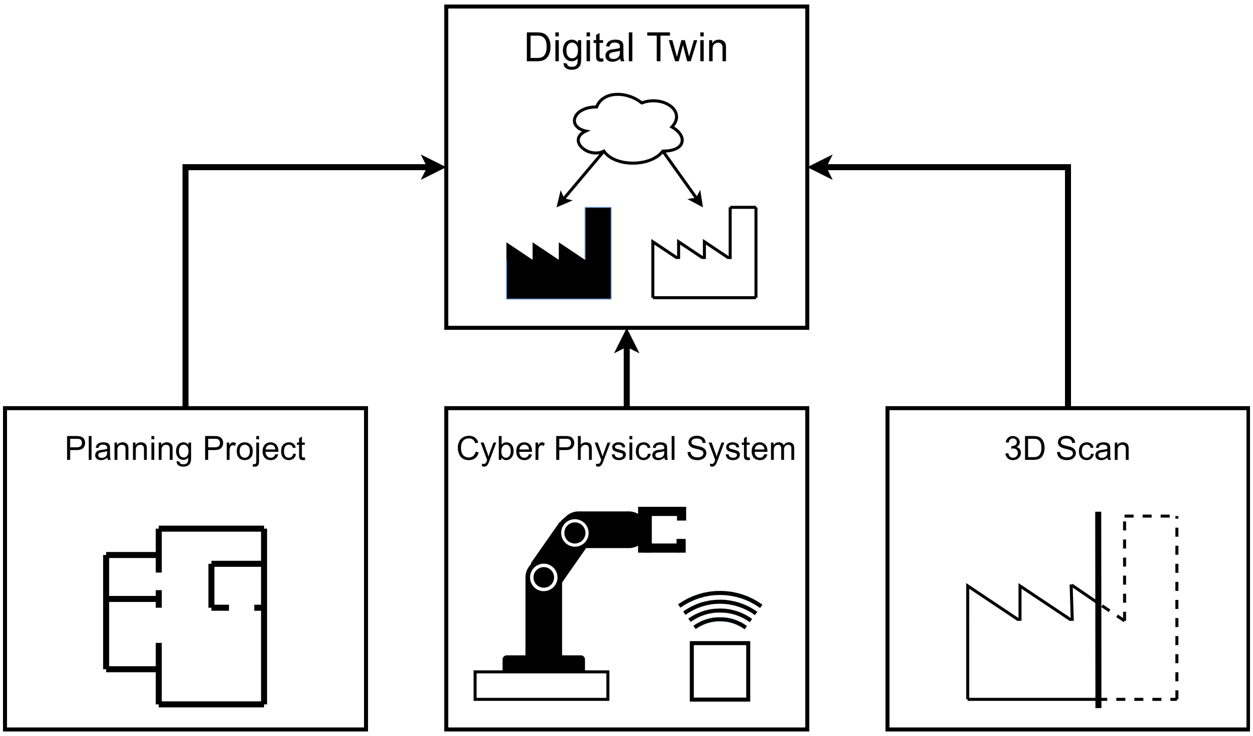

Digital Twin for Development and Installation of Production Systems

Overcoming challenges with increased digitalisation in small and medium sized enterprises

Master's thesis in Production Engineering

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Gothenburg, Sweden 2021
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Master's thesis 2021

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Cover: A digital twin of production systems connecting to three sources of data, planning, cyber-physical system and 3D-scanning adapted from Biesinger et al. (2018)

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Abstract

Traditional production systems need to become more flexible and sustainable with increased digitalisation due to expanding individualised product demands. Small and Medium-sized Enterprises (SMEs) are a key part of sustainable economies and need to adopt new technologies from Industry 4.0 to stay competitive but tend to fall behind due to a lack of methodological framework. To address these challenges, Research Institute of Sweden (RISE) has initiated a project called "Digital twin for development and Installation of production systems" (DIP) to adapt methods from larger corporations to SMEs. The DIP project has resulted in a work method called the DIP method to reduce time, cost and risk when implementing changes in production systems. This thesis explores the challenges and needs in SMEs, with an evaluation of the DIP method by making a comparison of findings from a literature study and an interview study. The thesis identified several challenges and needs focusing on economic constraints, resistance to change, active top management, a digital strategy, and clear goals. Further identified was the lack of skill and technical resources and need for support. Therefore, this thesis has developed a change management model to address the challenges and needs of SMEs, called the DIP model. The DIP model aims to provide a structure to minimise challenges presented by working in four phases, exploration, planning, action and integration. Additionally, the model provides directives for DIP-central to support companies working with the four phases. Finally, the DIP model will serve as a base to further develop the DIP method by creating material for marketing, workshops and support.

Keywords: production systems, digitalisation, SME, digital twin, point cloud, change management, DIP.

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Emma Valtersson Viktor Bengtsson, Gothenburg, June 2021

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1
Introduction

This chapter presents the background, introducing the topic and the relevance of the thesis. Thereafter, presenting the thesis aim, limitations and research questions.

1.1 Background

New technologies within communication and information have led to a shift in the manufacturing industry, from traditional mass production to mass individualisation. Traditional production systems tend to suffer from low efficiency. With expansions of individualised demands and growth in product variety, pressure increases on production systems to be more flexible and sustainable (Ding et al., 2019). To handle increased competitiveness and shorter cycle times, virtual verification has become significant in recent years. Furthermore, optimisation of products and production systems have been enabled by using technologies from Industry 4.0, such as Internet of Things and digital twins (Wärmefjord et al., 2017).

Small and Medium-sized Enterprises (SMEs) are a key part of sustainable economies and to stay competitive it is fundamental for SMEs to adopt new technologies involved in Industry 4.0 (Issa et al., 2017). Bigger companies already integrated strategies for digitalisation in contrary to SMEs who struggle to initiate Industry 4.0 technologies (Matt & Rauch, 2020). According to Modrak et al. (2019), there is a significant challenge in adopting Industry 4.0 to SMEs, such as a lack of methodological frameworks for initiating and using the technologies.

Research Institutes of Sweden (RISE) is a research institution cooperating with the public sector, companies, and academia to contribute to a sustainable society and competitive market. RISE has an ongoing research project called "Digital Twin for Development and Installation of Production Systems" (DIP), which develops cost-effective solutions for virtual planning and control of production system installations. The project aims to support SMEs in reducing time, cost, and risk when implementing changes in the production layout by using a digital twin.

In this project, the partners have developed a method named the DIP method and a technical platform to support different phases in implementing layout changes in production systems. By evaluating the newly developed DIP method, opportunities for a better understanding of the difficulties with implementing and using the method can be achieved. Furthermore, the evaluation will help the future development of the DIP method to simplify the implementation of new technologies for SMEs.

1.2 Aim

This thesis aims to provide recommendations to address and take advantage of the DIP method, with challenges in mind, for an easier implementation process. Furthermore, the aim is to evaluate challenges with the DIP method and compare them to already existing challenges and needs with digitalisation in SMEs.

With this aim, the thesis will be able to improve the use of the DIP method for SMEs and to easier introduce new technologies for increased digitalisation. Furthermore, create an understanding of challenges, generate feedback, and introduce a strategy for continued work with the DIP method in future projects.

1.3 Limitations

The thesis is limited to only addressing the participating companies in the project, classified as SMEs. Furthermore, the recommendations are mainly aimed towards the new companies wanting to adopt the DIP method and support the cooperating companies. Lastly, the intent is to provide recommendations for improvement.

1.4 Research Questions

Based on the background, aim, and limitations the following two research questions are proposed to fulfill the aims of this thesis:

- What challenges and needs do SMEs face in the development and implementation of digitalisation in production systems?

- How can an implementation process be adapted so SMEs can take advantage of the DIP method?

2
Theory

This chapter presents the theoretical framework of the thesis by displaying findings from the initial literature review and introducing relevant information for the thesis and the methodology.

2.1 Overview

This chapter is divided into two parts following a sequential structure demonstrated in Figure 2.1. The first part presents relevant theory, including productions systems, digitalisation and change management. Digitalisation includes concepts of, Industry 4.0, cyber-physical systems, digital twin, point cloud, big data, and change management includes resistance to change. The second part presents theory connected to the methodology used for this thesis, divided into research strategy, interviews, grounded theory and observations.

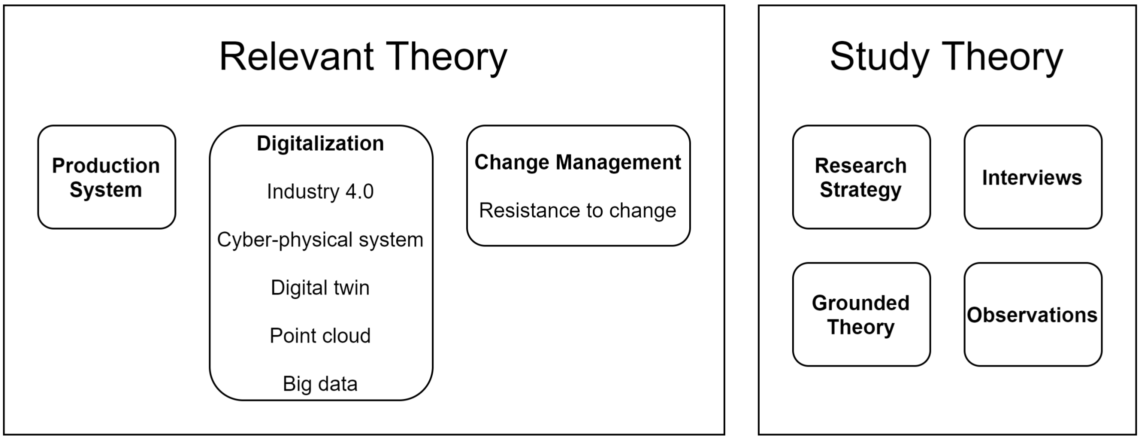

Figure 2.1: The theoretical framework for the thesis, divided in relevant theory and study theory

2.2 Relevant Theory

This section presents the relevant theory in the thesis, including production systems and digitalisation, including Industry 4.0, digital twin, cyber-physical systems, point cloud and big data. Last section present change management, including resistance to change.

2.2.1 Production Systems

According to Bellgran and Säfsten (2009) production is the process of creating goods or/and services for customers in any market. This thesis will focus on production systems that are creating goods and services for the industrial market.

A production system is often used as a synonym for a manufacturing system or assembly system. Nevertheless, there are differences in what the different terminologies describe. According to Bellgran and Säfsten (2009), a manufacturing system is the most superior and describes the whole chain of humans, machinery, and equipment standard flow of material and information. A production system consists of a product realization process, from planning to finished product, see Figure 2.2 for the hierarchical level of systems (Bellgran & Säfsten, 2009).

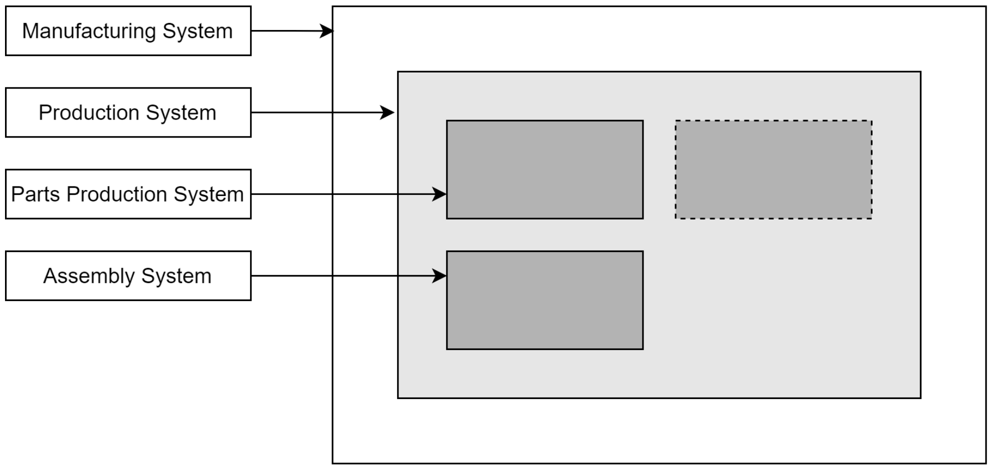

Figure 2.2: Hierarchical levels of production system, adapted from Bellgran and Säfsten (2009)

A production system consists of several different elements which have a relation with one another. Some elements mentioned by Bellgran and Säfsten (2009) can be parts of a production system are premises, humans, machines, equipment, software, and procedures. There is a possibility to add another dimension of a production system, which is the decision-making process. This process includes the owner, business management, and production management of the production system.

Furthermore, testing a production system virtually, using various virtual tools, is beneficial for planning quality and increase speed and avoid production shutdowns. Ultimately, minimizing the impact on the entire system (Yang et al., 2015). When modelling a system, a database with object information and interrelationships is provided. Generating information about layout, features, and process information to create a complete description of a model (Lindskog et al., 2017).

2.2.2 Digitalisation

Digitalisation is described as the process of adopting new technologies in a broader perspective at an individual, organisational and societal level (Legner et al., 2017).

Fundamental for digitalisation is digital technologies which have progress and expanded on the market today, including technologies for creation, processing, transmission, and using digital products (Urbach & Röglinger, 2019). As digital technologies emerge on the market, the need for change increase, developing organisations and removing old structures (Gimpel et al., 2018).

Digitalisation has a tremendous impact on organisation leaders and politicians. Several initiatives have been created to address its effect, challenges, and opportunities, such as Industry 4.0, also called "Smart Manufacturing" and "Smart Industry". Digitalisation represents the change in many various functions while these initiatives are limited to improvement in manufacturing processes (Björkdahl, 2020).

2.2.2.1 Industry 4.0

Throughout history, there have been three industrial revolutions, which have occurred by leaps in technological development. The first revolution was the steam engine, the second electrical energy, and the third a widespread digitalisation. The combination of the internet and future-orientated technologies in products and machines of today spotted a new leap in technological development. The new leap has come to be the fourth industrial revolution where product regulates the production, mass penalisation, and maintaining the economic benefits of mass production (Rüßmann et al., 2015).

The fourth industrial revolution differs in speed, scope, and complexity compared to previous revolutions (Lutovac & Živković, 1960). It covers fundamental aspects, including automatic exchange of information and connecting production resources, such as machines, sensors robots. Ultimately, generating smart and intelligent factories with the ability to control production processes. The smart factory will use modelling and simulation to analyse manufacturing, applicable for several purposes, such as production planning, production design, and production engineering (Pereira et al., 2019).

The fourth industrial revolution, also called industry 4.0, includes key technologies such as big data, cloud computing, autonomous robots, cyber-physical systems, simulation concepts, and Internet of Things (Patnaik, 2019). Another key concept mentioned by i Casas et al. (2019) is the usage of a digital twin, which will connect all existing system elements, see more in section 2.2.2.3.

2.2.2.2 Cyber-physical system

Cyber-physical systems(CPS) create an interaction between the cyber-system and the physical system, which is the main difference between current and smart manufacturing. The principle is a communication network that interacts between virtual cyberspace and physical devices (Bazaz et al., 2019). The link generates technical standards such as communication within the network, processing, and specifications of data exchange, with the help of computational devices as sensors and controllers in the physical system (Yao et al., 2019).

A digital twin is a prerequisite for a CPS to be created and is fundamental for a well-functioning CPS to ensure reliability and predictability. (Liu et al., 2020).

2.2.2.3 Digital twin

A digital twin is a well-renowned concept included in industry 4.0 that describes a virtual replica of a physical system or device (Negri et al., 2017). The entities elements include 3D virtual geometry models, 2D plane layout models, 3D layout models (Wang & Luo, 2020). These models present attributes of the physical object (structure and shape) and behaviour (rules and logic) to which is transferred into virtual spaces to create the real imagery of the physical space (Chen et al., 2020).

A digital twin should contain all process information and obtain technical and operational data and organisational details. The historical and real-time information must interact, and the same goes for the integration between the virtual and physical world (Errandonea et al., 2020). This integration depends on the amount of incoming data, which also differentiates misconceptions about digital twins (Fuller et al., 2020). The distinction is how the flow of data transmits between the Digital and Physical object, from a complete manual flow to an automatic flow. There are three different levels: Digital Model, Digital Shadow, and Digital Twin; see Figure 2.3.

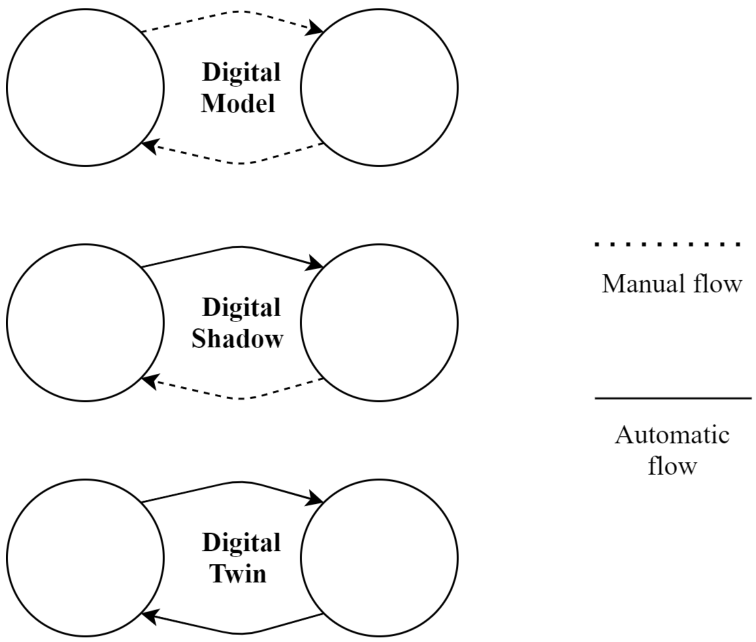

Figure 2.3: Differences between digital model, digital shadow and digital twin adapted from Errandonea et al. (2020).

A digital model has a pure manual integration. Next, a digital shadow is a combination of automatic and manual integration, and a digital twin has a pure automatic integration (Errandonea et al., 2020). Entire production systems and individual products create a digital shadow with the process and operational data. The differentiation of a digital twin is the unique instance, with its digital shadow, own digital model, and intelligent linkage (algorithms, correlation) between two components (Stark et al., 2017).

For digital twins in production systems, there are many optimisations to generate an increased production base on various sources of data. There are three central data sources for production systems, see Figure 2.4. The first is planning data, which means that electrical devices in production have a virtual counterpart to update the bill of resources. Secondly, data from the CPS system enables monitoring and control. Lastly, to enable positions of objects and identify where ventilation, transport systems and other objects within the production system, a third data source is generated from 3D scanning of the production system. The data enables visualisation for layout optimisation in an effective way (Biesinger et al., 2018).

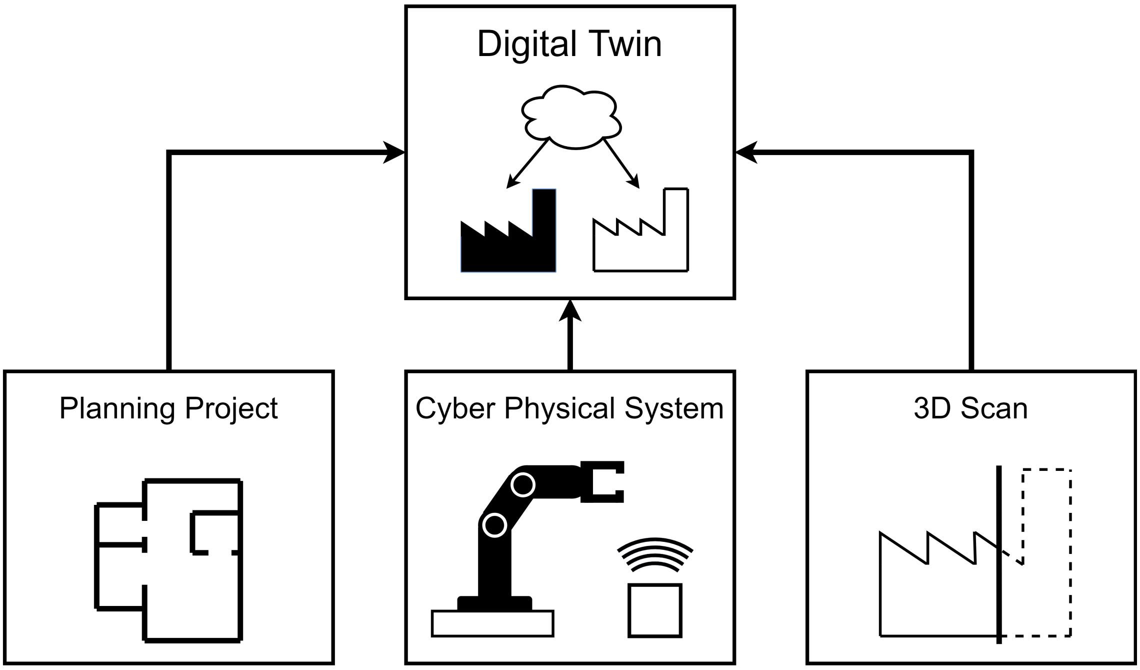

Figure 2.4: The relations between planning, CPS, and 3D scan for digital twin optimisation adapted from Biesinger et al. (2018)

Digital twins significantly impact manufacturing to save time and money and create connectivity, which is the main driver for implementation. Furthermore, an environment of real-time data makes it possible to test and evaluate systems or specific products, as well as store immense amounts of data used for greater accuracy in performance and predictions analysis (Fuller et al., 2020). Additionally, a digital twin can be used for different types of simulation, synchronisation of real-time data, and used for decision making (Negri et al., 2017). Thus, the digital twin will assist in achieving the goal of lowering the production cost by optimising production planning with possibilities of testing production changes, without interrupting the ongoing production (Rüßmann et al., 2015).

2.2.2.4 Point cloud

A point cloud is a surface reconstruction enabled by data points to create physical shapes virtually that is possible using laser light (3D scanners), LiDAR scanners or laser-based range scanners (Berger et al., 2017). The technique of point clouds uses reflected pulses to measure distance and angles to collect data that generate 3D coordinates (Xu et al., 2019). By using ranging and light detection, 3D point clouds can be created, which are utilized for various functions and fields, proven highly effective in 3D mapping (R. Huang et al., 2020).

Moreover, point clouds can be used in digital twin development by gaining point cloud data via scanning of an area to build digital models and align the models with objects in the physical world (Tao et al., 2018).

2.2.2.5 Big data

Big data defined as a high volume of data divided in terms of volume (how to store data amounts), variety (the heterogeneity nature of data), and velocity (analysis time) (Gandomi & Haider, 2015).

In Big data, data management is one of two parts to gain insight into big data, which focuses on data collection and storage of data with the help of various technologies. The second part is analysis, where technologies are used for analyzing and receive intelligence from big data (Gandomi & Haider, 2015). There are several possibilities for collecting data, for example, by using sensors in industry and business transactions. The emphasis is on using correct data to be able to take advantage of big data in optimization of processes and improving quality of products which will reduce cost (Wärmefjord et al., 2017).

Three Big data analysis techniques are highlighted in the development of digital twins. The first, hidden meaning emphasizes the importance of analyzing the meaning of a feature and the relation to the real world. Secondly, timeliness represents low-latency data processing, e.g. cloud-based industrial control enabling time-sensitive applications. Lastly, high quality highlights the importance of data quality rather than volume for a possible result. Finally, efficient handling of the data is seen as fundamental to create a Digital Twin, and big data collected from different input references is used in the creation of a digital twin (Lu et al., 2020).

2.2.3 Change management

Daily, someone worldwide discovers or innovates something that will push the opportunity for someone else to improve their business model. For this to happen, the business model needs to change to implement innovation into the organization and increase its competitiveness. Change is therefore inevitable if companies want to stay in business. However, any new work method affecting people will generate some resistance (Murthy, 2007).

Change management is a concept to guide individuals, groups, or organizations in a structured way to achieve a desired outcome (Hayes, 2018). There must be a comprehensive understanding of why and what things need to be done to implement change successfully. The purpose of implementing change management is to increase the chance of success and return of investment (ROI) (Murthy, 2007).

When implementing new technologies in a company, the manager and executive team must be in the leading role of the change process, not just an IT department. The role of a manager is to build a stable team working with the change process and be the communicator of the change-making sure everyone understands why the change needs to be implemented. The manager often uses storytelling to convince the importance of the change (Cameron & Green, 2019).

A way of successfully implementing change management is to follow a change management model. There is a lot of models available for implementing change. The models can have different purposes and be used for different types of changes dependent on what areas in an organization the changes affect (Cameron & Green, 2019).

2.2.3.1 Resistance to change

Resistance to change is a frequently used term describing organisational change providing descriptions of why efforts in introducing production methods, management practices and changes in technology fail or fall short (Laumer, 2011).

Changes in technology such as digital change mainly focus on transforming products and practices, where the resistance is mainly condensed to rejection of new technologies and implementation. To be successful in digitalisation, consensual implementation and adoption of new technologies is fundamental (Scholkmann, n.d.). An initial step in a digitalisation process is to consider new technologies, which will affect the success of the company (Richey et al., 2007).

Parasuraman (2000) discusses technological readiness and divides the needs into four different dimensions: optimism, innovation, discomfort, and insecurity. Optimism suggests a positive view of technology and an increased belief in control, effectiveness, and flexibility. Innovation focuses on pawing the way and be leading. Discomfort means being overwhelmed and lacking control of technology. Lastly, insecurities focus on trusting the technology and the ability to function correctly.

2.3 Study Theory

This section presents the theory behind methodology in this thesis including research strategy, interviews, observations and grounded theory.

2.3.1 Research Strategy

According to Bell et al. (2018), the connection between theory and research need to be characterised, which can be seen from two different approaches, deductive or inductive. Deductive research builds on exiting theory to develop a framework for data gathering, creating a hypothesis that will either be confirmed or disapproved. Inductive approaches use already existing data to analyse in greater detail, to build theory Hennink et al. (2020). Generally, qualitative studies represent a more inductive approach compared to quantitative research, which is more deductive in the relation of theory and data (Bell et al., 2018).

Mixed research methods is a combination of several research methods within the same research project. The methods are either the combination of qualitative and quantitative research or a mix of qualitative methods. Qualitative methods are helpful for a new or complex problem and typically useful processes or behaviour. Quantitative research is centralised to find trends, statistics, correlations, and generalising in a more prominent framework by measuring and counting issues (Hennink et al., 2020). Using only one research method is more sensitive to errors connected to that particular method. With multiple methods, using cross-referencing as validation, it is possible to enhance the credibility of findings (Taylor et al., 2015).

Triangulation plays a significant role in mixed methods, which is the objective to view research problems from various perspectives from multiple sources. Consequently, the accuracy of the data can be confirmed by receiving the same results with various data collection methods. Furthermore, the method is generating a complete image of the problem in the study (Denscombe, 2014).

2.3.2 Interviews

There are three different types of interviews formats in qualitative research, *structured interview*, *semi-structured* and *unstructured*.

Structured interviews has a controlled format regarding both questions and answers, with limitations for the respondent to give responses with limited options (Denscombe, 2014), in other terms called closed-ended questions. These type of questions is believed to generate more accurate data and clear analysis. Typically when considering a structured interview, a survey or poll is used (Yin, 2015).

Semi-structured is very common in small scale research to evaluate issues in detail and investigate attitudes. The format is flexible, where the questions to be answered is clearly defined. However, the order of topics and the respondents can give open-ended answers and speak more freely (Denscombe, 2014). The semi-structured interview allows discussion and elaboration of the respondents' answers.

Unstructured interviews are non-directive where the interviewer introduces a topic or subject to create their ideas and thoughts (Denscombe, 2014). Respondents are encouraged to describe only one or two topics in detail. (Mann, 2016).

2.3.3 Grounded Theory

Grounded theory is an inductive method to compile data used for various qualitative data types. The principle of the method is to thoroughly analyse text (transcript, for example), code and categorise it into bulks of data, generating theories. Before initialising the coding, the data needs to be familiarised with by reading and identify themes. The text is last divided into codes or themes that are later categorised, and the categories provide concepts used to generate newfound understanding and suffice as a base for conclusions from the work (Denscombe, 2014). The first level of coding is open code, where the labels are close to and even the same as the original format, reusing the original form of data to create codes (Yin, 2015).

2.3.4 Observations

Observations aim to gain detailed and in-depth data by observing a setting, events occurring in the setting, and people included. It provides deeper knowledge to specific issues or topics, which might have been disregarded or avoided in an interview (Patton, 2015). Observations are often combined with other qualitative research methods, such as interviews and surveys, to better understand the problem from various perspectives, with complementary data. There are two types of observations forms, *participant* and *non-participant*.

Participant observations is real-life participation by exposure or involvement to a situation or members (Hennink et al., 2020). Participant observation is common when doing fieldwork, where the researcher can work actively or passively. This by either participate, observe, or a combination of both (Yin, 2015). It is important taking detailed notes and stay objective to avoid interpreting the situation.

Non-participant is observations with no involvement, being excluded from the situation without any influence on the actual situation and generating more freedom to observe and take notes. However, a complete non-participant observation is challenging to achieve (Hennink et al., 2020).

A concern with observations is that observers could generate different data from the situation, depending on how it is perceived. In addition, the perception might be affected by personal factors, such as competence, commitment and psychological reasons. A way to minimise the risk of personal perception is to use *systematic observation*. *Systematic observation* is a method using observation schedules to produce more consistent data. The schedule is used by observers and includes what is observed and measured, similar to a checklist. Ultimately, to ensure looking for the same events and looking out for the same things (Denscombe, 2014).

3
Methodology

This chapter presents the thesis methodology. Firstly by presenting the research strategy followed by used methods. Firstly, presenting the literature study, followed by observations and initial interviews. After that, presenting a detailed description of the interview study, including planning, execution and compiling of data. Consequently, presenting analysis including a second literature study, analysis of findings, and lastly introducing recommendations .

3.1 Research Strategy

In this study, both inductive and deductive research approaches have been used to gather information rooted in the aim and research questions and later when analysing gathered data in detail to create a concept for continued work. The study followed a sequential structure seen in Figure 3.1.

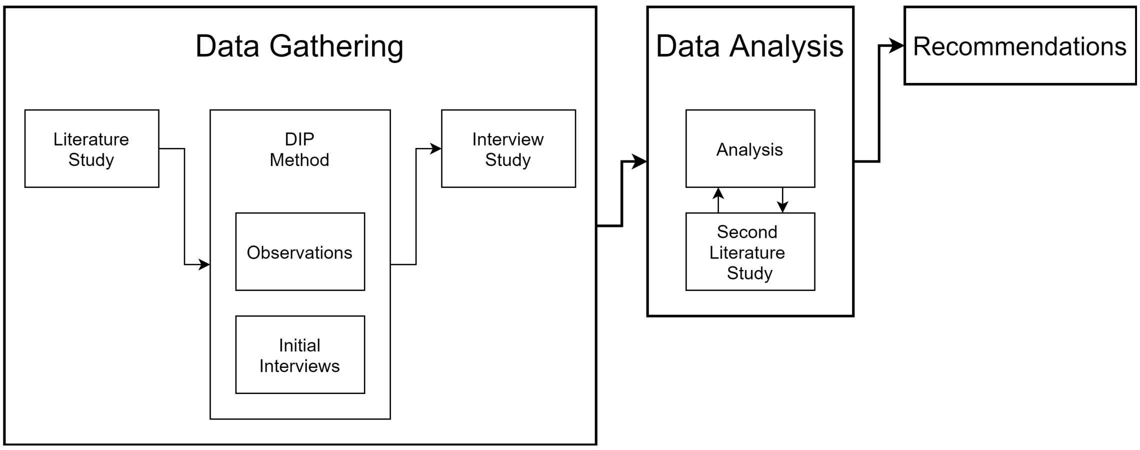

Figure 3.1: The sequential structure of the study including data gathering, data analysis and conclusion

A qualitative research approach was chosen for the study since the research investigates a specific problem, which was not measurable with quantitative data. As Hennink et al. (2020) mentions, qualitative methods are used when analysing behaviour, which aligned with the aim of this thesis to evaluate challanges for SME in digitalisation.

Furthermore, a mixed-methods approach was chosen in line with (Taylor et al., 2015) for the possibility to validate and enhance the credibility of findings. Therefore, chosen methods were interview study, literature study, and observations, described in further detail in the following sections. To use several methods also connects to the concept of triangulation mentioned by Denscombe (2014), to get various perspectives of the problem and to confirm findings.

3.2 Data Gathering

This section presents the various methods used to collect data in the thesis. Firstly, introducing the literature study and the methods used to gather background information on the thesis topic. After that, presenting methods used to gain insight into the DIP method, including observations and initial interviews. Lastly, presenting the interview study and how the study was prepared, executed and analysed.

3.2.1 Literature study

Yin (2015) mentions that before conducting a study, it is relevant to build a study bank of previous studies, and in accordance, initial information about the topic was gathered. The initial literature study focused on gathering information on the background of digitalisation, production systems, and SME. Furthermore, the focus was to learn about technologies used in the DIP method, including a digital twin.

Various platforms were used to find papers fitting for this thesis, mainly using the platforms lib Chalmers and Google Scholar. However, the Google search engine was also used to gain initial knowledge but not used as a reference in this thesis. The papers provided in this thesis are based on different search strings such as digitalisation, digital twin, SME and digitalisation, Industry 4.0, and Production systems.

Additionally, documents from RISE was provided to gain insight into the DIP projects background and the developed DIP method. The documents were PowerPoints used as an introduction for participating companies, evaluation documents, and the DIP method's created guidelines.

3.2.2 DIP Method

To learn more about the DIP method, observations of the processes and initial interviews were performed with DIP-central.

3.2.2.1 Observations

Observations were carried out to gain more detailed information about the DIP method and to gain more in-depth knowledge in accordance to Patton (2015), as a complement to the initial interviews conducted with DIP central. By combining qualitative methods and observations, the DIP method was seen from different perspectives generating a better understanding, in similarity to Hennink et al. (2020).

A systematic method was used in accordance to Denscombe (2014) to prepare for the observations. Therefore, checklists were created with questions to be answered. Since the observation did not need a measure for quantitative data, the systematic method was used to define what was important to identify during the observation. Therefore, to prepare for the study visits, checklists were created, including questions wanted to be identified during the observations.

The first observation was carried out at RISE institute, participating in a 3D-scanning of the facilities, gaining a better understanding of the initial phase of the DIP method. The observation was a participant observation with an active role in alignment to Yin (2015) by being exposed to the situation and taking part in the scanning process by assisting and contributing with input for the procedure.

The second observation was at one of the participating companies observing the installation of a robot to understand the last phase of the DIP method. The observation was also participant observation with a passive approach in accordance to Yin (2015), where the robot installation was observed from a distance, with the possibilities of asking questions to the people executing the installation.

3.2.2.2 Initial interviews

Three unstructured interviews were carried out with different DIP project group members from RISE to learn about the DIP method. An unstructured format was chosen in accordance to Denscombe (2014), so the interviewees had freedom and could speak about the topic openly. As a frame of reference, the guidelines connected to the DIP method used as a base and questions were asked as they emerged.

Moreover, attending meetings every second week with the DIP central, continuous information was received about the ongoing projects, creating a better understanding of the DIP project and DIP method.

3.2.3 Interview study

This section present the preparation, execution and compiling of interviews for the main interview study.

3.2.3.1 Interview preparation

With the limitation to this thesis, interview targets were focused on participating companies in the DIP project. The interviewees were contacted via mail and consisted of both manufacturing and automation companies. In total, three manufacturing companies and two automation companies were interviewed. All the manufacturing companies work in the plastics detail industry, and the automation companies deliver automation solutions. Furthermore, one interview was held with a company providing services for the DIP method and one person with expertise in research communication. The expert in reaserch communication was interviewed to gain information on how to transmit and present information.

A format template by Yin (2015) was used as guidance to prepare for the interviews. The model is divided into seven themes: Pre-History, Intermediate Context, Definition of the doing, Learning Curve, Variations in the doing, The Highs and the lows, and Distanced perspective on the doing see Table 3.1. The template presented a holistic framework, which minimised the risk of missing relevant information throughout the interviews. Furthermore, assurance that all areas were adequately covered gave the interview a structure that was easy to follow. Questions used for the survey were based on the thesis aim and findings from the initial literature study.

Table 3.1: Template used for interview structure adapted from Yin (2015)

Theme	Description
Pre-History	Explaining involvement, how the informant learned about it and what motivated participation
Intermediate context	What is the informant currently working on, how involvement fit into context
Definition of the doing	How it works and the most important features
Learning Curve	Assessment of initial experiences, drawbacks, trial and error and feedback received
Variations in the doing	Difficult or easy cases, categories of doers(competence), changes in the informants approach over time, disagreements etc
The highs and the lows of the doing	Payoffs, Aspects that was the most enjoyable, risks in the doing and techniques for managing risk
Distanced perspective on the doing	Giving advice to others, express thoughts about future and changes because of involvement

Before conducting interviews, the questions were sent to DIP-central for feedback, to which the interview questions were modified before initiating the study.

3.2.3.2 Execution of interviews

During the interview study company, representatives involved in the DIP project were interviewed using a semi-structured format with clearly defined questions. The semi-structured format was used to create an environment for the respondents to elaborate on the questions in similarity to Denscombe (2014), to discuss issues and difficulties connected to digitalisation and the DIP method further. The interviews were conducted using the format described in the previous section 3.2.3.1, adapted for this interview study, see Table 3.2 for the aims with each theme.

Table 3.2: The template used for interview structure with the aim of each phase

Theme	Description
Pre-History	The aim was to gain knowledge of how companies got involved in the project and how much they knew before starting
Intermediate context	Aiming to determine why companies go involved in the project and how they worked with digitalisation prior.
Definition of the doing	The aim was to define participating companies project in DIP, along with the availability of knowledge and resources
Learning Curve	Aiming to know the results of the project and what support was given from DIP-central. Additionally, how to motivate a change and if they encountered any problems during the project
Variations in the doing	Aiming to see benefits with a change in work methods and what motivates that.
The highs and the lows of the doing	The aim was to identify benefits and gains with the DIP-methodology and potential areas for development
Distanced perspective on the doing	The aim was to summarise and provide general about the DIP method and digitalisation in general

Six interviews were carried out with people responsible or part of the digitalisation process connected to the DIP project. One interview was carried out with an expert in research communication. The duration of the interviews about one hour. Two follow-up interviews were carried out with two manufacturing companies to identify success factors and revive more details of specific topics. The interviews were conducted in the same format as previously but with altered questions. The interview duration was 30 minutes.

All but two interviews were carried out via teams or zoom. The initial thought was to do face-to-face interviews, but the idea was neglected with restrictions due to COVID-19. However, one interview was carried out on-site in conjunction with a study visit, and one was a phone interview. For the semi-structured interviews online, a PowerPoint with the questions was prepared to create better visualisation and avoid misinterpretation. All interviews were recorded, and notes were taken during each interview by one of the interviewers. To avoid confusion, one person was the narrator of the interviews, and both asked follow-up questions.

3.2.3.3 Interview compiling

No transcripts of the recordings were made since both notes and recordings were made. If anything was unclear from the notes, the recordings were used to compliment the notes, thereby avoiding misinterpretations and wrong information.

The grounded theory approach was used to compile the information from the interviews suggested by Denscombe (2014), to analyse and generate theories from the interviews. Firstly notes from the interviews were read through and then compiled into a spreadsheet in Excel, in an open code format presented by Yin (2015). The Excel sheet was divided into a label that was chosen beforehand based on the interview questions. The interview data was placed in each label, either entire sentences or shorter phrases. As coding progressed, labels were modified where some complied during the process of adding data, and some labels were removed. Subsequently, the labels were then categorised.

The interviews were coded as soon as possible after each interview to avoid forgetting and missing information. Ultimately, the categories created several relations between each interview connecting to the aim of the study.

3.3 Data analysis

This section presents the execution of the analysis in the thesis. The analysis is based on findings from the interview study and the second literature study described in the first section below.

3.3.1 Second Literature Study

After conducting the first round of interviews, new realisations were made, and therefore a second literature study was conducted. The study focused on identifying needs and challenges for SMEs in literature to connect to the identified challenges from the interviews. Additionally, searches were made in the field of resistance to change and change management.

When analysing the literature, the primary step was to review the title and reading through the abstract. Papers of relevance were collected and gathered, and sorted in an excel file which generated a total of 32 articles on the topic of SME and digitalisation. After deeper reading, many papers did not cover the specified area and were therefore removed. As a result, 16 papers were used in the literature study. Challenges and needs were sorted by what they mentioned, and gradually, similarities were identified. Thus, similar topics created categories. As reviewing more papers, categories were added, altered, or removed. Another round of reading was made to validate the articles, which also caused changes in categories and additional papers.

3.3.2 Analysis of findings

A comparison between the literature study and the interview study was made to analyse the findings. The aim was to identify similarities between needs and challenges in SMEs found in the literature versus the identified challenges connected to the DIP method.

The comparison started by finding matching headlines. The matching topics were immediately compiled into one section of analysis. The next step was to extract information in the interview study corresponding to the appropriate topic in the literature study. After, each headline in the literature study was broken down and read thoroughly and matched with the current headline in the literature study. Two headlines from the literature study were compiled to one, and one headline was created from the interview study. Ultimately compiling the similarities in six categories, highlighting the needs or challenges of each specific topic.

Furthermore, an analysis of two change management models was made to decide which model could suffice as a base for adaption. The comparison was made based on the DIP method's overall process and how the change management models were structured. A model was then selected based on structural similarities to the DIP method.

3.4 Recommendations

Recommendations were created with a change management model as a base, aligned with the DIP method. A change management model, the DIP model, was created by following the order of phases and processes in the planning model from Bullock and Batten (1985) to create a framework adapted for the DIP method.

The adaptation bases on findings from the literature and interview study, by a step by step evaluation of each phase of the planning model. In each phase, the processes from the planning model were viewed by reading the description connecting the processes to the DIP method. After that, each process from the planning model was transferred to the DIP model, simultaneously considering the challenges and needs identified in the findings. Other processes were included in the DIP model through discussion to address some of the challenges and needs presented in the findings. The DIP model was then compared to the original planning model to verify that all processes in each phase were properly addressed.

Moreover, for each phase in the DIP model, recommendations for support from DIP central was generated by using the same approach as previously mentioned. Some of the identified challenges were more addressed towards DIP central and, thereby, relevant to provide a support strategy.

4
DIP Method

This chapter presents an introduction to the DIP project and a description of involved organisations. After that, presenting a complete presentation of the DIP method divided into three categories digitalisation, configuration, and installation. Lastly, presenting a short description of guidelines. The chapter is based on unstructured interviews, documentation from RISE and observations of the digitalisation and installation processes.

4.1 Project introduction

The DIP project is a three-year project, starting in 2018. The project's initial purpose was to develop a methodology based on several big companies' way of working with digital twins, to adapt for SMEs. In addition, the project aims to reduce cost, time and increase quality in installing new production equipment. The DIP method describes how digital twins can be created with the assistance of 3D scanning and how to use them to work with layout planning, 3D-construction, robot programming and to enable easier installation of the physical object, see in detail section 4.3.

4.2 Organisation

A digital twin enables more interaction between various parties, like personnel from logistic, maintenance, and collaborating partners. Therefore, various parties need to be involved in the DIP project. The DIP project has three central organisations and roles connected to the project, who interact with each other, see Figure 4.1.

DIP-Central - Responsible for the web hotel, Webshare, which lodges digital twins for the collaborating partners, provides both scanning tools and infrastructure to create a digital twin as a service for manufacturing companies.

Manufacturing company - The end costumer of the solution and owner of the digital twin, which all have a person responsible for the digital twin, is called a Digital plant manager.

Automation company - Develops and installs automation equipment at the manufacturing company.

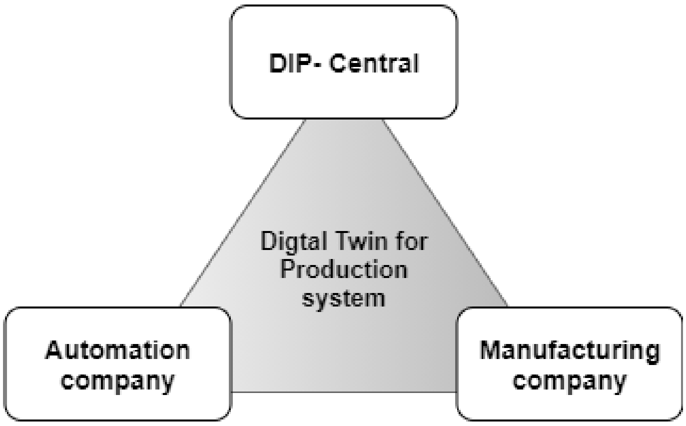

Figure 4.1: How the different roles interact with each other and the digital twin

4.3 DIP Method

DIP method consist of three parts, described in Figure 4.2, *digitalisation*, *configuration* and *installation*. Digitalisation focuses on capturing and measuring data, facility modeling, and data processing and distribution. Configuration includes virtual engineering such as layout design, simulation, and verification. Installation represents the physical installation, providing preparation for installation and complete system validation. The entire procedure is described in sections 4.3.1-4.3.3.

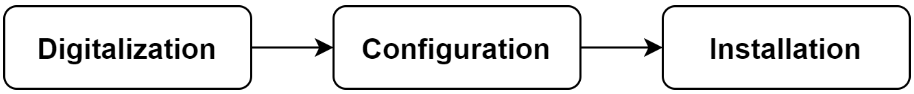

Figure 4.2: Current state of the work method in DIP

4.3.1 Digitalisation

Digitalisation is divided into three parts:

1. Preparation - planning requirements before conducting the scan
2. Execution - how to perform the scan and data collection
3. Data collection - how to process data collected from the scan

4.3.1.1 Preparation

The first step in initialising a digital twin is to have a clear list of requirements. The needs are specified to the area of interest that can be an entire factory or smaller areas inside a facility. The requirements are connected to creating a coordinate system in the factory or area. Creating a coordinate system requires a blueprint of the space, including automation equipment, construction details, and other relevant objects. Blueprints are typically provided physical format of 2D sketches.

A coordinate system of the area is also needed to measure the positions of elements and other equipment, which is essential to avoid errors in blueprints when working with modelling and installation of equipment. Therefore, the following information is needed before establishing a plant coordinate system in a factory or area:

- Floor plan of the factory including a coordinate system, including building elements. Here equipment can be included if they exist.
- Material of the building construction.
- Areas of interest and objects of significance in the digitisation.

4.3.1.2 Execution

To initiate the digitalisation, a work plan of how to execute the 3D scanning is created. During ongoing production, the work can be carried out to avoid any production disturbances and increase transparency towards the manufacturing company.

The next step is creating infrastructure on scanning points by assembling bricks of references, fixed points attached on permanent elements. The reference points positions are evenly spread out in the area with an altitude that enables clear vision from a distance. The bricks need a visibility of 180 degrees. As a result, a list of fixed points is created from the XYZ positions of each reference point. Scan positions for the reference frames should be scanned from a few spots as possible.

The sphere is an extension of the reference points for the scanner. They are used to merge the point clouds and find the points in each scan. The spheres are placed on the fixed reference points in the facility before continuing.

The next step is to select scan positions, which include as much information about the area as possible. The aim is to see as many fixed reference points as possible from the scanning position. Additionally, it is crucial to have at least one reference point in each quadrant of the area of focus. Therefore, temporary reference points are sometimes used to support the fixed references in areas with blocked vision, for example, in narrow spaces. Subsequently, the scanner is placed and levelled on the predefined scanning spots. The collected data from the scan is automatically stored on a memory card.

4.3.1.3 Data processing

Every scan creates a file containing a small point cloud that merges into an immense point cloud. The files containing the point clouds are uploaded to a server and ready to be quality checked. The data is processed and projected on the blueprints provided and locked into place by aligning the data with the reference spheres and blueprint coordinate system. For every project, a quality report is created to display the digital twin's accuracy to validate that the data meet the specific project's requirements.

The data is available for view on the Webshare platform. Webshare is a database that enables visualization of the factory, measuring distances and exploring areas of the factory. In Webshare, an overview of the factory's digital twin is displayed. The scanned positions generate a virtual reality of the factory where it is possible to move around using the scanned data points. No extra software is necessary to use the platform. For advanced applications, the point cloud is extracted and compiled for 3D layout planning, CAD-modeling of new components or existing ones in the point cloud.

4.3.2 Configuration

The configuration focuses on layout planning but can be used for various purposes. For example, installation of robotics, communication of robots between different production processes, production flow simulation, and access simulation. Before initiating configuration, one of the following data items is needed, where the first-mentioned is the optimal source of reference:

- The most important factor is the data of the point cloud. It needs to be accurate with many details, normally down to 2mm, true and neutral, scanned with a laser where the possibility of interpretation of the data is eliminated.
- If it is not possible to receive point cloud data a detailed and correct measured 3D- models of the installation is required. The models should be as close to reality as possible with correct measurements.
- The last possibility is a volume correct 3D model, similar to a cube with maximum measurements if the details of the construction are completely unknown.

After receiving the point cloud data, the primary step is to prepare it by breaking it down into segments, dividing the point cloud into different parts and separate the movable objects. For example, walls and beams are helpful as fixed positions, while movable objects, such as machines or other equipment, need to be movable for layout planning. After separating the point cloud, a draft layout is created to visualize the idea and form available data, containing a merge of 2D blueprints, 3D CAD data, and point cloud data. Several different programs work with the point clouds, such as Autodesk Recap, Farosin, Cloud Compare, and Navisworks.

Working with the draft model enables many opportunities for analyzing and improving the future settings, layout and finding possibilities for further development. In addition, when reaching a close to a finished model, a virtual reality model of the layout can be used to visualize the actual scenario better to display real-life settings virtually.

The mature, finished model requires validation to ensure that all-important system functions are covered, including a safe and efficient workplace, eliminating installation problems, and ensuring maintenance abilities. To collect feedback and validate the finished model, meetings involving various experts in the field, such as operators, logistic personnel, and maintenance. If necessary, changes are made to the mature model based on the feedback. Ultimately, the model needs to be accepted and approved by all interests of relevance before considered finished.

4.3.3 Installation

Data is collected and need to be prepared so that the installation uses correct information, ensuring that the physical objects match the objects in the digital world, such as attributes as beams and baulks. Furthermore, the point cloud contributes with references and relations to structure that identifies limitations or obstacles, such as uneven floor and blocking beams, which might cause issues in the installation process. As reactions, measures might need to be taken to enable the installation to work correctly.

The next step is to measure the main reference characters, such as robots and machines. These will be placed first since they cooperate with other parts of the production. Material handling is installed afterwards with the main characters as a reference point.

There are different methods for measuring points, a tachometer, laser tracker, measuring tape. The ambition is to use a tachometer or laser tracker, but a stencil can be used for placements of points if not possible. Thus, placement points are marked along with possible areas of collision in the surrounding environment. Additionally, plausible deviations are marked before drilling holes and bolts. After, the equipment is placed according to the point cloud data and controlled measured before conducting a test run.

4.4 Guidelines

During the last year, guidelines to the existing methodology have been created. Three guidelines have been created by DIP central that has been divided into areas of digitalisation, configuration, and installation, following the DIP method. The purpose of the guidelines is to provide a described and structured way of work with the DIP method.

5
Findings

This chapter presents two main sections, findings from the literature study and findings from the interview study. Firstly, presenting the literature study including two topics, challenges for SMEs in digitalisation and change management models and after that, presenting findings from the interview study. The structure of the interview findings follows the structure used during the interviews.

5.1 Literature study

The literature study divides into two fields, the relation between SME and digitalisation and change management models. For the relation between SME and digitisation, several needs and challenges were identified, and as the study progressed, similarities were identified with papers mentioning the same topics. In change management, several models were examined to find possible correlations to this study.

The articles were divided into categories based on the paper's topic, which ultimately generated seven categories; Economic assets, resistance to change, leadership, digital strategy, lack of skill, and technological resources and change management. Insights from the study show that SMEs have small economic resources, and resistance to change are significant factors that should not be overlooked. Leadership in the organisation has a big responsibility to promote change and new ideas. Furthermore, SMEs often lack a digital strategy fundamental for digitalisation and a clear vision for the future. Moreover, SME lacks the required skills, knowledge, and technical resources to implement the required technologies. Lastly, two change management models were found to help to implement changes in organisations. Table 5.1 presents a summary of the topics and references used, all of which will be described further in sections 5.1.1-5.1.7.

Table 5.1: A compilation of found literature and the topics they represent

Category	Description	References
Economical assets	Economical possibilities for SMEs to implement digital solutions	(Peillon & Dubruc, 2019) (Masood & Sonntag, 2020) (Mittal et al., 2018b) (Moeuf et al., 2018a) (Kumar et al., 2020)
Resistance to change	Where resistance to change can be found in SMEs	(Eller et al., 2020) (Wiesner et al., 2018) (Mittal et al., 2018a) (Moeuf et al., 2018a) (Amaral & Peças, 2021) (Peillon & Dubruc, 2019)
Leadership	How leadership affect digitalisation in SMEs	(Eller et al., 2020) (Amaral & Peças, 2021) (Kumar et al., 2020)
Digital strategy	What strategies can be used to implement new digital solutions in SMEs	(Eller et al., 2020) (Florian et al., 2018) (Gressbauer et al., 2016) (Genest & Gamache, 2020) (B. Huang et al., 2013) (Wiesner et al., 2018)
Lack of skill	What competences SMEs are missing	(Eller et al., 2020) (Mittal et al., 2018a) (Masood & Sonntag, 2020) (Amaral & Peças, 2021) (Genest & Gamache, 2020) (Moeuf et al., 2018a) (Kumar et al., 2020) (Florian et al., 2018)
Technological resources	What technical limitations exists	(Peillon & Dubruc, 2019) (B. Huang et al., 2013) (Moeuf et al., 2018a)
Change management	Two models limitations exists	(Kotter, 2012) (Bullock & Batten, 1985) (Szarek, 2017)

5.1.1 Economical assets

ROI is an essential factor in any enterprise, along with the availability of financial resources, where SMEs are presented with many risks due to fewer margins (Mittal et al., 2018a). Masood and Sonntag (2020) also discusses financial resources, cost, and finance issues as immense challenges for SMEs. Furthermore, SMEs lack finances for research and development due to a lack of knowledge, how to manage complex technology solutions and have expertise devoted to only production processes (Moeuf et al., 2018b).

SME are economically constrained compared to big corporations, generating reduced possibilities to access available technical resources and abilities to develop production when focusing on digitalisation and Industry 4.0 (Mittal et al., 2018a; Peillon & Dubruc, 2019). Thereby, the financial risk increases when implementing a developing project for production in SMEs. In developing countries, this is especially difficult due to bad economies (Kumar et al., 2020).

5.1.2 Resistance to change

In organisational culture, an often underestimated problem is peoples unwillingness to adapt to radical change when working with digitalisation (Peillon & Dubruc, 2019). In the process of digitalisation, employees' willingness to change is fundamental. Thus, tools used to work towards Industry 4.0 requires alignment with the workforce for easy adaption (Amaral et al., 2019).

Furthermore, flexibility in organisational culture is limited, which restricts initiation of advancement in new technologies (Mittal et al., 2018a). According to Moeuf et al. (2018b), SMEs are afraid of investing in the wrong technologies beyond their main competencies in-house due to lack of resources. Therefore SMEs typically have a longer initiation time for adopting new technologies. Furthermore, introducing new technologies needs to be introduced together with a focus on culture, relieving pressure on the workforce to change their behaviour rapidly. Thus, it is fundamental to prioritise deciding how the company will work, what skills are required, and evaluate people's willingness to change before taking action (Wiesner et al., 2018). In similarity, Eller et al. (2020) discusses future normality, values carefully and promote knowledge exchange between people.

5.1.3 Leadership

The top management has a significant responsibility in digitalisation to work with culture change and see investments as a long-term goal instead of focusing on short-term winnings. Furthermore, to support and create awareness and promote winnings for employees using new technologies (Kumar et al., 2020). Moreover, management is responsible for leading and keeping the new ideas' momentum and determining goals and milestones in a digitalisation process (Amaral et al., 2019). Additionally, educating employees to obtain the required skills needed for digitalisation (Eller et al., 2020).

5.1.4 Digital strategy

SMEs usually lacks a long-term development strategy (B. Huang et al., 2013). In digitalisation, there is a need for a digital strategy that encourages innovation to absorb knowledge from all available sources where the organisation must promote creativity, risk-taking, and innovation. Applying digitalisation and creating awareness in organisations requires the availability of competent people, well-connected and informed (Florian et al., 2018). Additionally, a well-established business strategy will ease implementing components in industry 4.0, where organisations with a well-defined strategy are more likely to succeed (Genest & Gamache, 2020).

To strive for industry 4.0 and be more digitalised, a vision for the future needs to be clearly defined. An organisation needs to evaluate its maturity to set realistic goals for the following years. Thereby, organisations can identify their strengths and realise what competencies are required. Pilot tests are encouraged to identify competencies and map how industry 4.0 can enhance the overall business and processes. Pilot tests attack issues such as difficulties in calculating the economic benefits of new technologies and time limitations in demonstrating technologies. Furthermore, pilot tests can teach the methodology and create possibilities for the organisation to support the new ideas (Gressbauer et al., 2016).

In SMEs, managers are responsible for developing a digitalisation strategy, including key performance indications and concrete actions to overview the transformation to ensure the desired outcome (Eller et al., 2020). One method to display benefits and means of application is to provide success stories, which will contain motivation, support, and training for a successful implementation (Wiesner et al., 2018).

5.1.5 Lack of skill

The biggest obstacle in implementing new technologies, such as industry 4.0, is a lack of knowledge and skill (Genest & Gamache, 2020). SMEs need varied skills, from hard skills, providing technology usage, and analysing prominent volumes of data to soft skills, which focus on accepting change, problem-solving, idea creation, and recognising opportunities. These skill sets and collaboration within a network are critical elements in a digitalisation process (Eller et al., 2020).

SMEs lacks access to shared knowledge which makes the knowledge more concentrated in a specific area (Moeuf et al., 2018b). Despite that, SMEs have a low probability of gaining a high level of knowledge in a specific field because SMEs have more variation in daily responsibilities.

Furthermore, employees lack available resources providing supervised training, mentors, and workshops (Mittal et al., 2018a). According to Amaral and Peças (2021), personal training of employees is a prerequisite in a digital transformation. Masood and Sonntag (2020) mentions hands-on workshops to provide solutions and create awareness of the newest technologies, with the help of training and support. Additionally, providing education and training will allow employees to gain capabilities and skills required (Florian et al., 2018) where one possibility to acquire the expertise needed is to turn to external sources (Kumar et al., 2020). Another method in digitalisation is to minimise changing employees' routines, where an option is to take advantage of already known digital tools (Amaral & Peças, 2021).

5.1.6 Technological resources

For SMEs, high technology production is necessary for survival on the market today, which is a challenge for many companies since they are still using old and not updated technologies (B. Huang et al., 2013). With digitalisation, several new tools are emerging with a variety in complexity (Peillon & Dubruc, 2019). However, SMEs have problems handling complex computer solutions, which is palpable by a low application of new technologies. Most technologies are entirely ignored, such as CPS, big data, and collaborative robots, allowing genuine transformations. However, the cheaper and introductory technologies as simulation and cloud computing are more established in SMEs (Moeuf et al., 2018b).

5.1.7 Change Management

As mentioned in section 2.6, there are several change management models used today. Two models considered for this study is a planning model of Bullock and Batten (Bullock & Batten, 1985) and Kotter's eight accelerators for change (Kotter, 2012), each described below.

5.1.7.1 Planning model

Bullock and Batten created a change management model focusing on entire organizations and not interpersonal relationships during an implementation (Szarek, 2017). The model is divided into phases and processes, where phases is standard carried out in consequential order and the processes will occur within the phases. The model is divided into four different phases, *exploration*, *planning*, *action*, and *integration*, see Figure 5.1 with included processes (Bullock & Batten, 1985). The planning model is explained in accordance to Bullock and Batten (1985) below.

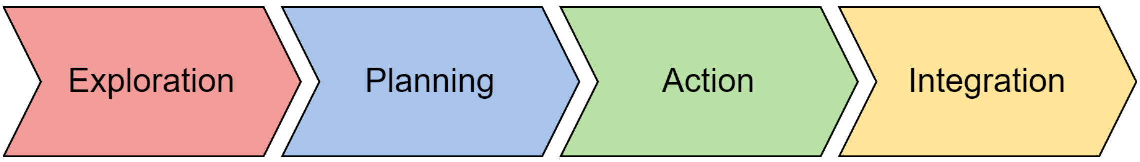

Figure 5.1: Phases of the planning model by Bullock and Batten (1985)

Exploration phase is a pre-planning phase where the need for change will be verified. The phase contains researching what types of skill is necessary, how to allocate them for the change project to progress and taking decisions in development.
Planning phase involves decision-making, where experts around change make decisions and approve the proposed plan.
Action phase, focuses on implementing change according to plan and validation of the change. If the changes are progressing according to plan, there will be an opportunity for re-planning and making changes permanent.
Integration phase is a post-auction phase to stabilise and integrate the change process. Here, the change will be aligned with other areas of the organisation by establishing new policies, rewarding the use of change, and updating the company about continuous change.

Table 5.2: Phases, Processes and process description adapted from Bullock and Batten (1985)

Phases	Process	Process description
Exploration	Need awareness	Creating awareness of problem or need
	Search of resources	Establish contact with possible consultancies and resources
	Contracting	Develop economical and psychological contracts
Planning	Diagnosis	Gather data of current state in organization. Analyse data
	Design	Set goals and priorities
	Decision	Decision maker approve developed plans and strategies
Action	Implementation	Implement and develop the action plan
	Evaluation	Evaluate effects of the implementation
Integration	Stabilization	Integrate change into the social system and terminate external consultation
	Diffusion	Successful change are spread to other parts of the system
	Renewal	Continual learning and change is encouraged

The planning model is commonly used in case studies where the four phases create an opportunity to compare each phase between studies to understand differences and learn from them. Furthermore, creating possibilities to display how variations in each step affect the desired result between cases. Thus, the model supplies a general structure for planning and for others to gain knowledge. Also, the model provides understanding, help identify strengths to avoid backlashes and create possibilities to test theories and accumulate knowledge (Bullock & Batten, 1985).

5.1.7.2 Kotters Eight Accelerators for Change

Kotter created a model based on eight accelerators, see Figure 5.2, which will change the organisations' way of handling change and resistance to change (Kotter, 2012). Preparation of the internal environment is required to prepare for change, where and after initiating change, new habits in team behaviour are created focusing on employees (Szarek, 2017). In the list below, Kotter's eight accelerators are presented in accordance to Kotter (2012):

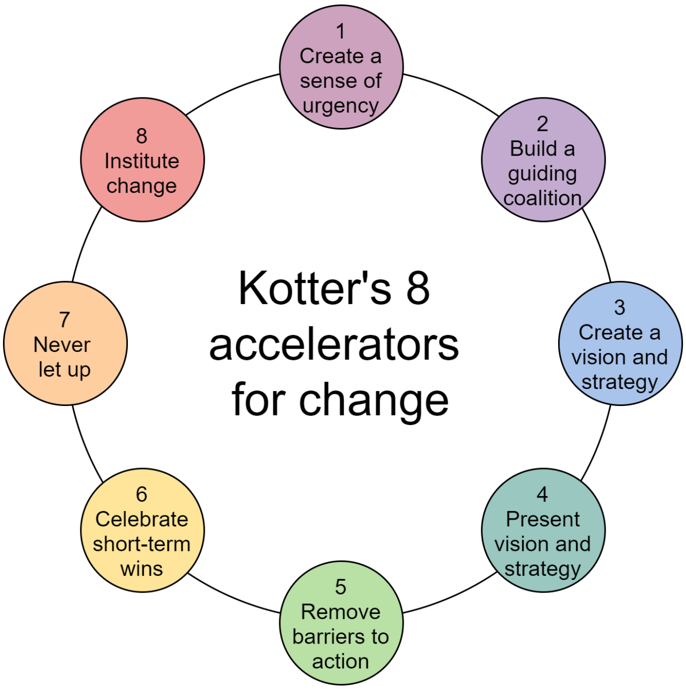

Figure 5.2: Visualization of Kotter's 8 accelerators for change adapted from Kotter (2012)

1. Create a sense of urgency around a single big opportunity which is important for the organisation to keep being aware of the constant need for improvement to stay compatible. The urgency has to start from the top of the hierarchy to spread to the rest of the organisation and make people do their best to improve their everyday work.
2. Build and maintain a guiding coalition to collect and process information about the organisation, groups from each hierarchy level. The group are voluntarily put together to have the responsibility to make decisions about their hierarchy level. As a consequence, generating faster decision-making because hierarchy levels in the organisation are more connected.
3. Formulate a strategic vision and develop change initiatives designed to capitalise on the significant opportunity. If there is a well-formulated vision, it can help the guiding coalitions to stay motivated, doing good work, and taking decisions without seeking continuous permission.
4. Communicate the vision and strategy to create buy-in and attract a growing volunteer army. The guiding coalition needs to spread the vision in a way to becomes memorable and exciting. If carried out correctly, the vision will go viral and attract employees to commit to the new change. As a consequence, a violent army backing the vision will form.
5. Accelerate movement toward the vision and the opportunity by ensuring removed barriers in the network. The guiding coalition can investigate all types of problems across the organisation.
6. Celebrate visible, significant short-term wins. To convince those who are sceptical about the change about positive effects. All small progress linked to the vision will be celebrated to show that the vision is manageable and the volun-

teer army will grow.
7. Never let up, keep learning from experience and do not declare victory too soon. An organisation must keep finishing the project and constantly find new ones to adapt to the shifting business model to ensure competitiveness. If slowing down on the working pace, the volunteer army will shrink.
8. Institutionalise strategic changes in the culture. No change is done until it has been incorporated into the daily activities in the organisation.

5.2 Interviews

This section presents findings from the interview studies held with participating companies in the DIP project and one expert in research communication. In total, eight people interviewed in the study, including two follow up interviews with two representatives. In total, nine interviews were carried out with people with six different titles. A complete list of roles of representatives is presented in Table 5.3. As a clarification, the research communication expert responses is only referred to in section 5.2.6.

Table 5.3: Roles of the interviewees

Occasion	Role
1	CEO
2	Lean Champion and Manufacturing Engineer Automation Engineer
3	Senior Manufacturing Engineer
4	CEO
5	Automation Engineer
6	CTO
7	Research Communication Expert
8	Lean Champion and Manufacturing Engineer
9	Automation Engineer

5.2.1 Getting involved in DIP-project

The interviews stated that to be a part of the DIP project the companies was either in close contact with people from DIP-central or joined via other included parties. Also mentioned was that one person at each company was the main driver, promoting the ideas from DIP-central and pushing the project forward.

All respondents said the knowledge level going into the project was relatively low. Most technologies in the DIP method have been on the radar, heard of, or discussed as new possibilities. Additionally, none of the participating companies has implemented any of the technologies used in the DIP method before the invitation to the DIP project. All respondents confirmed that there had been no clearly defined goals with participation in the project. The overall motivation for participation was to try the techniques, learn more about using a digital twin, and use point clouds to perform layout planning.

5.2.2 Old vs new methodology

Respondents explained that the traditional and established method for working with layout planning and installations uses 2D sketches with blueprints or 2D CAD software, which all the participating companies are used to working with for a long time. The typical view of working with 2D layout planning is that experienced layout planners more easily understand the layout than a less experienced person, primarily due to lack of visualization. One respondent mentioned that the lack of visualization generates spending time going to the physical work area, checking potential risks and space problems. Several interviewees mentioned the lack of height measurement in 2D sketches, which generates time spent at the physical work area to take measurements. Additionally, several interviewees mentioned possibilities in creating a 3D model from a 2D sketch by modelling the objects in the 2D sketch using 3D CAD software. However, the idea was neglected by most interviewees due to time and the risk of not being accurate enough.

All the interviewees stated that the DIP method could offer better visualization, which would generate more efficient work. Most respondents also liked the idea of taking measurements without having to enter the physical factory. Some other examples of benefits of using a 3D model mentioned by the interviewees were:

- Reduced planning time
- Open discussions about insecurities
- Possibilities to identify and prevent problems early
- A basis when communicating with suppliers
- Creating a good dialogue between operators

5.2.3 Resistance to change

All the interviewees considered the DIP method helpful. However, the organizations had issues implementing and spreading the DIP method due to strong resistance to change. Some factors mentioned was:

- Lack of understanding of the new technology
- Not fully understanding why the DIP method was necessary
- Not completely understanding what the DIP method will generate
- Older generation had stronger resistance to change
- People tended to be judgmental and critical towards the new method

The interviewees mentioned that when new methods were presented, the work was carried off as previously. Additionally mentioned was alignment with market needs, where implementation would be considered if the market demanded it.

5.2.4 Transfer knowledge throughout the organization

All the respondents were very convinced about using the DIP method and new technologies the DIP method presents. Moreover, most respondents said that people within the same organization had little insight into the DIP project. Some interviewees gave access to information about the DIP method via Web Share, but the interest level was low. Furthermore, one case tried to implement the method in another factory without success where the work methods were not applied, and the traditional way of working was used. Finally, when considering the involvement of management, respondents had a mix of interaction from top management, where some had complete support while others lacked enthusiasm.

5.2.5 Skill and recourse

Multiple interviewees said that a big issue for them was not having enough skill to carry out some of the steps in the DIP method. A significant challenge was to keep track of the many software needed and the interaction between them. Moreover, one interviewee said the overall process was initially quite complex. As for now, the interviewees said not having enough educated and competent personnel to work with the DIP method alone. However, they felt great confidence in the method when assisted by DIP central or other external scourers.

One interviewee also said that they do not have the technical resources to perform some of the tasks the DIP method suggests, such as robot simulation in a point cloud. The reason was that the task requires a lot of computing power with today's available software. Another interviewee said that a significant challenge is handling a large amount of data in the point cloud.

5.2.6 Support

The expert in research communication described difficulties in transferring research to others due to its complexity. Researchers tend to be extremely good at answering what, but not the question of why. Moreover mentioned, the focus needs to clarify answers to why to attract people and make messages/information understandable.

The expert in research communication described the guidelines created for the DIP method as a complex with a confusing mix of information and instructions, making the guides unclear to fit one purpose. Furthermore, explaining that the guidelines are high in complexity needing to be made more straightforward, for example, by using bullet points. Ultimately, instructions and information need to be separated to avoid the text being long and dull.

All interviewees stated that they had barely viewed any of the created guidelines handed out by DIP-central, aside from reviewing the documents. For one of the interviewees, specific projects were conducted before the guidelines were created as an argument. However, most interviewees could not justify not viewing the guidelines.

5.2.7 Continued work

After participating in DIP, all respondents said that the enthusiasm for continued work is high, and multiple responses will continue working with the DIP method. All interviewees mentioned an increased level of knowledge, and several interviewees mentioned that 3D layout planning would suffice as a complement to the 2D layout. One interviewee motivated this by saying that cooperating partners and companies are still using 2D models. Many respondents also mentioned the usage of point cloud for installations where space is limited and the margin is minimal. Additionally, some respondents did not believe the methodology will be used in daily work.

After finishing the project in DIP, not all respondents know how to proceed correctly. The examples given were due to a lack of knowledge, not knowing how to maintain and expand the proposed DIP method, and insufficient motivation or support.

One participant highlighted that to make future changes in technologies, and it is essential to explain what amount of money is earned by doing so, which needs to be visual and concrete. Additionally, time is money, and money is a substantial driver in decision-making and a limitation in investing in new technologies.

6
Analysis

This section presents an analysis with a comparison between findings from the literature and interview studies. The comparison highlights findings on challenges and needs both described in the literature and interview study. The analysis is divided in topics in similarity to findings, economic aspects, resistance to change,lack of top management, digital strategy, lack of skill and support.

6.1 Economic aspects

The findings from the literature study show that SMEs most considerable challenge when investing in new technologies is the economic aspect. SMEs tend to have small investment opportunities due to their low financial assets. The study also shows that if an SME should invest in new technologies, there needs to be a clear plan of the ROI to motivate the investment. In similarity, the interview finding present economic gain is a priority when implementing any new changes such as new technologies to motivate any investments. The DIP-central has managed to find SMEs willing to invest in the DIP method due to close contact with the companies and some discount on the work performed.

Furthermore, it is essential that DIP-central motivate SMEs to invest in the DIP method and motivates companies of the benefits and applications by using success stories connecting to findings in the literature study. The interview study generated a positive response from in using 3D modeling together along with good feedback after execution that can be taken advantage of. So far, DIP-central has not documented any success stories of how long the ROI can be or how much the participating companies have earned or saved with the DIP method. However, there is an opportunity to find success stories in both economic and performance aspects to make the DIP method more attractive and spread to new companies.

6.2 Resistance to change

The literature study presents that resistance to change is an underestimated problem when implementing new technologies. In similarity, interview study findings suggest several issues when implementing DIP method. More details entail struggles with old generations, old habits, and people's tendency to be reluctant to new technology. Also, staying with already established work methods, such as 2D and not applying new technologies is seen as a factor of resistance to adapt to changing environment.

The literature emphasises introducing change carefully with a key focus on culture to reduce resistance to change. On the contrary, stated in the interview study, companies did not thoroughly plan for the activation of the DIP method but seized the opportunity given not having a plan. Therefore, most participants in DIP did not have a structure of how to present new technologies(change) to the organization.

The literature study explains that before initiating change, it is necessary to know how to carry out change, what skills are required and how people perceive change. Furthermore, the expert in communication pointed out the importance of motivating why to do something, where findings from interview study suggests that both the knowing how and why has not been fully acknowledged since a vision and predefined goals were missing.

Findings from the interview study identifies difficulties in not fully managing to spread awareness of the need for change and the methodologies. Literature presents the need for competent people to create awareness and strive for change.

6.3 Leadership

The literature identifies the necessity of active top management responsible for culture change and to leading and keeping new ideas. In similarity, Kotter's model describes the need for a guiding coalition and the need to formulate a strategic vision. Findings from the interview study, on the contrary, describes not having a strategy or goals for taking part in the DIP project, not initiated by top management and with a low-level interaction from top management. Instead, the main drivers pushed the project forward.

Engagement and strategy formulation from the manager is according to the literature study important, and findings from the interview study present several companies lack directives in continuing with the DIP method. Additionally, the interview study presented issues in lack of motivation and support for continuation. The literature findings emphasises the importance of adequately set goals and educating employees from top management.

6.4 Digital strategy

From the literature study SMEs need to have a strategy of working with digitalisation, and usually, SMEs lack just that. In similarity, as stated from the interview study the companies did not have a plan or intention for involvement in DIP. Moreover, there were no clear goals set, which from the literature study is fundamental including the need for a strategy towards industry 4.0 and digitalisation. In relation, the interview study presents an unclear and non directed continuation of using the new technologies after terminating the DIP project, which is probably a reaction to not having a strategy.

6.5 Lack of skill

The literature study shows that SMEs' lack of skill and knowledge are immense challenges for SMEs. Due to the variety in daily responsibilities knowledge in SMEs tend to be concentrated in specific areas, that puts limitations in allocating knowledge. In similarity, findings in the interview study presents difficulties in transferring knowledge throughout the organization. Furthermore, employees who have not participated in implementing the DIP method lack skill and knowledge of how the methodology works, how to use it and lack general interest in learning the DIP method. The interview study shows that the DIP method is initially quite complex and the amount of software needed to use the DIP method makes the process slightly harder, confirming findings of a knowledge gap.

The literature study also shows that SMEs do not have access to the same amount of technological resources as larger corporations. Additionally, showing that SMEs struggles in handling advanced technologies, which is confirmed by the literature and interview findings. Additionally, an interviewee said they did not have enough computing power to perform robot simulations in a point cloud, an example of an SME not capable of handling big data.

The literature study presents pilot tests as an adequate method for mapping and creating possibilities to support new ideas, where a gained knowledge has led many people to continue. Participation in DIP can be seen as a pilot tests, which can therefore relate to a positive factor of gaining knowledge, also supported by interview findings.

6.6 Support

The interview study mentions that employees lack available resources to provide training, mentors, workshops and to sufficient support. Moreover, the findings from the interview study, says the initiative for education has to come from management. A parable is the guidelines created by DIP central to provide support. However, as further mentioned, the formation of the provided guidelines is complex and, at the moment, does not fit a single purpose. Thus does not suffice as support, which can be connected to the shared use of the guidelines so far.

6.7 Summary

A comparison of findings in literature and interview studies identified several similarities and information that supported each other. The literature study expressed several cases of needs which on the contrary was identified as missing in the literature study. Furthermore, challenges with DIP method go in line with already established challenges SMEs face with digitalisation and the similarities in challenges in need presented in Table 6.1 below.

Table 6.1: Identified challenges and needs for SME and DIP method

Title	Identified challenges and needs
Economic aspects	Low economical assets in SMEs Need to provide economical gain to motivate investment Reaching out to companies
Resistance to change	Difficulties in spreading awareness Sticking to old work methods Transferring knowledge throughout organisation Not knowing how or why
Leadership	Need to initiate new technologies Low engagement from top management
Digital strategy	Lack of strategy No clearly defined goals Need of pilot tests
Lack of skill	Lacking initial knowledge Low knowledge about new technologies Struggles in using advanced technologies
Support	Need of support Adapting guides for various uses

7 Recommendations

This chapter presents three sections. The first section provides a structure and motivation for the creation of the developed DIP model. The second part provides recommendations for DIP-central of how to support and help companies with the DIP model to handle the challenges and needs in SME. The last section presents a summary, connecting to challenges and needs acknowledged in the previous chapter.

7.1 Applying Change Management

Using change management is a recommendation to address issues identified in the previous chapter. By providing a holistic framework following the planning model by Bullock and Batten (1985) a systematic structure can be used to work with the DIP method. The structure is presented as the DIP model aiming to reduce resistance to change and make top management more involved from the start. Furthermore, the DIP model creates possibilities of gaining more knowledge and spread it in the organization and foremost providing a strategy to define goals and vision in an organized way.

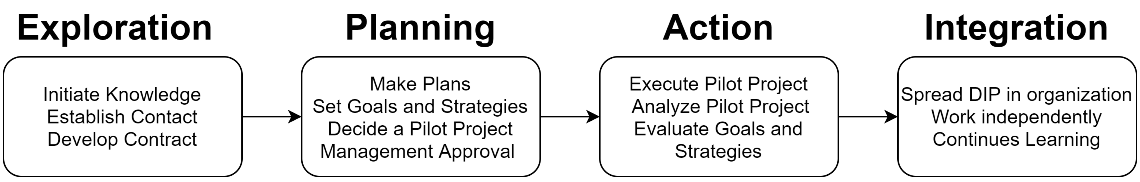

Figure 7.1: Summary of the created DIP model

The DIP model is divided in similarity to Bullock and Batten (1985), in four phases: exploration, planning, action, and integration. Each phase includes processes adapted for DIP, see Table 7.1 for a description of the processes in each phase. The processes are somewhat altered, and the DIP model includes a pilot project since it felt relevant to test the DIP method on a smaller scale. Furthermore, the DIP model includes a process in the action phase called "Evaluate goals and strategies" to ensure the preset goals are updated after the pilot project. Lastly, a final process was added in creating own standards in an organization based on the DIP method to integrate the DIP method in the organization altogether.

Table 7.1: Suggested framework based on the planning model by Bullock and Batten (1985)

Phases	Processes adapted for DIP
Exploration	Spread awareness about problems and challenges Gain knowledge about the DIP method Establish contact with DIP-central Develop contracts with DIP-central and necessary resources
Planning	Analyze internal capabilities and resources Define strategy and set goals for DIP method Decide a pilot project Top management involved to approve plans and strategies
Action	Carry out pilot project with support from DIP-central Analyze and evaluate the results of pilot project Evaluate goals and strategies
Integration	Start integrating change in entire organization Work independently with less or no assistance from DIP-central Continuous learning about DIP method and technologies Create own standards for DIP method in organization

Section 7.1.1-7.1.4 presents the DIP model in greater detail with a complete description of all phases and processes.

7.1.1 Exploration

The goal in the exploration phase is to gain knowledge of how the DIP method can be applied and benefit the company to address challenges with digitalization. The goal will be reached through establishing contact with DIP-central.

DIP-central will educate material about the DIP method and its essential parts, digital twins, point cloud, and the DIP method in general. The provided material will lead to a higher knowledge level of how the DIP method can be used and convince the decision-makers that the new methodology will be economically beneficial.

When the decision-makers have been convinced of implementing the DIP-methodology contracts with DIP-central and necessary resources can be allocated.

7.1.2 Planning

Initially, the company will evaluate capabilities and available resources to understand what prerequisites exist. Thereby, gain knowledge of what action can be performed with competencies in-house and evaluate what competence and assists to be acquired from DIP central.

Furthermore, strategy planning and goal definition is an essential process in this phase. The company and DIP central will work together to develop a defined future strategy with clearly defined goals. Thus, setting intentions for an initial pilot project on what will be done, how, and future ambitions.

Top management is the drivers for strategies and goals to be enforced and approves proposed plans.

7.1.3 Action

The company follows the DIP method in changing projects for production layout planning. Support is adjusted for the company's knowledge level and competence. The aim for this level is to gain further knowledge of how to work with a digital twin by using the available tools provided by DIP-central.

When the pilot project has been carried out, the project is summarised and evaluated. The project is evaluated by comparing the outcome with the goal. If the goal has been achieved, the pilot project is considered a success. If the goal is not achieved, the company needs to evaluate the pilot project further and adjust the goal and strategies accordingly.

7.1.4 Integration

The company integrates the DIP method in the organisation, and work with layout planning requires less or no assistance from DIP-central. To increase the use of the new methodology, the organisation involves more instances for the DIP method to spread knowledge and be helpful to more people and not only layout planning.

The pilot project results can be displayed and communicated to increase involvement and use internal workshops to spread knowledge about the DIP method. Resulting in continued learning about techniques and a deeper level of knowledge.

Those who adopt the new methodology should be rewarded for using it to increase the chance of successful integration. New areas of implementation need to be explored to keep utilising the DIP method.

When the DIP method is wholly integrated into the organisation, new standards, and work methods are applied, customised for specific organisations.

7.2 Support from DIP-central

As the planning model by Bullock and Batten (1985) proposes, DIP- central will have an active role in phases one, two, and three of the DIP model. The support from DIP-central aims to address issues as economic aspects, definitions of goals and strategies, and availability of assistance.

In each phase, several means of assistance will help organisations throughout the entire process, see Table 7.2. The assistance focuses on introducing the project as which the subsequent sections will present in greater detail containing setting goals, providing workshops, and creating manuals both informative and instructing.

Table 7.2: Suggested support from DIP central

Phases	Suggested support
Exploration	Contribute success stories about DIP method Offer workshops about the DIP method Mediate contact with necessary resources Help develop contracts with necessary resources
Planning	Develop strategies and goals with the company Workshops to find out capabilities at the company Decide a pilot project
Action	Support in pilot project Supply material for evaluation Retrieve feedback
Integration	Provide manuals for software Emergency contact Evaluate project by comparing between cases

7.2.1 Exploration

DIP-central needs to create a marketing strategy so that decision-makers can find it. They need to share success stories and economic gain to raise awareness of advantages to make SMEs interested in using the DIP method. Furthermore, DIP-central has to create marketing material to reach companies for a long-term sustainable solution for companies finds the DIP method. The marketing strategy will enable easy contact with DIP-central and get further information and guidance on starting working with the DIP method.

Since DIP-central already has established contact with cooperating partners, companies will have available recourse via DIP-central and do not have to spend time finding appropriate cooperating companies.

Increasing initial knowledge motivates why the DIP method is essential to convince companies about the benefits of working according to the DIP method. Then, how to proceed, DIP-central can provide workshops. The expert in research communication suggested a framework for workshops using 4-MAT.

4-MAT is a teaching method that provides a framework for individuals based on different learning styles and how individuals perceive information. Furthermore, generating learning for all participants, addressing organisational problems (Kaplan, 1998). 4-MAT is beneficial for increased learning motivation, application, and extension of learning (Sezginsoy-Şeker & Dikkartın-Övez, 2018). 4-MAT is structured in four quadrants with two divisions, see Figure 7.2. The quadrants are personal meaning(why), fact-leading to understanding(what), knowing how things work(how), and self-discovery(if) (Tatar & Dikici, 2009).

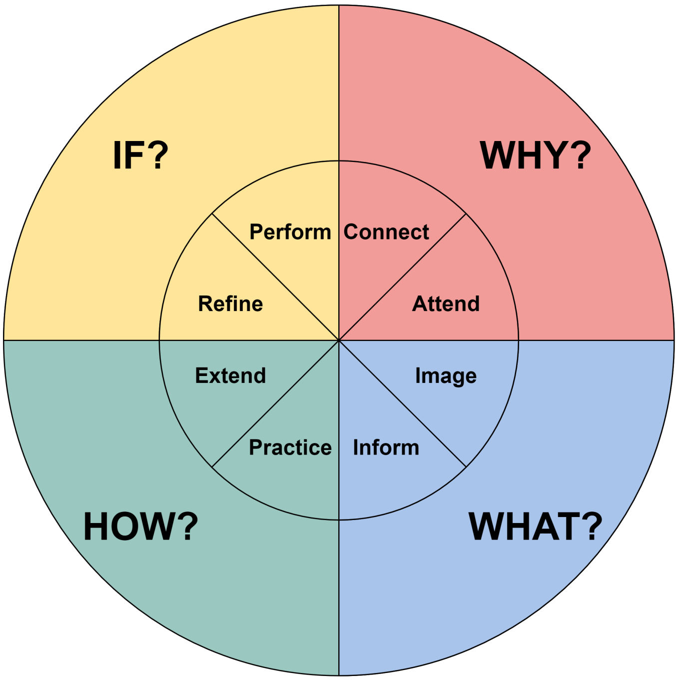

Figure 7.2: Structure of 4-MAT

The four quadrants are presented by (Aktas & Bılgın, 2015) and (Fickl et al., 2020) below:

The first quadrant answers the question of why connecting to value and knowing the actual purpose of doing something. Furthermore, focusing on associating and familiarise with a new concept and motivate learning. The two divisions are connected and attend. Connect strives to create a relation between old concepts and new by connecting to own experiences. Attend is to analyse the previous step of experiences, to share and learn about other people's experiences.

The second quadrant provides essential information about what will be learned, basically displaying facts and details. It also focuses on concept generation by comparing old and new work methods. The two divisions are image and inform. Image is about envisioning the concept to create a better understanding that can be made by sketching. Sketching allows visualisation of relations and seeing parts of the concept. Inform focuses on activities for people to learn about the concept by providing easily accessible information, for the subjects to do investigate further.

The third quadrant gives a sense of learning where the knowledge is practically tested to grow confidence, which focuses on individualised learning. The two divisions are applied and extend. Apply is trying knowledge of the concept using worksheets as guidance where the subjects are active with support from a teacher to solve a problem. In Extend, the subjects get the opportunity to create their materials to individualise the experience, enhance their knowledge, and create their projects.

The fourth quadrant is vital for continuous development, where a problem is identified, and real-life scenarios will be discussed and explored to analysed. Furthermore, enabling sharing of knowledge by sharing experiences. The two divisions are refine and perform. Refine focuses on making the subjects able to apply learned experiences where the teacher help correct mistakes. Perform is about sharing experiences and displaying lessons learned throughout the process to see variations in experiences and skill.

7.2.2 Planning

In the planning phase, DIP-central needs to provide material about how the company can develop a strategy and define goals for implementing the DIP method. The implementation process can be taught by providing workshops.

DIP-central also needs to find out what capabilities or skills the company has about layout planning to know how much support the company needs. Then, depending on the set goal and available skills, the organisation and DIP-central decides on an appropriate pilot project. A well-fit pilot project will increase the chance of a successful implementation of the DIP method.

7.2.3 Action

In this step, DIP-central needs to drive the pilot project forward with adapted support according to the company's knowledge level. The previous phase should already have defined goals and the companies capabilities for the project so that DIP-central will support according to the previous agreement. DIP-central will assist in the various parts digitalization, configuration, and installation.

After termination, a complete evaluation of the pilot project will be done. DIP-central has to provide material for this to be possible and thereby be able to receive feedback. Goals and strategies created together will be adjusted accordingly.

7.2.4 Integration

DIP-central has much responsibility to enable the organisations to work more independently with the DIP method. To do so, DIP-central is responsible for supplying material. The material will consist of manuals for software used in the DIP method and provide material for workshops that can be used internally. DIP-central will suffice as support to take part in the events and initiate seminars to increase the general level of knowledge.

Since the organisation is rather independent, DIP-central will work as a discussion partner and emergency contact. Specific details of the DIP method can be discussed, and issues can be ventilated and solved with help from DIP-central.

Using the structure of the DIP model, DIP-central can evaluate and compare each project. Thereby, find areas that might be more challenging and adjust the level of assistance and material provided.

7.3 Summary

Foremost, the DIP model will provide a systematic approach to working with the DIP method, generating helpful information for increased knowledge, developing a strategy and goals, evaluating projects, and providing assistance and possibilities to develop the DIP method further. In addition, the DIP model aims to handle issues identified for the DIP method and SME, see Table 7.3 for a summary of connected to what phases and participating companies.

Table 7.3: Identified challenges and needs, phase and recommendations for participating companies

Identified challenges and needs	Phase	Participating Companies
Low economical assets in SMEs	All	Using DIP method
Need of providing economic gain to motivate investment	Exploration	Displayed benefits
Difficulties in spreading awareness	Exploration, Planning	Increases level of knowledge
Sticking to old work methods	All	DIP model
Transferring knowledge throughout organization	Integration	Internal workshops
Not knowing how or why	Exploration	Increased initial knowledge
Need to initiate new technologies	Exploration, Planning	Digital strategy, setting goals
Low engagement from top management	Planning	Using 4-MAT
Lack of strategy	Planning	Defining strategy
No clearly defined goals	Planning	Setting goals
Need of pilot tests	Action	Gained knowledge by pilot test
Lacking initial knowledge	Exploration	Increased information early
Low knowledge about new technologies	Exploration	Using 4 mat
Struggles in using advanced technologies	Action	Pilot test to learn
Need of support	Planning	Evaluate resources and capabilities

Furthermore, the use of the DIP model suggests several actions for DIP-central to support the establishment of the DIP method. Table 7.4 presents a summary of challenges identified in the findings and which part of the DIP model aims to address the specific issue. Moreover, providing recommendations for DIP-central to support challenges and needs.

Table 7.4: Identified challenges and needs, phase and recommendations for DIP-central support

Identified challenges and needs	Phase	DIP-central
Low economical assets in SMEs	All	Provide the DIP method
Need of providing economic gain to motivate investment	Exploration	Provide success stories
Reaching out to companies	Exploration	Define marketing strategy
Difficulties in spreading awareness	Exploration, Planning	Provides workshops
Not knowing how or why	Exploration	Using 4-MAT
Low engagement from top management	Planning	Using 4-MAT
Lack of strategy	Planning	Provide workshops
No clearly defined goals	Planning	Help define goals using 4-MAT
Need of pilot tests	Action	Support with expertise
Lacking initial knowledge	Exploration	Have a marketing strategy
Need of support	All	Provide needed support
Adapting guides for various uses	All	Create proper material

8 Discussion

This chapter presents the authors' discussion regarding the thesis, focusing on the DIP method, similarities in findings from literature and interview study, and using change management. Additionally, presenting a discussion about the methodology with limitations in the research, sustainability and recommended future research.

8.1 Results

The result section presents a discussion about findings in this thesis, including the DIP method, similarities in challenges from literature and interview study, and the usage of change management.

8.1.1 DIP Method

The DIP project is a new initiative that has been under development for the last three years, which means it is not a complete, established methodology. Since the DIP method is still on the subject of alternations and development, the thesis provides impact at a specific time duration for the DIP project.

Since the DIP method still is under development, there are possibilities in expanding the strategy and adoption. Therefore a DIP model seems highly relevant during this phase of exploration and development. Integrating the DIP model in an early stage might promote an easier usage of the entire DIP method by fully taking advantage of the DIP project's flexibility. In a scenario where the DIP method was a well-established procedure, establishing a DIP model might have been more challenging to integrate.

8.1.2 Challenges for SMEs

The challenges and needs presented in the second literature study were much in line with identified problem areas from the interview study, which for the authors was a bit surprising. Unexpectedly, the literature complemented the same challenges identified in the interview study. Some of the problems found are pretty expected, as economic challenges and lack of knowledge. However, a near-complete match was not expected.

Since the second literature study was carried out after the interview study, the authors served at risk of bias when identifying challenges and needs from the literature. Consequentially, there might be problems in the literature that might have been overlooked. However, this study aimed to identify similarities, which the literature study provides.

Challenges within SMEs and digitalisation are not a newly emerged problem, and there is a lot to do in SMEs. SMEs have a disadvantage compared to more prominent corporations, which need to be put to more attention. By solely using a digital twin, it provides savings in both money and time, so SMEs need help to take advantage of the technologies used.

Since SMEs lack both knowledge and technical resources, the DIP project and DIP method provide possibilities for using digital twins to work with their production system more efficiently. Furthermore, enabling SMEs to expand their digitalisation without putting effort and cost into development. Consequently, making the process of digitalisation easier to apply for SME to remain competitive on the market.

8.1.3 Using Change Management

The use of change management emerged since resistance to change was highly discussed throughout the project. As Murthy (2007) mentions, change is inevitable for any business to survive, and resistance to change will always play an essential part in changes. With this in mind, the model seemed fitting since the area of digitalisation, and the fourth industrial revolution is a relatively new concept with fast-developing technologies and development. The environment is constantly changing, and for SMEs who are already falling behind, the need for addressing resistance to change is grand. The benefits of a change management model are that there is a lot of research and several models as the planning model by Bullock and Batten (1985) and Kotters eight accelerators by Kotter (2012) have been established and used for several decades.

One drawback of applying the DIP model might be initiation and development. It will require spending time applying the model, thereby adapting and conceptualising new work methods for the DIP model to be sustainable. Furthermore, the DIP model will require DIP-central to develop much material to promote, guide, and support companies that want to use the DIP method, which will be another time-consuming activity. However, DIP-central has knowledge and mindset of assisting companies that the provided guidelines are a great example. Thereby, DIP-central has the advantage to initiate changes proposed by the authors.

Another essential factor to consider is giving a reasonable amount of support. Companies might serve a risk to rely on DIP central if given too much support. As a consequence, companies might struggle to continue and adapt the DIP method individually.

8.2 Methodology

The strategy for the thesis was not a straightforward as the authors would have wished. After the interview study, the authors were somewhat confused about proceeding since the findings did not align with the hypothesis beforehand. The interview study results did not provide enough information for the initial thoughts, which made the authors face challenges in compiling the findings from the interview study. The problem was later solved by some brainstorming and a second literature study, which redirected the focus of the study. In terms of results, this affected the possibilities of carrying out further interviews, which could have been helpful to confirm and add depth to the study.

It is the authors' perception that the interview study had its limitation. Within the constraints of this study, a limited number of company participants were available for participation. The interview study was conducted with eight people from the participating companies, which are somewhat low. It was difficult for the authors to find the interview subject since there were not many people involved at each company. The study only seemed relevant to include people who knew about the DIP method since the study aimed to identify challenges with the actual DIP method used by the companies. In retrospect, it would have been interesting to compare differences between companies who applied the DIP method versus companies who have not and see how they work with digitalisation.

Although the number in interviews was relatively low, the authors interviewed all participating companies but two. Thereby, the ratio was relatively high, and the thesis received various perspectives on the topic. The authors believe that the results from the interview study are reliable since the study was carried out with a clear structure. The creation of the study was made from a sheet model from literature, and the compilation of interviews was carried out with the support of well-established methods, thereby avoiding bias in interpretation.

8.3 Sustainability

When considering economic sustainability in the thesis, the DIP method provides SME with resources and a work method adapted from larger companies. As a result, the DIP method provides SME opportunities to develop their production system in an economically sustainable way. Using a digital twin will increase efficiency and productivity, essential for SME to stay competitive and sustainable. A well-developed DIP model might provide a better allocation of resources since the model aims to assess companies capabilities beforehand and adapt the support accordingly.

Furthermore, the digital twin's visualisation enables less travelling since with the possibility of virtually seeing entire factories, move around and take measurements. Thus, developing the DIP method is also beneficial from an environmental sustainability point of view. Additionally, social sustainability will increase with less strain on spending time away and with the possibilities of predicting errors that might cause stress later in the project. Also, more people can be included in changes in layout planning since 3D models enable a simple overview and do not require as much knowledge as the traditional 2D models to understand.

8.4 Future Research

This study provides a DIP model for how to use the DIP method. However, it is not complete with its details since the limitations of time restricting further development. The ambition from the authors is for DIP-central to apply this structure to help companies face challenges and needs presented in this report. However, the model needs further work to clarify each phase and process further. There are possibilities of providing a full concept with courses of action with complete time frames for each phase.

Furthermore, there are possibilities in defining and creating feasible material matching each phase, used for information, workshops and evaluation. From the authors' perspective, there is a challenge in promoting SMEs' DIP method that needs to be further investigated and defined. Additionally, marketing material and similar material for learning opportunities, manuals for software need to be investigated.

Ultimately, the authors believe the DIP method with the DIP model can provide the means for optimal implementation of digital twins and point clouds to simplify installing new equipment in SMEs.

9 Conclusion

The main conclusion drawn from this thesis is that SMEs have many challenges and needs in the development of digitalisation in production systems. A literature study and interview study was carried out to identify the various challenges and needs. The main takeaways are that SMEs face economic limitations and resistance to change when implementing new technologies. Furthermore, the top management plays an essential part in the implementation process to initiate new ideas. There is a need for a digital strategy when working with new technologies and setting clear goals. Moreover, SMEs generally face challenges in both skill and resources to increase their level of digitalisation and need to be provided with proper support.

The thesis studied and analysed two change management models to develop an adapted model for the DIP method to address the identified challenges. The developed management model, the DIP model provides a general structure and aims to minimise resistance to change and increase knowledge by activating and introducing companies to the technologies in the DIP method early in the process of change. Furthermore, the DIP model aims to create strategies, setting goals for working with the DIP method and development in digitalisation, and create broader integration in the organisation. Moreover, the DIP model provides a base for DIP-central to support and continue developing the DIP method. This is accomplished by recommending how DIP-central can reach out to companies, create proper material for marketing and workshops, and be continued support. The DIP model will serve as a solid base for future research. There are possibilities to clarify each phase of the DIP method and create matching material, information, workshops and evaluation.

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