, and at the start, when a new hire joins ASML, he will be assigned to SMT. In SMT he can track his skills and tasks himself, what he can and can't do. If you go to training they will ask to update your SMT list, and*

			for SOJT that is exactly the same. The SOJT list is measured by knowledge managers in Spotfire. That's a reporting tool. So that's where they monitor.'
	Current KM communication patterns	Interactions the KM has with other individuals	*'So I wish KM X was more engaged with each individual engineer. When I came through in my first year and a half, I probably only talked to X only three or four times.'*
Current management activities	Currently: manager facilitates SOJT	Ways in which management enables learning in SOJT by creating suitable conditions	*'They can arrange the planning. Like, planning the junior to different machine or different feel for SOJT. They just arrange the planning, management.'*
	Currently: manager regulates SOJT	Ways in which management is responsible for the learning in SOJT. This can be related to the what, how, when and evidence of learning.	*'So two things. Common for all sectors, and the other is it must become completely end to end.'*
	Current management communication patterns	Interactions management has with other individuals	*'However, if you think about management as in higher management, no. there wasn't any really direct communication between them and me in terms of my training.'*
Current mentor activities	Current mentor arrangements	Current arrangements on how the mentoring is structured	*'We will change the mentor. Based on the competency. Because all their engineers have their good skill in a different competency. So if today's action is engineer A is good at the scanner parts I will let the new hire to follow him to do SOJT.'*

	Currently: mentor facilitates SOJT	Ways in which the mentor enables learning in SOJT by creating suitable conditions	*'during our actions there are plenty of opportunities to learn what we do, so typically I start with showing them how to do it, and then, I will have them do it under my supervision.'*
	Currently: mentor regulates SOJT	Ways in which the mentor is responsible for the learning in SOJT. This can be related to the what, how, when and evidence of learning.	*'They demonstrate. So not only does the engineer have the feel that they are capable of doing it, but they have to demonstrate their capability to their mentor. So the mentor has to go, yes, I see that you can do that. You're good to mark it off in SMT that you can perform that action by yourself without assistance.*
	Current mentor behaviour	The observable actions the mentor undertakes	*'Nobody goes into the depth of saying, hey how did you mentor these engineers. We don't go into that very much.'*
Current shift lead activities	Currently: shift lead facilitates SOJT	Ways in which the shift lead enables learning in SOJT by creating suitable conditions	*'My role in the process is just to get the people to the tool. And the people that will be able to train them, if possible.'*
	Currently: shift lead regulates SOJT	Ways in which the shift lead is responsible for the learning in SOJT. This can be related to the what, how, when and evidence of learning.	*'We just follow strictly, we just focus on which action, which service action they can. They are ready or they can start leading the action.'*
	Current shift lead challenge	A challenge the shift lead currently faces	*'So there's a balance between getting people to learn stuff and having people to get the tools back up. So you want a good balance. You don't want actions to take too long, but you still want to give*

			people the chance to learn in a non-chaotic environment.'
Current qualification procedure	Current qualification method	The way in which qualification is currently established	*'and then to verify that, we do one on one discussions with these engineers on a regular basis. Usually about a monthly basis.'*
	Current qualification criteria	Criteria that are currently used to establish when an engineer is qualified	*'We just, like, when we have enough experience to knowing the items on the list, like the thirty percent or fifty percent of the list, we are considered as a qualified engineer.'*
	Current performance standards	Things that engineers are currently being qualified on, the actions they have to be able to perform	*'In my case my manager and shift leader asses new hire by they can do basic PM action or not.'*
	SMT characteristics	Characteristics of the Skill Management Tool (SMT)	*'Even though we have a certain granularity on SMT, but the possible judgment may vary per person. So for example, because question is pretty much subjective. Like, you know, can you do this or not? He, or what is your rating on a certain action? But… this is quite in a subjective and relative.'*
Current SOJT materials	Current overview of learning objectives	Ways in which learning objectives are currently communicated to the engineers	*'You may know from X that we have created a SOJT list in SMT of an X number of procedures that we want the engineers to focus on.'*
	Current engineer usage of training materials	The types of training materials engineers currently use	*'A lot of training classes publish OneNotes to help show the engineer, this is what you're going through. And some of those OneNotes contain some pretty good information.'*

	Current mentor usage of training materials	The types of training materials mentors currently use	*'I utilize the Service Knowledge Base (SKB) pretty heavily, just for imagery. Because sometimes, you know, the part of the system that I am describing is not always available to show, so I use SKB for 3D modelling images.'*
	Current other training materials	Other training materials engineers currently use	*'I mean there are trainings such as total customer focus, and other soft skills training that's kind of HR more involved with.'*
Current SOJT process	Current way of working	The current way of working with SOJT that is happening at the local sites	*'I think it was mostly opportunity based. There were a few, I think we had a list of a few vain actions. Items that we needed to hit, but mostly it was all opportunity based. And the ones that were on the list were typically the regularly occurring scheduled actions.'*
	Current SOJT challenges	A challenge within the SOJT process that is currently present	*'There is, at least not for me, a clear mentorship. So mentor mentee system.'*
Desired engineer behaviour	Desired engineer behaviours	The desired observable actions the engineer undertakes	*'Learning demonstrating, advertising, selling themselves… Like, I can do this, see?'*
	Desired engineer characteristics	The desired characteristics for the engineer to possess	*'probably having a proactive mindset of you know, always looking for what else you can do, what you can do in order to keep going on whatever project you're working on.'*
Desired KM activities	Desired: KM facilitates SOJT	Desired ways in which the KM enables learning in SOJT by creating suitable conditions	*'It's also knowing the engineers are at a level and getting them to the level they need, and making sure they have what they need.'*

	Desired: KM facilitates qualification process	Desired ways in which the KM enables the qualification of engineers within SOJT by creating suitable conditions	*'So in the process from start to beginning is, we build their expectations. So you have one year to finish this, you're going to go through all kinds of formal training, we help them through their formal training, we help them after their formal training, the SOJT blocks.'*
	Desired: KM regulates SOJT	Desired ways in which the KM is responsible for the learning in SOJT. This can be related to the what, how, when and evidence of learning.	*'Well, I think it would be the reporting, providing the information on what the engineer knows.'*
	Desired: KM regulates qualification process	Desired ways in which the KM is responsible for the qualification of engineers within SOJT. This can be related to the what, how, when and evidence of learning.	*'So for me a key area is to engage with the engineers in routines and seeing how they are getting along, and seeing what they need. For me the key of the assessment and being involved with the assessment would be to check and verify that the development program they're working on is effective, right.'*
	Desired KM communication patterns	Desired interactions for the KM to have with other individuals	*'So a little more interaction with the shift lead is something I'm recognizing that I need to have at this level.'*
Desired management support	Desired local management facilitation	Desired ways in which local management enables SOJT and the qualification of engineers	*'But sometimes they support like, if there's a… Let's give some example of an upgrade or some collector swap. Is there not common change. So a number of engineers in SOJT stand by in the office, or stand by in Veldhoven, not always in the fab. But maybe*

	within SOJT by creating suitable conditions	*manager can ask him to go to that kind of big upgrade to get experience, something like that. If he does not get that kind of direction, he will just stand by.'*
Desired non-local management facilitation	Desired ways in which non-local management enables SOJT and the qualification of engineers within SOJT by creating suitable conditions	*'And then other than that it's allocating time and making sure it fits in with the planning. Because depending on what you're doing, right, if this assessment takes place in Veldhoven or Taiwan, or wherever it would take place, the manager would need to free up time for that engineer to attend.*
Desired local management regulation	Desired ways in which local management is responsible for SOJT and the qualification of engineers within SOJT. This can be related to the what, how, when and evidence of learning.	*'They should be applying the qualification process the same across all shifts.'*
Desired management availability	The desired availability of management to certain individuals	*'And for the direct manager to that group, I think it's important to have an openness with both the trainer and the trainee. So that they can, you know, give constructive feedback. But also that they can provide that space so that the person training feels comfortable and confident that they can learn something.'*
Desired management way of working	The desired way of working of management with regards to SOJT and qualification of engineers within SOJT	*'So then I review the skill matrix and also I check this process is well maintained or not.'*

Desired mentor activities	Desired: mentor facilitates	Desired ways in which the mentor enables SOJT and the qualification of engineers within SOJT by creating suitable conditions	*'He should be able to provide the shift lead feedback, because the engineer probably was not able to do everything within the same shift. … I think the role of the mentor is to feed back to the shift lead. The shift lead should talk with other shift leads like, hey, I miss this in my team, how can you help.'*
	Desired: mentor regulates	Desired ways in which the mentor is responsible for SOJT and the qualification of engineers within SOJT. This can be related to the what, how, when and evidence of learning.	*'And then after that person, the mentor, says, this person has seen it enough and I feel like they're ready, that person gets handed off.'*
	Desired mentor communication patterns	Desired interactions for the mentor to have with other individuals	*'So my role as a mentor would be that…I'm conversing with KM X on to what they need, where they can get that, and what their progress is. Because right now, that conversation does not even happen.'*
Desired shift lead activities	Desired: shift lead facilitates	Desired ways in which the shift lead enables SOJT and the qualification of engineers within SOJT by creating suitable conditions	*'I think shift leader, they are working with engineers, field service engineers in the shift. So then shift leaders also can support the supervisor to complete the calibration process.'*
	Desired: shift lead regulates	Desired ways in which the shift lead is responsible for SOJT and the qualification of engineers within SOJT. This	*'So the shift leader and the manager should supervise them together how all of the junior engineers are growing well or not.'*

		can be related to the what, how, when and evidence of learning.	
Desired qualification outline	Desired # of assessments	The desired number of assessments	*'And one thing we mentioned earlier is, doing multiple times with different observers. And that, it kind of takes some of the subjectivity out of it.'*
	Desired: requalification	The desire to implement requalification or not	*'Probably not every year, but every two years you have to be assessed to verify that you know how to do it.'*
	Desired location of qualification	The desire to have to qualification be done locally or non-locally	*'So the training centres, actually. They send engineers and they have a trainer doing this. The sites, from my perspective in the US, don't like that at all. They think that's horrible. They would much rather have the engineer, the best engineers at their site that they trust, do the examination. And if they say the engineer is good, then they're going to, they'll be happy.'*
	Desired qualification procedure	Desired procedures to follow or ways to work within the qualification process	*'All that stuff needs to be up front. These are your expectations. Because if you don't give them the expectations, how do they know what they need to know.'*
	Desired timing of qualification	The desired timing to have a qualification established	*'I think first three months is probation period to decide whether we accept the candidate, or new guy, or… But mostly we use it simply to pick out really extraordinary guy. So that means, it's too short to qualify the engineers capability, three months. At least one year.*

Desired way of qualifying	The desired way in which qualification is established. This is not related to assessment methods, but the level of flexibility within the whole qualification process	*'You know, a full assessment being a one time and date assessment. … But then also incorporating some kind of continuous, you know, maybe like an expectation. Like it's expected that you should be able to do this by, you know, four months whatever. But if you feel confident, maybe you had lots of opportunity to a routine action, for whatever reason. And you're like, oh yeah I think I'm ready. And if the mentor agrees you're ready, you can move it up.'*
Desired hard skill/soft skill ratio	The desired ration between hard skills and soft skills within the qualification	*'I would think in terms of routine actions, I think I would put a little more weight on the hard skills. Because that's something that they'll be doing a lot.'*
Desired pass/fail boundary	The desired boundary to be used when deciding if an engineer has passed or failed the qualification	*'I think 80 percent would be enough. In my case, our shift team work always together. So my senior or shift leader can watch me. So I think 80 percent will be great, good. Yes.'*
Desired performance standards	The desired performance standards that should be included in the qualification. This includes both hard skills and soft skills	*'I would start with the periodic maintenance actions, which are what the engineer is mostly supposed to do. It's work on the machine. And then I would say the most critical actions that the most frequently hit on the machine.'*
Desired qualification criteria	The desired criteria to be used to establish when an engineer is qualified. This touches upon the categories 'desired performance standards' and 'desired way of	*'Categorize it based on safety and other areas that are high or are big issues, and minor things can be, you can rack up one or two suggestions if you do a minor mistake. But if you do too many minor mistakes that's also a fail.'*

		qualifying', but does not relate to it one-on-one	
	Other qualification outline desires	Other desires that relate to the qualification or the qualification process, but that do not fit in a single category	*'Well, there would have to be the basic level stuff, which is kind of surface level. And then deeper dives into the tool, which, I mean, they get pretty intensive. And there'd be like level one, two, three, and I can imagine even like, level four certifications.'*
Desired examiner	Desired: local examiner	The desire to have a local employee assess the engineer	*'Yeah. I like both. I like the mentor to make sure they're really ready, but then also have another mentor or engineer to watch them at the same time or a different opportunity. Just to help with bias.'*
	Desired: non-local examiner	The desire to have a non-local employee assess the engineer	*'So if it's about that aspect, then I think they will say: that's fine, bring in someone from the training centre to watch and perform the final assessment.'*
	Other examiner desires	Other desires that have to do with examination. It could be related to the number of examiners, experience of examiners, support, etcetera.	*'We can have either multiple assessors from the rest of the team. Or, it doesn't even have to be the same incident. It could be a couple of different incidents. You know, the same action a couple times with different helpers each time.'*
Desired assessment method	Desired assessment methods	Desired ways of assessment to use. E.g. observation, questioning, use of process data or not, etcetera.	*'So, but knowledge may help you or may not sometimes. So that is the kind of fundamental question I have. So that's why not only SMT, but you also need observation from managers.'*
	Desire to provide feedback	The desire to provide feedback and the preferred way to do so	*'I think two times will be good. I think we can give the feedback at the first time. And the new hire receive the feedback the first time and improve by*

			the feedback. At the second time he can improve his percentage of the checklist.'
Desired materials	Desired assessment materials	The desired materials to use in the assessment to qualify engineers within SOJT	*'A sort of checklist that you can use to tell, yes, you performed this well, or these are things I paid attention to and you did all of them well. Or points of improvement for the next time, or… Those kinds of things, yes.'*
	Desired training machine usage	The desire to use the training machine or not	*'Because, even if we do a test in the training machine, the training machine have some different in the real machine at the customer site. So I think the test is very hard to…'*
	Desired SMT usage	The desire to use SMT or not	*'Honestly, personally, qualification via SMT cannot be tracking the, be tracked well, I think. Because the SMT includes the bunch of the skill list. As it includes very, yeah, the SMT scores cannot tell us the exact, the engineer's level very distant. Like that.'*
	Desired mentor development	The desired ways in which mentor should develop themselves or be developed	*'So having senior engineers certify requires that you have some set of demands they have to meet, right.'*
	Other desired materials	Other desired materials to be used in the assessment to qualify engineers	*'Yeah, I wouldn't integrate them together. I would actually have classes on, and I used to take them at previous employers. They would have whole classes like toast masters or teamwork classes.'*

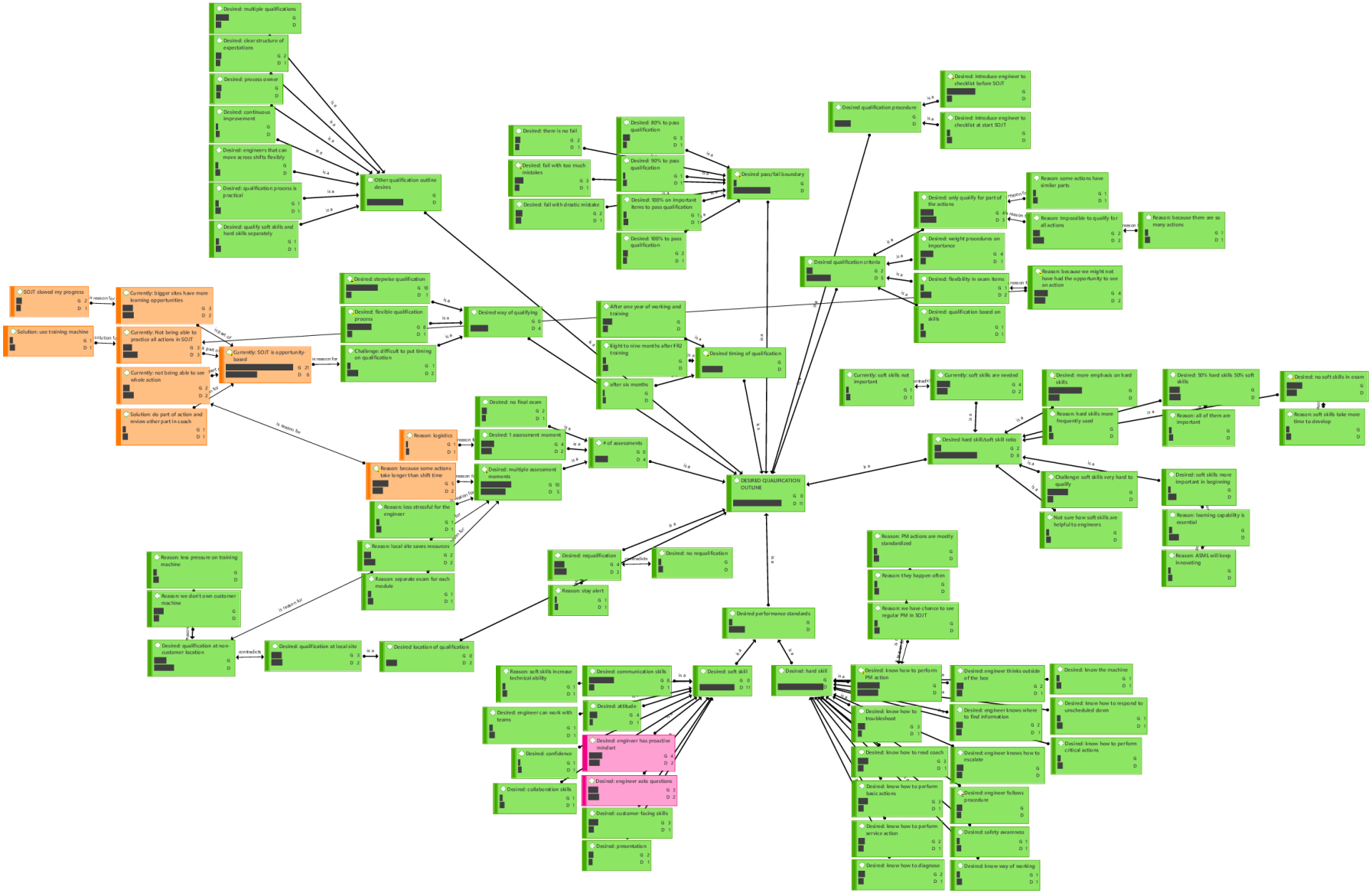
Past engineer activities	Past: engineer behaviour inside fab	The observable actions the engineer undertook in the past while inside the cleanroom	*'The mentor would sort of lead the work, and anywhere that the mentee felt comfortable, if it, you know, was a simple action pretty much following procedure, bolt turning or button clicking, the mentor would just watch over the mentee.'*
	Past: engineer behaviour outside fab	The observable actions the engineer undertook in the past while outside the cleanroom	*'Scheduled stuff would be like how to use different programs, so you're not trying to learn how to navigate a diagnostics program when you actually need to use it. So it would be like a beforehand thing in downtime.'*
Past KM activities	Past: KM facilitates	Ways in which the KM enabled learning in SOJT by creating suitable conditions	*'Previously we did not have any index of what they really needed to learn during their on site OJT. So each country's knowledge managers gather their opinions and we created SOJT procedure list in the system.'*
Past management activities	Past: local management facilitates	Ways in which local management enabled learning in SOJT by creating suitable conditions	*'Just from the group leads' feedback and the mentor's perspective and what they would feedback, yeah.'*
Past mentor activities	Past: mentor facilitates	Ways in which the mentor enabled learning in SOJT by creating suitable conditions	*'I guess most of the feedback would've been immediate, one on one with your mentor. Kind of as you're going through stuff, yeah. As far as after the fact, there was some follow up stuff. Like there's questions about why we did certain actions.'*
	Past mentor arrangements	Past arrangements on how the mentoring is structured	*'But when I joined we were officially assigned mentors. And that was, oddly enough, when we were*

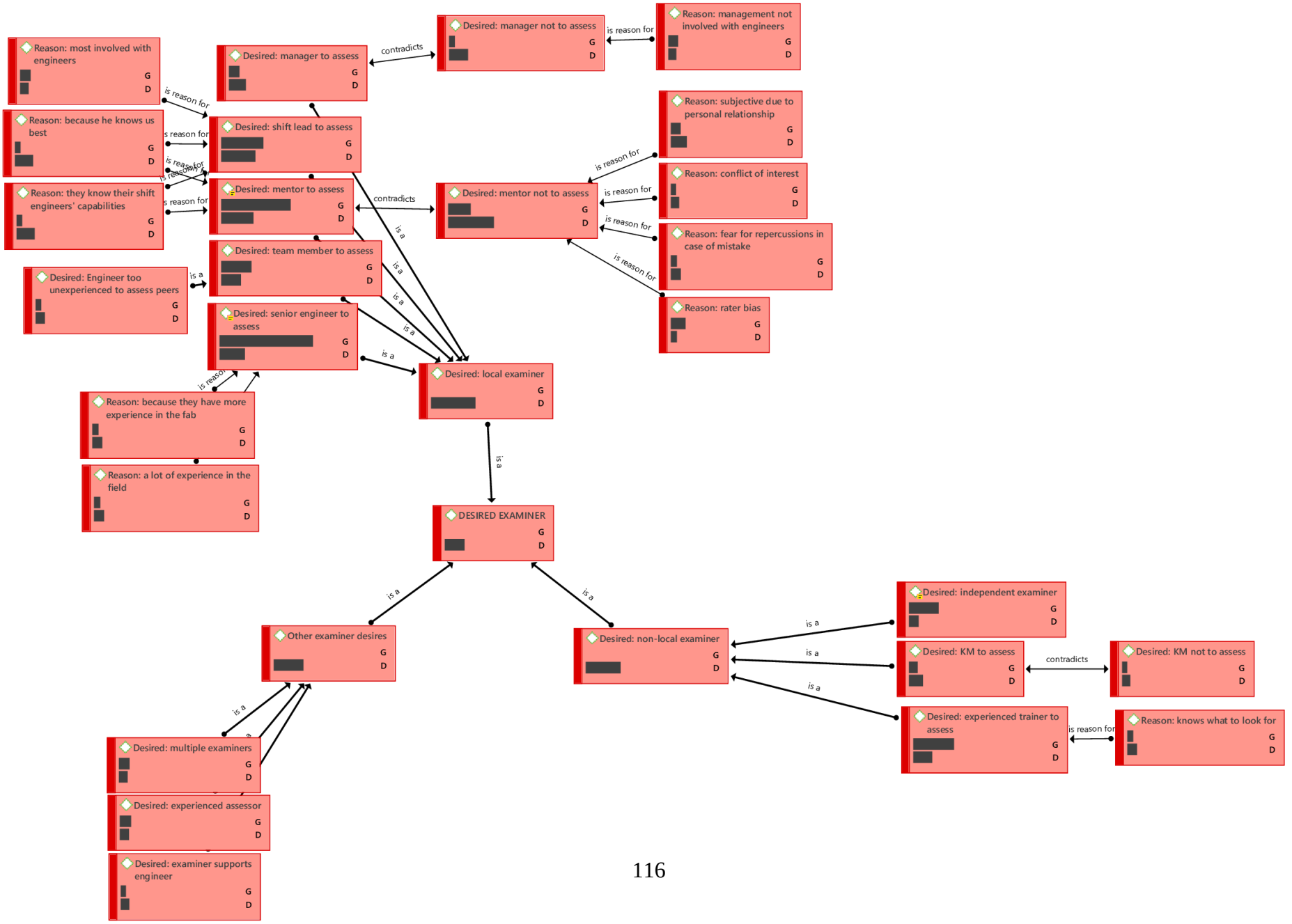
			first assigned them, I think my mentor was actually on a different shift from me.'
Past qualification procedure	Past: no assessment	No assessment was being conducted	*'Yeah, I think it was generally the mentee would shadow for the activity once or twice and then… Essentially it was kind of left to them when they would decide that they could do that action without a mentor present. Kind of whenever they felt comfortable, they would say: Oh I got it, I don't need you to come with me this time, or something.'*
	Past: self-assessment	Self-assessment was being conducted	*'I think that's been fairly left to the individual as well. Sort of your own confidence and feel comfortable doing… I'd say even now some people that we've been working with for years, some of them will say: Oh yeah I haven't really done that action in a while or ever even. So it's no real formal, I guess, you're ready, or anything like that.'*
Past SOJT process	Past: unstructured OJT	The level of structure that was present within the SOJT process in the past	*'There would be no necessary structure, I think what you learn would be mainly focused on what actually happens.'*
	Past: more influence as KM on smaller site	The influence levels that were present in the past	*'Being KM on a smaller scale, when this office was first starting, it would have four to five machines, it was easier to connect with the individuals and talk to them.'*
	Past: list with learning objectives	The way in which learning objectives were communicated to the engineers in the past	*'I think it was mostly opportunity based. There were a few, I think we had a list of a few vain actions. Items that we needed to hit, but mostly it was all opportunity based. And the ones that were on the list*

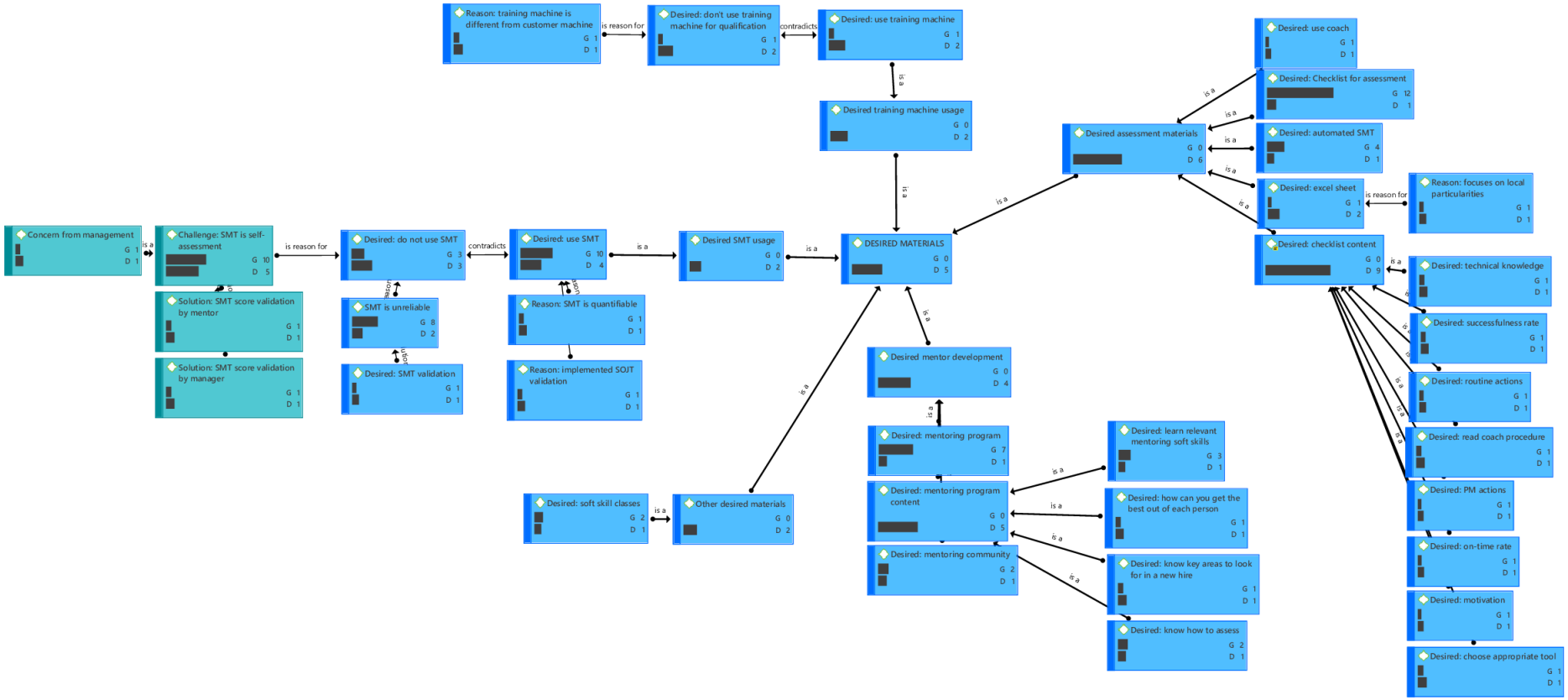
			were typically the regularly occurring scheduled actions.'
Qualification opinions	Qualification is good	Opinions that relate to qualification of engineers within SOJT as being a good thing to do	*'I think it definitely will kind of add to almost an important, not an important, but check that the engineers are learning while they're on their SOJT, they'll have to make the most. But it will kind of push the engineer to do their own work as well and look for their own opportunity.'*
	Qualification is tough	Opinions that relate to qualification of engineers within SOJT as being a tough thing to do	*'The problem I have with an assessment is, the machine is so complicated, you can't really test specific technical questions.'*
	Other qualification opinions	Other opinions on qualification of engineers within SOJT that do not relate to it either being a good or a tough thing to do	*'It's kind of like, you know, I've been in the industry for a long time, so it's all about the individual learning and having that individual drive to learn something. That's something that needs to be within an engineer. And if you have to hold their hand and describe every step of what they need to do, then they're not that investigative engineer that wants to learn. So there has to be a desire within the engineer to want to approach this. ... So there has to be a balance between the two. ... and that's what I mean by fifty-fifty in terms of, I can provide the process but the engineer has to provide the motivation.'*
SOJT opinions	Opinions on SOJT in general	Opinions on the SOJT process in general	*'For engineers, even if they completed training, if they don't have enough hands-on experience, it means they don't know how to do well. So they have a very low confidence on the activities. So their*

			hands-on activities during the SOJT is the best option for them to develop.'
	Opinion on people involved in SOJT	Opinions on the people involved in the SOJT process	*'…it would be identifying the correct person to be the trainer. So I think that's an important step. Because also you can be knowledgeable in a certain subject or a certain part of the system. It's a different story to pass that knowledge to somebody else.'*
	Opinion on SOJT timing	Opinions on the timing of SOJT	*'Because if we go into the fab for like three months, we have enough time to see the action.'*

Appendix G – Thematic analysis




Reason: most involved with engineers
Desired: manager to assess
contradicts
Desired: manager not to assess
is reason for
Reason: management not involved with engineers
is reason for
Reason: because he knows us best
Desired: shift lead to assess
Reason: they know their shift engineers' capabilities
Desired: mentor to assess
contradicts
Desired: mentor not to assess
Reason: subjective due to personal relationship
Reason: conflict of interest
Reason: fear for repercussions in case of mistake
Reason: rater bias
Desired: Engineer too unexperienced to assess peers
is a
Desired: team member to assess
Desired: senior engineer to assess
Desired: local examiner
Reason: because they have more experience in the fab
Reason: a lot of experience in the field
DESIRED EXAMINER
Other examiner desires
Desired: non-local examiner
Desired: independent examiner
Desired: KM to assess
contradicts
Desired: KM not to assess
Desired: experienced trainer to assess
Reason: knows what to look for
Desired: multiple examiners
Desired: experienced assessor
Desired: examiner supports engineer


Reason: training machine is different from customer machine
G 1
D 1
is reason for
Desired: don't use training machine for qualification
G 1
D 2
contradicts
Desired: use training machine
G 1
D 2
is a
Desired training machine usage
G 0
D 2
is a
Concern from management
G 1
D 1
is a
Challenge: SMT is self-assessment
G 10
D 5
is reason for
Desired: do not use SMT
G 3
D 3
contradicts
Desired: use SMT
G 10
D 4
is a
Desired SMT usage
G 0
D 2
is a
DESIRED MATERIALS
G 0
D 5
is a
Desired assessment materials
G 0
D 6
is a
Desired: use coach
G 1
D 1
is a
Desired: Checklist for assessment
G 12
D 1
is a
Desired: automated SMT
G 4
D 1
is a
Desired: excel sheet
G 1
D 2
is a
Desired: checklist content
G 0
D 9
is reason for
Reason: focuses on local particularities
G 1
D 1
is a
Desired: technical knowledge
G 1
D 1
is a
Desired: successfulness rate
G 1
D 1
is a
Desired: routine actions
G 1
D 1
is a
Desired: read coach procedure
G 1
D 1
is a
Desired: PM actions
G 1
D 1
is a
Desired: on-time rate
G 1
D 1
is a
Desired: motivation
G 1
D 1
is a
Desired: choose appropriate tool
G 1
D 1
Solution: SMT score validation by mentor
G 1
D 1
Solution: SMT score validation by manager
G 1
D 1
is reason for
SMT is unreliable
G 8
D 2
is a
Desired: SMT validation
G 1
D 1
is reason for
Reason: SMT is quantifiable
G 1
D 1
is a
Reason: implemented SOJT validation
G 1
D 1
is a
Desired mentor development
G 0
D 4
is a
Desired: mentoring program
G 7
D 1
is a
Desired: mentoring program content
G 0
D 5
is a
Desired: mentoring community
G 2
D 1
is a
Desired: learn relevant mentoring soft skills
G 3
D 1
is a
Desired: how can you get the best out of each person
G 1
D 1
is a
Desired: know key areas to look for in a new hire
G 1
D 1
is a
Desired: know how to assess
G 2
D 1
is a
Desired: soft skill classes
G 2
D 1
is a
Other desired materials
G 0
D 2
is a

Appendix H – Validation of solution design

Topic	*Manager CS Learning*	*Thesis supervisor*	*Engineer*
Reliability	The reliability depends on discipline with which the process is being followed, the elements are in clarity of process/relevance and completeness of criteria/training of examiners, and consistency of tracking results (globally/per region/per country/per site)	Generic process should stay exactly the same, if you dive into specific requirements/criteria, then there will be quite some fluctuation, due to the renewal of machines within ASML.	The intent of the qualification process has reliability at its heart, however, the variability in this design will end up coming from the final exam. A PM or two alone does not cover the scope of the full system.
Validity	Good, after clear definition of pass/fail criteria based on business impact (for example: safety zero fails, high cost component damages 99% pass, ...)	Validity wise it does not really measure what needs to be measured, since what needs to be measured is defined in the criteria/requirements, not in the process itself,	I have somewhat experienced this process due to how I was trained on one shift and then moved to another. While it wasn't formal, it was definitely a challenge to myself to make sure I was up to the new shift's standards. I think this formal process will bring that mindset to all SOJTs.
Feasibility	Seems straight forward and logical: so all good. Concern is available time for trainee SOJT engineers to get their hands-on experience and on the availability of trained examiners	Feasibility should be no issue, considering the fact that it is very straight forward, and the preconditions like requirements, criteria, mentors and examinators are all aligned and present. Only constraint will be time.	I think this will be a difficult area to make headway into. I, as a CSE3 in HBO, spent approximately 20 hours total out of 168 working hours outside of the fab last month. Time is extremely valuable to us and is constantly being filled with other projects by

			our site management. I foresee this as being tacked on to what we already have to do instead of formally devoting time to it.
Cost effectiveness	seems straight forward, so good	This process will help to ensure that people are trained in a global and standard way, so communication and sharing resources will be easier, and ASML has set standards of what is expected of the engineers. With this in mind, we should definitely see an increase in faster and better prepared engineers who can work independently and anywhere on the world.	I think this is very cost effective; it can be done using existing personnel along the whole KM chain and senior engineers that already train others.
Acceptance	I'm supportive, SOJT is quite new here. We need to make it more structured, to make the S of SOJT bigger. This process will add structure.	The investment will initiate a lot of discussions --> is this really needed, and there needs to be agreement on multiple preconditions like mentors and examinators, This can raise questions/discussions --> can have a negative impact on the acceptance. Local--> less people for actual work	I'm all for more structured learning, especially compared to how I was trained. My only concern is that this adds to my overall workload.

		VPs --> more FTE's per site available	
Educational impact	if executed well, it will really be a step-up towards operational excellence preparations	From an engineer’ s perspective is the process on its own not very motivational, showing multiple tests, also failing possibilities, and further not much info. It does provide a good overview of what is coming, high level.	I think that knowing there will be an assessment made by other engineers and pass/fail criteria will make SOJTs more invested in their learning. Right now there is nothing, and they know this, so there is no real incentive to be hungry for knowledge.
Equivalence	consistency of quality is mainly safeguarded by common criteria and common exams, so should be ok	Since the criteria and standards are set, and mentors are trained in the same way, and proving feedback in the same way, then it should definitely be very equivalent globally.	Site to site will vary quite a bit I think, even with top down control of the criteria and standards. This is rooted not just in culture, but also the way different customers operate. For example, TSMC routinely works on their own systems, and Intel does not.
Catalytic effect	for the engineer it is ok, for the improvement of the process/criteria/learning methodologies an overall review process needs to be added on top	The fact that it contains formative testing, is already making sure that the standard is set, so it will definitely help to continue the self learning in the future.	My gut feeling is that once SOJTs pass the mark, they will consider themselves "done" and ready for their "normal job". They will not be interested in continuing to learn further.

Topic	*Manager CS Learning*	*Thesis supervisor*	*Engineer*
Functional requirements	the design fits with the criteria, however the concerns on SOJT availability within a certain timespan as well as having sufficient well trained examiners are items to be arranged	* Due to more testing and feedback, I believe the competence level will increase. * It does not implements timings or anything else, this can really be individually implemented. * Standardization will be needed, otherwise this process is not reliant. Overall, the functional requirements are very important and are also met.	The qualification process meets the functional requirements well, with one exception. The solution design may standardize some basic knowledge between locations, but ways of working are fundamentally different at each site. You will not be able to transplant an HBO SOJT into Taiwan or Korea without some local WoW training.
User requirements	this is being met, but of course the detailing of the process/criteria/... will determine if all further underlying user requirements can be met	* In even multiple occasions. * In summative assessments, also no soft skills are tested, since they are measured in the formative assessment. * the examiner is local senior engineer, but directly working together with the engineer. so also for this, the user requirements are met. Pay attention: in my opinion, the role mentor and examiner should never be done by the same person. An senior	The process meets these user requirements well.

		engineer is either mentor, or examiner.	
Boundary conditions	the process does not guarantee timeliness of the SOJT itself for the customer, this will have to be explained to the customers and safeguarded in practice to see if the extra time loss is acceptably low. rest is ok	The valid assessment cannot be taken from the process itself, it is how strict and clear the criteria/standards are written. The rest I totally agree that the process meets the boundary conditions.	SOJT always has an impact on machine repair time, but I don't think this process will add any additional time. Otherwise the solution meets these conditions.
Design restrictions	the first two requirements are covered. when "who does what" is made a little more explicit, also the last requirement will be covered	Clearly defined pass/fail criteria are in my opinion not present, 80%, is too vague. The central governing body is very important and needs to be very independent.	As discussed, the separation of mentor and examiner removes a lot of bias from this process. I think the solution meets the design restrictions well.

Topic	*Manager CS Learning*	*Thesis supervisor*	*Engineer*
Would you implement y/n	Yes	Yes	Yes
Why?	two aspects to add to the current process: 1. after a fail in the final exam a feedback moment (including improvement actions agreed upon) needs to be formally added into the flow, before going back into an SJOT loop 2. in the final exam add observations on soft skills (pass/fail remains only on hard skills though)	Brings structure, shows gaps within our current system. It shows exactly what is needed, does both include soft/hard skills, and shows that it is not only the engineer who is responsible for the learning, but also, the team, management and customers. (higher self-sufficiency)	I would use it as designed, but I do not foresee it being implemented as designed. As mentioned before, I see this being thrust upon me without any time or structure, as ASML tends to do things. I foresee the process getting watered down from where it is now to after implementation based on past experiences with other projects in ASML. I think they would take your structure, tell me to do it, but not give me the time or resources to do so.
Opinion of process of analysis and design that has led to the design of the qualification process	Structured and well carried out, leading to the improvement proposals for ASML to work on	I think the analysis has been done very thorough, via literature and interviews. the design is completely fitting of what has been analysed. Well done!	I like this process of analysis, design, and research that went into this; a breath of fresh air compared to the typical method of just throwing out ideas in a single meeting. It showed that many engineers feel the same way about many

	things, without it being.... diluted by non-engineers.

Appendix I – Additional information literature review

Description of SOJT

The objective of SOJT is to improve organisational performance through improving employee performance. Improving employee competence with SOJT may for example result in increased productivity, better quality of production, and a decrease in time spent on projects and defect rates (Ahadi & Jacobs, 2017; Jacobs, 2003; Molnar & Watts, 2002; Orser, 2001).

Some advantages of SOJT as opposed to unstructured OJT are increased performance characteristics of the trainee in four to six times less time, two to eight times lower cost of training due to less time spent retraining, a better relationship with customers, and development of the understanding that effective training (SOJT) is an asset rather than a liability (Jacobs, 2003; Jacobs & Bu-Rahmah, 2012; Molnar & Watts, 2002).

Furthermore, research indicates that SOJT outcomes are stronger than those of unstructured OJT (Choi et al., 2015; Jeon et al., 2011). Compared to classroom training, SOJT generates higher learning motivation, learning performance, and self-efficacy (Huang & Jao, 2016). Hence, it can be concluded that SOJT is an effective training method.

Description of mentor training, and its components and methods

By appointing and training mentors, the mentoring becomes formal. Informal mentoring typically contributes to greater and more significant effects on career outcomes than formal mentoring (Ghosh, 2014; Underhill, 2006). However, Ghosh (2014) points out that with some circumstances formal mentoring programs may surpass informal mentoring.

Matching and establishing mentor-mentee relationships based on personalities may be beneficial to the effectiveness of formal mentoring. This matching can be carried out by the mentors and FSEs themselves. By doing so, the establishment of mentor-mentee relationships would be based on self-selection (Forret et al., 1996; Underhill, 2006). By incorporating informal mentoring elements like this one into a formal mentoring program, the effectiveness of the mentoring may surpass informal mentoring; as the mentoring is not only effective, but more structured as well. this could lead to more lasting and stable competence development through SOJT.

The knowledge and skills that are essential to effective mentoring and that can be trained include: coaching skills, training techniques, how to best facilitate learning, collaboration skills,

evaluation skills, and assessment methods (Cho, 2009; De Jong & Versloot, 1999; Levine, 1996; Molnar & Watts, 2002).

There are several approaches possible to train mentors in these knowledge and skills. for instance, social interactions that happen between the mentor and FSE during the SOJT process can be used as input for reflection (Cho, 2009). Or, more practically, mentors can be provided with a guide on how to perform SOJT (De Jong & Versloot, 1999). Considering what the duration of a training program for mentors should be is an important step in the creation of such a program; when evaluating the successfulness of an SOJT program, Van Zolingen et al. (2000) concluded that the program under consideration was not as successful as expected. They found there had been too limited time to sufficiently prepare the mentors, which led to mentors working with insufficient mentoring knowledge and skills.

Description of trainee characteristics

Concept	Meaning
Learning agility	"The ability to come up to speed quickly in one's understanding of a situation and move across ideas flexibly in service of learning both within and across experiences" (DeRue et al., 2012, pp. 262-263). This means that an FSE can use what he has learned in other situations to adapt to new situations more easily.
Person-job fit	Refers to whether the role of FSE fits the individual's needs, wishes and preferences, and whether the individual meets the requirements to become an FSE (Choi et al., 2015).
Self-efficacy	An individual's belief in their own capabilities to perform a task successfully (Bandura, 1994).

According to the findings of Choi et al. (2015) a trainee (FSE) with higher levels of learning agility, person-job fit, and self-efficacy is likely to develop faster or more, compared to colleagues with lower levels of these characteristics.

Examples of management support

- Training the mentors;
- Providing time to develop training materials;
- Allowing mentors time for training;
- Aligning mentors' and FSEs' work schedules;
- Appointing and training mentors that are conscious of the FSE's training needs

References used: Burkett (2002), Cho (2009), De Jong and Versloot (1999) and Jacobs (2003).

To support the mentors further and increase the attractiveness of mentoring, management should make the mentors feel appreciated and recognize their efforts to the

development of their colleagues (Ghosh, 2014). Monetary rewards are also optionable, however it should be noted that this can lead employees that are less suitable to become mentors solely for the extra money. Moreover, Choi et al. (2015) found that monetary rewards do not have significant effects on SOJT activities. They argue that the optimum scenario is for employees to become mentors based on their affinity with training and mentoring. Management should keep this in mind when facilitating SOJT.

Additional information on checklist usage

Fletcher et al. (2018) found that using checklists increases accuracy and minimizes psychological strain, but also mention that it decreased work speed. Of course, only well-designed checklists minimize psychological strain. Checklist content should be carefully decided on. For evaluative checklists, like the ones used in assessments, the content should include the competences and criteria trainees (FSEs) have to meet (Kang & Park, 2017).

When deciding to use checklists, one should decide whether the advantages outweigh the disadvantages. In the case of SOJT it is expected the advantages may outweigh the disadvantages; since checklist usage increases accuracy and consistency and minimized psychological strain (Ahadi & Jacobs, 2017; Fletcher et al., 2018), and since a case study by Jacobs et al. (1992) has proved SOJT to be efficient and financially beneficial.

Appendix J – Additional information interview results

4.1.1. Rationale

Opinions on SOJT

The general opinion the interviewees have on SOJT is that it is beneficial. This opinion was found with interviewees in all different roles and from all different locations that are in the interview sample. Most interviewees say that SOJT is crucial for engineers to get hands-on experience. Some even find SOJT to be better than formal training. However, one engineer mentioned that although he finds SOJT to be effective, he is missing some structure to it. No other interviewees have commented on lack of structure to the SOJT-process. This could imply differences in the way SOJT has been developed and implemented locally.

Quote illustrating the importance of SOJT:

"Training center cannot cover all the issues we have on our machine. And then it's very critical for them to learn from their seniors and colleagues by utilizing on the job training. And also we are working at the customer environment. Not in our premises. So customer environment may have a different setting. And different ambiance. So it's not easy for you to figure it out what they are in the beginning without any advice or guidance. So then through the structured OJT you can gather certain support to get familiar with these new setting surrounding the customer site." – CS VP

Quote illustrating the lack of structure currently present in SOJT:

"So SOJT is good, or sorry, I should say, OJT is good. So we do have our OJT, but I would say there is not much structure to it locally. But definitely OJT is, you know, you can't teach someone without them doing it." – Engineer

Higher management's aim for standardization

Quote illustrating higher management's aim to standardize the SOJT process:

"When I look at SOJT, I am pushing for it to be common for all sectors. So DUV for example had OJT, right, they left out the S. EUV started structured OJT. And what I have seen, and what I am particularly pushing for is, such a process should be common, regardless of the sector or tool." – Manager CS Learning

Opinions on qualification

Two main categories emerged in the data of all the opinions on having a qualification process. One is that qualification is good, and the other is that qualification is tough to implement. The group of interviewees that are of the opinion that qualification is good, have three arguments for this:

- Qualification enables standardization;
- Qualification enables more solid data to be shared with management and customers;
- Qualification can push the engineer to look for opportunity

The group of interviewees that are of the opinion that qualification is tough, have two arguments for this:

- There are a lot of specific customer site and system dependencies;
- Qualification is hard to standardize

The most striking observation made in the analysis of this theme, is that standardization is perceived as valuable and desired, but also as difficult to implement within the given context. The majority of interviewees, even the ones that questioned how it would be implemented in a standardized way, share the opinion that qualification is good.

Quotes illustrating the opinion that qualification is good:

"Because we have solid data to share to customer and also management can see their engineers' qualifications. So we will have the evidence to prove that our engineers have the skills. And the customer may not be able to complain anymore. And also the management, they will have a clear picture about their engineers." – KM

"And I also think an assessment, it changes the mindset of an engineer, right. So once you know there's going to be an assessment, for some engineers it kind of adds that bigger pressure. Where they really know they need to focus on something and they need to learn stuff." – KM

Quote illustrating the opinion that qualification is tough:

"I think it's tough. I think it's going to be very site dependent and system dependent. Because the different systems are different and at some sites engineers are assigned a certain type of system. Whereas our site, we have to cover all the system platforms. So it takes a little longer to get to the same level. Because there's multiple platforms to learn." – Engineer

4.1.2 Aims and Objectives

Skill Management Tool

SMT is a list containing all specific actions and procedures. FSEs fill in their SMT list on the basis of self-assessment. For each action and procedure, they fill in 'can' or 'cannot'.

Current situation regarding job performance standards

Quote illustrating how the creation of the general SOJT SMT list has provided more structure and a set of standards:

"Previously we did not have any index of what they really need to learn during their on-site OJT. So each country's KMs gathered their opinions and we created the SOJT procedure list in the system." – KM

Quote illustrating how the SOJT SMT list is used and what it contains:

"Because mostly we have SOJT SMT list that we have to learn at the first time. Like regular periodic maintenance or other action." – Engineer

Quote illustrating local sites develop additional site-specific job performance standards:

"But I did follow more of a different guide that my shift lead provided to me. And I think that he made it just in what he considers a person would have the skills to be able to be done with their training. So that was more helpful, because it was more relatable to the actions that we do in the field. Rather than just a mere checklist." – Engineer

4.1.3 Trainer role

Quote illustrating how mentors currently assess and monitor FSEs' progress:

"In our team we qualify the FSEs by the mentors. Each system module mentor, I will collect the feedback from the mentor, and they will tell me which FSE is ok or not. And if not good, just keep monitoring." – Shift lead

Quote illustrating how mentorship is currently arranged:

"We will change the mentor based on the system module. Because all the engineers have their good skill in a different system module. So if today's action is engineer A is good at the scanner parts, I will let the new hire to follow him to do SOJT." – Shift lead

Quote illustrating how mentorship was arranged in the past:

"So we would have a shift of very senior engineers, we would bring one new engineer into that shift, so we would basically, depending on what was going on in that fab, whoever the expert was, would be the mentor. Depending on their competency they would be the mentor and they would take the new engineer with them under their wing." – KM

Quote illustrating how mentors currently develop their skills:

"Not really specific to that, I would say. They will go into a call and there it will be like: 'Hey, our shift team struggled with doing this action, and we created a powerpoint on it. Here's the PowerPoint that we shared with our team.' There will be things like that, but that's probably the most. Nobody goes into the depth of saying: 'Hey, how did you mentor these engineers?' We don't go into that very much." – KM

4.1.4 Content

Desired ratio between hard skills and soft skills

Quote illustrating the importance of soft skills for engineers:

"It's in our title, CSE, customer service engineer. Soft skills definitely weight heavily as well, we're customer interface. I personally put a high value on soft skills as well as hard skills. And the combination together makes a wonderful CSE on the factory floor of the customer. Because you're representing ASML at the face, so." – Shift lead

Quote illustrating how hard skills are most important, but soft skills are needed as well:

"Yeah, it's, I would say in our job for the engineers, in my opinion it's probably around eighty percent. Eighty, maybe even higher to cognitive or motor skills. And then much less on the… It's hard to say. Much less on the soft skills, but it can be so if their soft skills are horrible though, it could really impact other stuff too." – KM

Quote illustrating why soft skills should be excluded from an exam:

"I think the soft skill like the communication need more time to prepare or training or test for a customer. And I think it cannot be these to take place in the exam." – Engineer

Quote illustrating why soft skills are hard to qualify when taking the circumstances in which SOJT takes place and the opportunities that arise into account:

"Yeah, that's kind of varied by person, too. Like, if I'm experienced in one area I might not reach out very soon because I have some ideas. But if I'm not experienced, I'll probably reach out a lot sooner because I have no idea. And knowing, yeah, how do you qualify knowing what you don't know?" – Engineer

4.1.5 Learning activities

FSE responsibilities

Quote illustrating how FSEs can take initiative in showing readiness:

"And basically at the beginning, when my training first started, first they would sometimes take the lead and then explain to me what we were doing. And then after that I would take the lead and start doing the hands-on myself. And when I started gaining more traction and more comfort with the system, then I would be more involved. I was fortunate to have a trainer who was really good and let me take initiative. He would just make sure that I was being safe and I had clear what steps to take and what to do." – Engineer

Management prepares FSEs

Quote illustrating management support provided by higher management:

"Of course, we have to give the engineers a certain overview and a background. And why we are working here. And also why we need to support the customer. And what is your position and where do you locate your position and the customer in the overall business context." – CS VP

4.1.6 Location, Materials, and Resources

Opportunity-based character of SOJT

Quotes illustrating how the opportunity-based character of SOJT is challenging for the continuity of engineers' development:

"Because, you take a small site they will probably never complete a hundred percent of the items, where a big site might be able to complete a hundred percent of the items. So there's going to be differing factors to how much you can complete of the items." – KM

"You learn as you go, currently. Hopefully find somebody that's willing to teach as well, and has time, energy. And being able to see an activity all the way through is another barrier and challenge. So, some of our activities are several days spanning several shifts. So you might see the beginning of something three or four times. But never the middle or the end, or vice versa." – Shift lead

Quote illustrating how the opportunity-based character of SOJT sometimes frustrates engineers:

"It was a little frustrating, yeah. It was just kind of like taking two steps backwards. All the knowledge you just learned, and you didn't get the opportunity to use it." – Engineer

SOJT needs more structure

Quotes illustrating reasons for the current (lack of) structure in SOJT, next to the opportunity-based character of SOJT:

"So one of the problems we face is that we don't really have someone that's formally appointed who keeps the process in place from, in the most extreme case, a new hire engineer to a fully qualified FSE." – Manager CS Learning

"There's a lack of mentoring. What I consider true training. I used to be a training coordinator for one role that I used to have back in the day. And I know what that looks like, and we do not have it." – Shift lead

"At least for myself, no. there is no structural way of giving feedback." – Engineer

SOJT takes place in a time-pressured environment

Quote illustrating the time-pressured environment from a shift lead's perspective:

"So there's a balance between getting people to learn stuff and having people to get the tools back up. So you want a good balance. You don't want actions to take too long, but you still want to give people the chance to learn in a non-chaotic environment." – Shift lead

Quote illustrating the time-pressured environment from an engineer receiving SOJT:

"I think, because we are in the customer fabrication plant, they need to release the machine to the customer. So we don't have enough time to think aloud. So we need to read the procedure after we go home and think what we just do in the work time. So I think in our on-job training we don't have enough time to think aloud." – Engineer

Quote illustrating the time-pressured environment from an engineer functioning as mentor in SOJT:

"I don't have the time to go over each individual step with them. Like right now, the way with our workload there is no opportunity to do that. There is no time to sit down with them, and being able to show them the ins and outs with that and how to utilize a tool to find what is going on with the system. I have to use my time effectively in order to, you know, I have to also get the machine up at the same time." – Engineer

4.1.7 Grouping and Time

Quote illustrating how management's attitude towards facilitating time for learning has changed:

"But I will say, in the last three to four years, we have had a little bit of a change, where line management is willing to take extra time to teach properly rather than just fix the system. So sometimes in the past they would just bring in the super experts and just fix it really quick to make the customers happy. And now we've actually worked with our customers to say it's more beneficial if we take our time and train other engineers to be able to do this as well. So we have gotten a big culture change in that aspect." – KM

Quote illustrating support desired from local management:

"Hmm… I think providing them with learning opportunities both with the correct trainer but also with the chance to get involved in the whole learning opportunities. I think that's about most that they can do. Especially being in the field, but I think that having that opportunity to get involved in those big actions make a difference. I think that I learned as much as I did because my manager was also very interested in helping me get there, wherever I needed to be." – Engineer

4.1.8 Assessment

Current perceived disadvantages of SMT

Quote illustrating why SMT is currently being perceived as a weakness:

"Even though we have a certain granularity on SMT, the possible judgment may vary per person. Because the question is pretty much subjective. Like, you know, can you do this or not? Or, what is your rating on a certain capability, on a certain action? But… this is quite subjective and relative." – CS VP

Quote illustrating that SMT does not always portray a trustworthy image of the engineer's competence level:

"We have requirements to check off SMT every month. Like, update it. But if we don't do anything new, no opportunities or anything new, but we just do the routine stuff that we've already checked off, the expectation is still that we check off new things. So we're checking off things so that we don't get backlash for not checking off new things, that we haven't actually done or are for systems that we don't actually have." – Engineer

Currently more structure to assessments than previously

In the past, there was either no assessment taking place or only self-assessment by FSEs without validation from the mentor or a manager. The following quote illustrates this:

"Yeah, I think it was generally the FSE would shadow for the activity once or twice and then… Essentially it was kind of left to them when they would decide that they could do that action without a mentor present. Kind of whenever they felt comfortable, they would say, oh I got it, I don't need you to come with me this time, or something." – Engineer

Additional information on SMT

Quote illustrating how and by whom SMT is being used in more detail:

"So we have a skill management tool, SMT. And actually at the start when an engineer first joins ASML, he or she is assigned to SMT. In SMT the engineer can keep track of their skills and tasks himself or herself, what he or she can and cannot do. When you go to training they ask you to update your SMT list, and for the SOJT SMT list we do the exact same thing. The SOJT SMT list is measured by KMs." – Program owner SOJT

Quote illustrating how SMT allows engineers to drive their own development:

"Whereas, I think with the SOJT, it really has embedded somewhere centrally within SMT what the key areas are you need to know. I think it just gives an engineer an actual path of things that they need to… So it could be that with their mentor they now can say: 'Oh, this is something I need to do on SMT.'" – KM

Using observation and checklists for assessment

Quote illustrating how observation can be used to assess FSEs:

"What I was going to say is that you would use the machine to run through and it would be a visual observation. So for me it would be a checklist or having an experienced trainer or engineer who visually assesses the person." – KM

Quote illustrating what the use of a checklist could look like in practice:

"Yes, I think that is indeed the way to go. A sort of checklist, that guides you to be able to make comments like: 'Yes, you performed that action well.' Or: 'These are the things I paid attention to, and you have performed them well.' Or points of improvement for the next time, or… Those kinds of things, yes." – Program owner SOJT

Views on using of SMT as assessment for qualification

Quote illustrating an opinion of why SMT should be used for assessment:

"So the engineer says, via that self-assessment: 'I can do this.' Then the next time the assessor comes in like: 'Hey, you say you can do this, let's see it then.' He confirms what the engineer filled in he can do. I think that is a very nice option, by the way, and practically feasible as well." – Program owner SOJT

Quote illustrating an opinion of why SMT should not be used for assessment:

"And you qualify, like a new engineer could come in and just start with everything new. Write everything and check it all off. When really, like it says you're a hundred person, but can they display the hundred percent capability in reality?" – Engineer

Desired examiner

<u>Local examiner</u>

Quote illustrating why a senior engineer should assess the FSEs:

"I do think it would be a good idea to get another senior engineer there. You know, somebody that has the most experience. And I think that that's a good way of using their time or their expertise in providing that neutral way of looking at it." – Engineer

Quote illustrating why a mentor should assess the FSEs:

"I guess the mentor could say at some point, I think you have all the skills to be able to do this on your own. And then over the course of the next three of four times they do that action, the mentor's just observing to make sure they hit every aspect of it and are fully capable… Or the actions before them they are more in a teaching role, than if they say: 'Ok, I'm going to step back.'" – Engineer

Quote illustrating why a mentor should not assess the FSEs:

"Because if I'm the trainer and I also evaluate my trainee, I don't think that there is much more benefit to it. Since I have been watching him do the same thing. I think another pair of eyes to check that is beneficial. Just because the way I see it, if I'm writing a paper for twelve hours and I try to find a mistake, I'm not going to find it probably. Because I already reread that many times. But if somebody else does that is new to looking at it, they might be able to pick it up." – Engineer

Non-local examiner

Quote illustrating why an experienced trainer should assess the FSEs:

"Oh, I think that it's a good idea given that if that's available. Because that's literally what they do, right? They train others in executing this task. So if this is something that is available to the field, then yes, that will be very beneficial." – Engineer

Stepwise and flexible qualification process

Quote illustrating what a stepwise qualification process can look like:

"Breaking it down into different steps makes it easier to measure the sub steps and say: 'Yes, you can do the first quarter of it. Let's focus on the second quarter and the third quarter. And then it allows them to be qualified in steps. Instead of it having being this single yes or no." – KM

Quote illustrating that flexibility in a qualification process is related to the timing of an exam:

"If the person who is mentoring says that they are a quick learner and they got it down in one or two times of seeing the periodic maintenance, that person, the mentor, can say: 'Hey this person is ready to be qualified.' The mentor reaches out to the qualifier and says: 'Please come qualify this person.' And then on the third, that person gets qualified. For some people it

might take a little longer. It might take five times for them. Whether that's due to only the opportunity they had to see the start of a procedure or the middle or the finish, or just the person's different. Maybe they retain information slower but they retain it longer. I mean, everybody's different, so." – Shift lead

Appendix K – The current and desired SOJT ecosystem

The current SOJT ecosystem

As mentioned in section 2.3.3, the interviewees are all stakeholders in the prospective qualification process. Since the qualification of engineers will happen within SOJT, all interviewees are part of the SOJT ecosystem. All interviewees described their current role and activities. The patterns found in the results are used to describe the current SOJT ecosystem. The positions will be described moving from a larger distance to a smaller distance to the daily SOJT-practice at the local sites.

From a larger distance, namely the central Veldhoven office, the program owner facilitates SOJT by organizing workshops with the KMs. In those workshops they can work together to develop and improve the SOJT-system further. They have already done this by writing down the competences they expect the FSEs to have within a certain timeframe, which caused the OJT to become SOJT. However, the program owner also mentioned that SOJT is still fairly new at ASML. The following quote illustrates the development from OJT to SOJT:

"The FSEs went to their first training, their second training, etcetera. But in between those trainings we did not do much, although OJT is where the FSEs learn the most. The expectations we have now written down have brought more structure. We have moved from OJT to SOJT, structured OJT. The structured has been developed together with the KMs, with the field. I think that's the power of it." – Program owner SOJT

The KMs' main activity is to regulate SOJT by monitoring engineers' progress and reporting on their findings. The main reason for the KMs to report is because their main responsibility is to develop the engineers. The reports allow them to track down knowledge gaps, feed learning opportunities to the engineers, and arrange knowledge transfers. The way the KMs currently monitor engineers' progress is by using SMT and measuring the local solving power, labour hours, and system availability. They do this for all engineers within their region.

"So I take care of all my local EUV engineers' learning path. So from the new hire engineers to the senior, including second line, engineers." – KM

The main activity management currently performs, is to monitor the engineers' progress. They do not do this by looking at direct sources like the KMs do. Rather, they look at the reports that are shared by the KMs. However, this mainly seems to be the case for higher management. Local management appears to monitor the engineers' progress more directly.

"And as far as from my local manager, it was kind of just, we had a meeting set every two weeks. And we had to provide a weekly email just kind of, how we're getting on, what we're doing during the week, what we learned, the key learnings from each week. That kind of thing."

The shift lead is currently mainly responsible for the facilitation of SOJT, not so much for the regulation. This means that in their day-to-day work, they align the planning and make sure the FSE is matched to a mentor to provide him/her with opportunities to learn and develop. In doing so, the shift leads face a challenge: to find balance between having much learning opportunities on the one hand, and having less machine downtime on the other hand:

"So there's a balance between getting people to learn stuff and having people to get the tools back up. So you want a good balance. You don't want actions to take too long, but you still want to give people the chance to learn in a non-chaotic environment." – Shift lead

The role and responsibility of the mentor and the FSE have already been described in detail. However, one thing that is important to note is that communication with engineers (FSEs) happens mainly within their direct environment. From the comments the interviewees made, it became apparent that there's a lot of communication happening within the local sites. Interviewees mentioned there is much interaction happening between the engineer and the shift lead, and that the local manager is also very involved with the engineer.

"Because my direct group lead was very involved. He was always checking up on me, making sure that I had what I needed. That SOJT was being effective, and if I was feeling like I was learning something or I was getting enough hands-on. Then yes, he made sure of that." – Engineer

Yet, there is not much communication between people from local sites with non-local people. Engineers and KMs both mentioned that currently there is not much interaction between them. However, KMs at smaller sites have more direct interactions with engineers than KMs at bigger sites, as they have fewer engineers they need to focus on. Once you move even further away from the local site, the communication happening with engineers becomes non-existent.

"In a larger office there's a lot less influence as there would be in a smaller office. Once you reach the point where you got 6, 8, 10 machines that transfers mostly to the shifts themselves, and my interaction becomes with group leads. Being KM on a smaller scale, when this office was first starting, it would have 4 to 5 machines, it was easier to connect with the individuals and talk to them." – KM

"However, if you think about management as in higher management, no. There wasn't any really direct communication between them and me in terms of my training." – Engineer

"Because I have my direct report, so there's quite a big distance from engineers and me." – CS VP

The desired SOJT ecosystem

The current SOJT ecosystem has been described in the previous part of this appendix. In the present section, the desired SOJT ecosystem as perceived by the interviewees is described. This is done for each member of the desired SOJT ecosystem, excluding the mentor and the FSE as their desired roles have been described in the results section.

Within the qualification process, the interviewees want the KM to increase the likelihood of qualification being established by feeding FSEs with learning opportunities within SOJT and building their expectations. They also want the KM to have a regulative role by monitoring and reporting, which they argue, should support them in their facilitative role. Except now, KMs should not only monitor and report on engineers' learning progress, but also on their development within the qualification process. The reason for this is twofold: on the one hand they do it to support the FSEs in their needs. On the other hand, they do it to assess whether the SOJT is being effective.

"It's knowing the engineers are at a level and getting them to the level they need, and making sure they have what they need." – KM

"So for me a key area is to engage with the engineers in routines and seeing how they are getting along, and seeing what they need. For me the key of the assessment and being involved with the assessment would be to check and verify that the development program they're working on is effective." – KM

Regarding management support, there is a distinction between local management and higher management in what support is desired from them. The interviewees want local management to stimulate the engineers and feed them opportunities. Besides this, they want them to regulate the process both by driving the qualification process and monitoring the engineers. When it comes to higher management, the interviewees want them to facilitate learning opportunities. Notice how they want higher management to facilitate learning opportunities, and local management to feed them to the FSEs. Concretely, the interviewees

want higher management to support SOJT and the qualification process by allocating time and aligning planning.

Lastly, the interviewees find that the shift lead should support the mentor in feeding opportunities to the FSE by helping to find them. They mentioned that the shift lead can do this by making sure the planning is aligned, so that the learning can actually take place. The interviewees also mentioned that shift leads are responsible for their shift teams. Hence, they want them to monitor engineers' progress. This goes hand in hand with supporting the mentor, as monitoring progress enables a shift lead to find the right opportunities for each individual FSE.

"The shift lead should be aware that it is a SOJT and should be giving them the opportunity, so the shift lead assigns who works on what, and basically you know, it takes 30 seconds, but working with the mentor to get the FSE on what (s)he needs to be learning, and it is kind of an interaction between the mentor and the shift lead. And I have done it like: 'Hey, you need to put him here for the day, he needs to learn that.' So the shift lead just delegates where the mentor and the FSE would be for that day." – Engineer

In short, to improve and prove competence levels, the itnerviewees find that the FSE should have a support system consisting of multiple people: their mentor(s), their KM, their local management, higher management, and the shift lead. The main responsibilities of the people in the support system are either to facilitate SOJT and qualification within SOJT, or to regulate it. The main responsibilities of each job role are displayed in Table 1, which is shown on the next page.

Table 1

The main responsibilities of each job role

		Role				
		Mentor(s)	KM	Local management	Higher management	Shift lead
Responsibility	Facilitate by teaching	■				
	Facilitate by providing feedback	■				
	Facilitate by feeding opportunities	■	■	■	■	■
	Facilitate by building expectations		■			
	Facilitate by stimulating			■		
	Regulate by monitoring progress	■	■	■		■
	Regulate by deciding on readiness	■				
	Regulate by reporting		■			
	Regulate by driving the qualification process				■	