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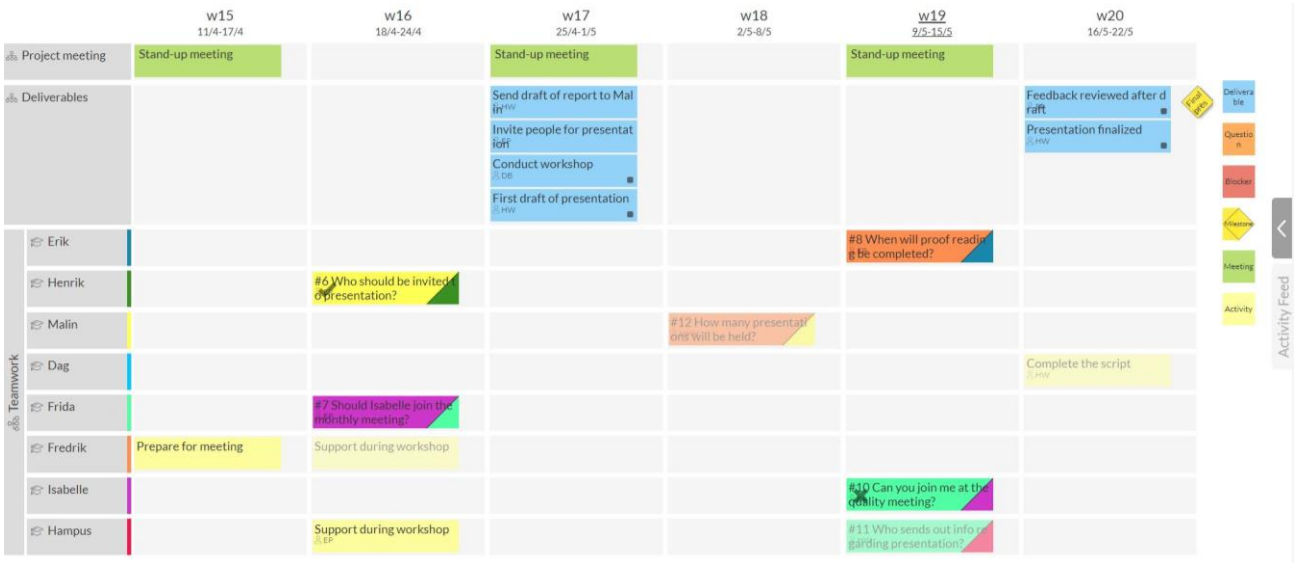

Why is communication so difficult?

Barriers to efficient project communication and how to address them with digital visual planning tools

Master's thesis in Quality and Operations Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

The world we live in is in constant change and new technologies are developing faster than ever before. For engineering organizations, this implies challenges, and the need for digitalization and efficient development projects becomes increasingly important. As a part of conducting successful development projects, *project communication* has been shown to play a vital role. Therefore, this study has on behalf of *Volvo Group*, aimed to uncover the barriers to efficient project communication in engineering organizations, and how to address them. The methodology of *digital visual planning* was tested through the implementation of a software, to discover whether this could be used to address the barriers and strengthen project communication. In total, three different engineering development projects were studied, projects A and B were at the beginning of implementation of digital visual planning whereas project C had already used the software for several years. Throughout the study, a qualitative research approach was adopted. Here, a combination of literature review, qualitative interviews, observations, and demonstrations have been conducted in all three projects.

In total, 27 barriers that inhibit efficient project communication could be discovered. Furthermore, it was found that eight of these barriers were addressable by using digital visual planning, enabled by the software that was studied. The implementation of digital visual planning led to several benefits, including the possibility to minimize the unclarity in responsibilities and minimize ambiguity in communication content by ensuring a high level of communication transparency. Furthermore, the software helped to structure meetings, and thereby reduced excessive time spent on meetings and associated administrative work. In addition, since the software does not require high technological skills to use and is easy to access, it lowers the threshold for implementation and actual usage.

However, some challenges and drawbacks could be identified as well. If not fully integrating the software, there is a risk that the software will become an addition to current systems which leads to more administration and few benefits. In addition, the usage of digital tools for collaboration was shown to increase the distance between people and risk leading to less communication if not managed well. To make the implementation of digital visual planning persistent, an important conclusion was the need to consider change management aspects. The software to be implemented also needs to be adapted to the specific project. Visualizations were considered to benefit all types of projects. However, for well-structured projects following a Stage-Gate model, the visual planning method was considered suitable whereas, for agile projects, Kanban boards are better.

Keywords: *visual planning, digital visual planning, project communication, project management, digitalization, visualization, lean product development.*

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Another special gratitude is directed to the employees at Yolean for providing us with the license and rights to study their software in our case projects. We would like to especially thank Amer Catic on Yolean for the help and support with the software. Moving on, we would like to thank all members of projects A, B, and C who took the time to participate in the interviews, invited us to your meetings, and participated in our workshops. Without you, this thesis would not have been possible. Last but definitely not least, thanks to our examiner Dag Bergsjö for coaching us and providing us with great ideas throughout this journey.

Thank you all,

Erik Panzar & Henrik Wahrén

Gothenburg, June, 2022

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1. Introduction

In this first chapter, the reader is introduced to the master's thesis study and the background to this work. The research focus which is two-folded, a research gap and an industrial problem is presented together with the overall aim of the study and the research questions. In addition, the case company which this study has been conducted on behalf of, and the digital visual planning software that was implemented during the study are presented.

1.1 Background

The giant leaps in the technological development of the last decades have provided companies with great opportunities but also new challenges. Through the constantly increasing level of digitalization, companies can improve their efficiency and offer new products and services. However, according to Ignat (2017), the digitalization in combination with globalization also leads to a tougher business climate. Traditional manufacturing companies have become subject to fierce competition from newcomers who take advantage of the new opportunities that arise from digitalization. To stay competitive in this quickly changing business environment, manufacturing companies therefore must learn to quickly adapt and develop their capabilities in the field of digitalization (Bilgeri et al., 2017). Conducting successful development projects is a crucial aspect needed to achieve this. Development projects exist in all kinds of forms with various scopes and time horizons, thus, there are many factors affecting the outcome and success of these projects. The definition of a successful project could however be viewed as a rather subjective measure. Since different individuals often have different agendas, a commonly agreed goal that determines the success of the project is often lacking (Shenhar et al., 2001).

According to Ramsing (2009), a majority of all problems that arise in projects are due to inferior communication. Succeeding in communication is considered a challenging task and the complexity of communication increases with the number of individuals involved in a project and the more ambiguous the goal and scope of the project are (Galli, 2020). Furthermore, Sicotte and Delerue (2021) describe that communication has been shown to have clear and significant impacts on the performance measures of a development project. The application of communications theory on projects is in research commonly referred to as *project communication,* and lately, the emphasis on using digital tools for communication in projects has increased in this branch of research (Nyandongo & Davids, 2020). However, despite the previously mentioned importance of communication, there has been surprisingly little research on the topic of project communication according to Sicotte and Delerue (2021). Thus, there is clearly a need to enhance knowledge regarding *project communication* and how it can be strengthened.

A popular strategy for operations improvement in the manufacturing industry is to implement lean production. This is a philosophy that has paved the way for enormous increases in efficiency in production systems. Likewise, the application of lean in development projects, the so-called *lean product development* methodology has been shown to benefit the development process (Marodin et al., 2018). From lean product development originates the promising but not so thoroughly researched methodology of *visual planning* (Lindlöf & Söderberg, 2011; Stenholm et al., 2016). Visual planning is used for planning and executing projects and exploits the advantages of visualization to improve the development process, by among other aspects

strengthening the communication (Lindlöf, 2014). As an aid to realizing visual planning in projects, physical visual boards have traditionally been used, but nowadays digital tools exist, and this is referred to as *digital visual planning.* By digitalizing the visual planning process, the aim is to increase the efficiency of the process further and increase the ability to work and collaborate remotely (Stenholm et al., 2016). Thereby, increased visualization could potentially improve the efficiency of project communication.

To enable a study with practical examples and with connection to reality, this master's thesis is conducted on behalf of *Volvo Group.* With more than 95.000 employees globally, Volvo Group operates in the automotive industry and is one of the leading actors in the market. The Volvo Group consists of several different business areas, of which some are Volvo Trucks, Buses, Penta, and Construction Equipment (Volvo Group, 2022a). This master's thesis is conducted in collaboration with *Powertrain Production*, which is part of the operations division at the company. Powertrain Production is responsible for both the operational and proactive work in all their globally dispersed plants where heavy- and medium-duty engines, gearboxes, remanufacturing, and associated parts are produced for commercial vehicles. These plants are located all around the world, including cities like Curitiba, Hagerstown, Skövde, Köping, and Vénissieux (Volvo Group, 2022b). Volvo Powertrain Production has aided this master's thesis with real-world projects and resources, which has implied a better connection to the applicability of the study in real contexts.

1.2 Research Focus

This master's thesis study has a two-folded focus. The study aims to both address a research problem and contribute with knowledge to the case company to address the industrial problem. This division is visualized in Figure 1.

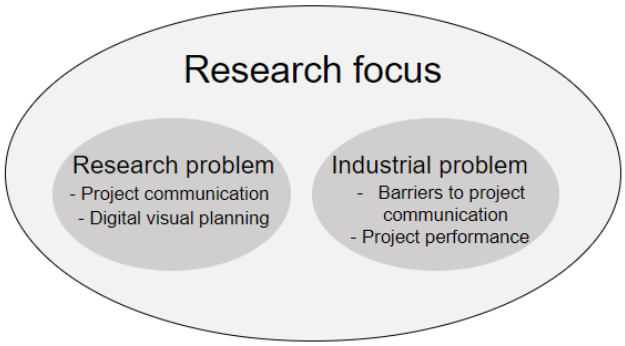

Figure 1. Research focus, including research problem and industrial problem.

1.2.1 Research problem

In the pursuit of improving the efficiency of communication in projects, this master's thesis study covers the research topics of *project communication* and *digital visual planning*. Project communication is a subcategory of the broad and well-researched area of communications theory, despite this, few research studies on the topic of project communication have however been conducted (Johannessen & Olsen, 2011). For the second topic, visual planning, and especially digital visual planning, there also exists a research gap and according to Stenholm et al. (2016), the research on visual planning is still limited. This master's thesis will thus aim to

contribute to the research on these two topics by studying and collecting empirical data from three real projects.

1.2.2 Industrial problem

The case company Volvo Group has expressed an interest in understanding which barriers exist related to project communication and evaluating how these can be addressed. By doing this, the aim is to increase the success of projects in terms of better project performance. Different projects in the case company measure project performance differently but three common measures were lead time, quality, and cost. In addition, there was a desire to also evaluate the health of the participants of the projects. As described by Lindhard and Larsen (2016), and visualized in Figure 2, the performance of a project is affected by several factors and project communication is one of them. In turn, digital visual planning is considered to be a potential way to strengthen communication in projects according to Stenholm et al. (2016). In addition, Xiong et al. (2021) states that the project performance can be increased by the usage of visual planning. The case company is especially interested in collaborative software since they are currently striving to digitalize their processes. Hence, they see such a software as an important step in the right direction in their digital transformation journey.

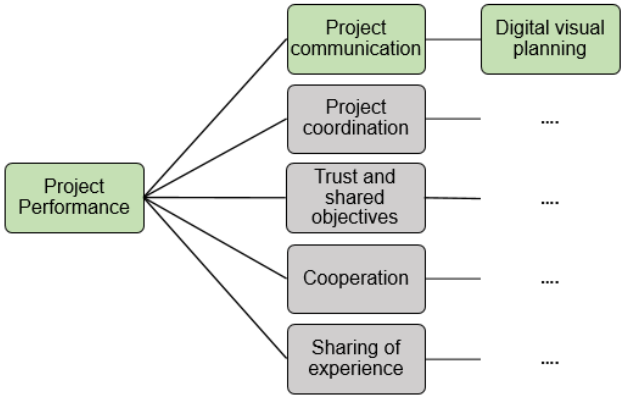

Figure 2. Factors affecting project performance adapted from Lindhard and Larsen (2016).

1.3 Aim and Research Questions

The aim of this research is to produce a contribution to research regarding digital visual planning by investigating if and how this can ease project communication in development projects. Furthermore, the purpose extends to address the applicability of digital visual planning in industrial settings by evaluating how manufacturing firms can benefit from such an implementation. To achieve this, there is a need to uncover which types of barriers exist that negatively affect the efficiency of project communication. When the barriers are identified, it is possible to assess which barriers can be addressed by using digital visual planning software. To be able to fulfill the aim of the study, the following two research questions have been formulated:

RQ1: Which are the barriers to efficient project communication in engineering development projects?

RQ2: How can digital visual planning software address the barriers to efficient project communication in engineering development projects?

1.4 Background to Yolean and case projects

To receive a better understanding of the specific software that has been used in this study and which projects it has been applied in, a description of these follows below. The software used is called Yolean, and three different projects A, B, and C have been studied and compared in a multiple case study.

1.4.1 Background to Yolean

The company Yolean was established in 2014 and has its origin in a research project from Chalmers University of Technology. Initially targeting the construction industry, it has now expanded the customer base to serve other industries as well, including the manufacturing industry. Building on lean principles, the tool is an enabler for digital visual planning and can be utilized by project managers when managing a project. It offers visualization of project work in a digital format on a project board and allows for communication and collaboration within the team. Meetings, deliverables, questions, and activities are visualized in the format of colored notes on the board which can be assigned to specific people since all members can have their own row. These notes are accessible to all members of the team. Furthermore, the software is not connected to a company intranet, and it is run on a web browser. New members are added to the board by inviting them through their email addresses, allowing members that are part of different organizations to collaborate on the same board (Yolean, 2022). An example of a Yolean board is visualized in Figure 3. The logic of the board is that the rows are used for visualizing the responsibilities of different individuals or functions and the columns visualize the deadline when each entry on the board should be conducted or finished. From here on in the report, Yolean will be mostly referred to as *the software*, and *the digital visual planning software.*

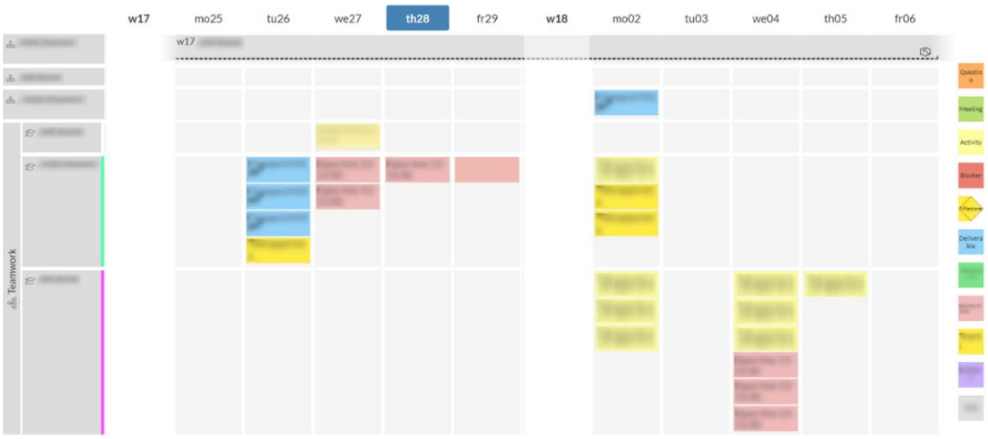

Figure 3. Example of a Yolean board from a real project.

1.4.2 Background to case projects

Project A is a research project consisting of a collaboration of several industrial companies. The overall aim of this project is to enhance the competitiveness of the Swedish industry by increasing the level of digitalization and collaboration. In the part of the project that was studied, two companies and one university are involved. From these three organizations, there are in total seven individuals involved in the project, and all of these were included as participants in this study. The reason why the project wanted to participate was because the

usage of a software for project communication and planning was seen as a possible step in digitalizing the work process in the project. This project follows no outspoken or defined model for project management, however, some similarities to the agile methodology could be identified during the study. This since the project is loosely defined and open-ended, and to fulfill the aim, new innovations need to be established.

Project B is a project from the case company Volvo Group. The project is located in one of the manufacturing plants of the company and it is a product adaptation project. In the function where this project belongs, the project managers handle several projects simultaneously and thus communicate with many individuals. The aim of implementing the software of the study was to facilitate the management of these projects by decreasing the number of collaborative tools and increasing the intuitiveness of collaboration and communication. There was also a request to find a way to visualize the projects in a holistic and easy to grasp way. The project is run sequentially according to the Stage-gate methodology and the project has clearly defined goals and a formalized and outspoken structure.

Project C belongs to another manufacturing company that wanted to participate in the master's thesis study but wanted to be anonymous. The project consists of a team working with updates in the product configurator at the company. There are two individuals in this team, and both are included as participants of this study. In contrast to projects A and B, this project has already implemented and used Yolean for several years. The software is used in this project to facilitate daily work through structuring upcoming deliverables and activities, both for short-term and long-term planning purposes. As a result of this, the project adheres to the visual planning methodology.

1.5 Delimitations

During this master's thesis, three different projects from three different organizations have been studied. Thereby, the study focuses on specific departments within each organization. The three different projects have conducted work in different stages of the implementation, where the *initial phase*, *development phase*, and *post phase*, which are described by Blessing and Chakrabarti (2009) have been compared. With a timeframe of 20 weeks for this master's thesis, this was considered a reasonable scope of the study. Projects A and B were used to cover the initial phase and the development phase of this master's thesis. Project C, which has utilized Yolean since previously, was used to find empirical data for the post phase.

1.6 Thesis Outline

Followed by the introduction of the report, the theoretical framework is presented where relevant literature and previous research associated with the study are described. Next, the method used to conduct the study is outlined, including a more thorough description of the research process, how data was collected and analyzed, and how ethical aspects have been considered. Thereafter, the results are presented based on the empirical findings from the interviews, observations, and demonstrations throughout the study. These findings are structured according to the theoretical framework *Activity theory*. Following, the analysis is presented, where the barriers to efficient project communication and possible ways to address them are discussed. Finally, the conclusions and recommendations of this study are summarized.

2. Theoretical Framework

In this chapter, the literature which has been reviewed is summarized and presented. The theories which have been reviewed are summarized in Table 1, together with an explanation of which research question each theory is used to answer.

Table 1. Connection between research questions and theory.

Research Question	Theory
RQ1: Which are the barriers to efficient project communication in engineering development projects?	2.1 Models for design and development 2.1.1 Stage-gate 2.1.2 Lean Product Development 2.1.3 Agile 2.2 Communication 2.2.2 Project communication 2.2.3 Barriers to communication 2.5 Activity theory
RQ2: How can digital visual planning software address the barriers to efficient project communication in engineering development projects?	2.2 Communication 2.2.1 The communication process 2.3 Visualization 2.3.1 Visual planning 2.3.2 Digital visual planning 2.4 Change Management theory

2.1 Models for Design and Development

The activity of designing and developing new products and processes, commonly referred to as the product development processes, is a crucial activity for companies to cope with competition. More specifically, companies need to shorten the lead times for their developments, while at the same time reducing the cost and increasing the quality (Karniel & Reich, 2009). There exists a multitude of models for achieving this, and the reason is the large variety and distinct characteristics of products and processes, both within and between different companies (Unger & Eppinger, 2011). To help project managers become more efficient by identifying suitable models for design and development, Wynn and Clarkson (2018) conducted an extensive literature review where the most prominent models were categorized according to a framework.

From the list of models presented by Wynn and Clarkson (2018), three models were identified as important to review in this study. These are the *Stage-gate model, Lean Product Development (PD),* and the *Agile model*. The Stage-gate model is the method that is currently applied in project B which is a project of the case company Volvo Group. However, the case company strives to change the method for conducting projects to a combination of agile and lean PD.

2.1.1 Stage-gate

Spurred by the increasing rate of technological development and globalization of competition during the 1980s, the Stage-gate model for product development was developed by Cooper (1990). The Stage-gate model, which follows the logic of a waterfall model, is sequential and covers the entire development process according to Wynn and Clarkson (2018). Each stage contains different tasks, and the stages are followed by gates, which are reviews in which the progress made during the last stage is assessed according to a set of predefined criteria (Schuh

et al., 2017). As can be seen in Figure 4, there are five sets of stages and gates in the original configuration of the model. At each gate, a decision regarding if the project should be allowed to continue, be killed, be paused, or be recycled is taken. The number of stages and the activities connected to each stage can be modified to suit the specific project, however, having between four and eight stages is recommended for most projects (Schuh et al., 2017). The first half of the stages in the model are explorative in their nature, focusing on identifying ideas and gathering knowledge. The second half instead focuses on developing and testing prototypes and then how these should be produced and offered on the market (Grönlund et al., 2010). As a project moves forward through the stages, the cost of each stage typically increases, hence, decisions made at each gate become increasingly critical. However, since uncertainty is reduced after each stage, the model leads to efficient management of risks, and the most expensive investments are postponed to stages where certainty is higher (Cooper, 2008).

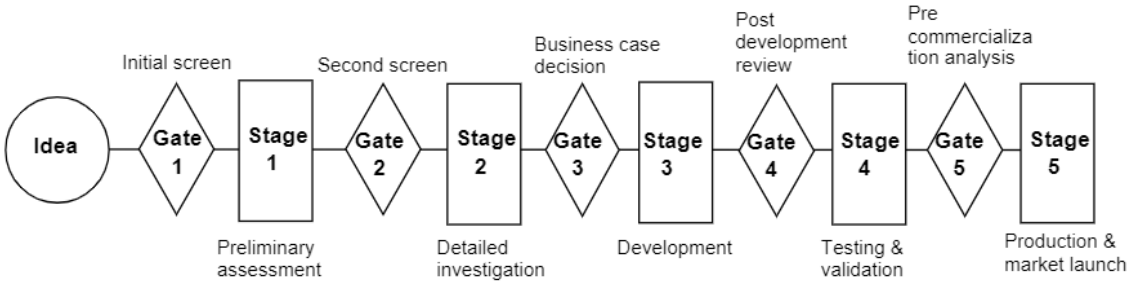

Figure 4. Stage-gate process adapted from Cooper (1990).

Each gate has a set of criteria and deliverables which must have been sufficiently met for the project to be able to pass the gate. The people assigned to review the project at the gates, the so-called "gate-keepers", should be senior managers and only once the gate criteria are fulfilled, the project should be granted the resources needed for the next stage (Cooper, 1990). This fact makes the innovation process more structured, and it can ensure sufficient quality of the products and processes being developed, which reduces the risk of costly changes needed late in the process. Additional benefits are that the speed of development can be increased, and the cost of development decreased (Cooper, 1990).

There has, however, been some critique directed toward the Stage-gate model. As stated by Sethi and Iqbal (2008), the formalization of the development process provided by the model can decrease flexibility and stifle innovation. Therefore, they state that the Stage-gate model is not appropriate for all types of projects, especially not projects aiming to achieve radical innovation. In addition, they express the importance of matching the design and development model with the specific project. Grönlund et al. (2010) state that the model also has been criticized for in some cases slowing down the development process since bureaucracy is introduced into the process and since the activities are conducted sequentially. This bureaucracy is said to lead to fewer opportunities for learning as well as more administrative tasks, which do not add value and consume a lot of time. In an article, Cooper (2008) answers this critique by presenting an updated version of the Stage-gate model which is less formalized and in which stages are more fluid and have the possibility of overlapping with each other to decrease the time for development.

2.1.2 Lean Product Development

Traditionally, the lean philosophy has mostly been applied to production systems in manufacturing companies. However, as the benefits of lean have become increasingly well known, the applications have been spread to other settings and industries as well (Marodin et al., 2018). One example of this is the adoption of lean in product development processes, known as lean Product Development (PD). The goal of lean PD is to reduce the cost of development by removing waste and by increasing speed. In addition, there is a large focus on value creation and, more specifically, value from the perspective of the customer (Hoppmann et al., 2011). According to León and Farris (2011), lean PD is surrounded by some ambiguity and there exists no common definition of the concept. In their article however, the definition as follows is suggested, "lean PD is viewed as the cross-functional design practices (techniques and tools) that are governed by the philosophical underpinnings of lean thinking – value, value stream, flow, pull, and perfection – and can be used (but are not limited) to maximize value and eliminate waste in PD" (León & Farris, 2011, p.29). Common methods and practices applied in lean PD are visualization, design for manufacturability, concurrent engineering, and modularization (Marodin et al., 2018). However, Hoppmann et al. (2011) describe the importance of not viewing lean PD as a toolbox of different methods but as a complete and thorough philosophy that should be applied to the entire PD process.

In an influential article by Karlsson and Ahlström (1996), a concept for achieving lean PD is presented. They emphasize that lean PD should be seen as an overall strategy for conducting product development and not as isolated methods and techniques. The parts of the concept presented are *cross-functional teams, concurrent engineering, supplier involvement, vision, and strategy.* By utilizing cross-functional teams in which all functions that are affected by the product or process that is being developed are represented, all needs, and constraints can be considered more efficiently (Karlsson & Ahlström, 1996). Concurrent engineering is a methodology in which the development tasks are done in parallel instead of sequentially as in traditional product development, for example by developing the product and its manufacturing setup simultaneously. By doing tasks in parallel, the speed of development can be increased and instant feedback from the functions involved can be received. An additional characteristic of concurrent engineering is that many designs and ideas are considered initially but as the project moves on, these are funneled down until only the best and most suitable solution remains, which is visualized in Figure 5 (Sobek et al., 1999). In traditional product development, suppliers are involved only at the end when the specifications are set, but by actively involving suppliers from the start, they can contribute with their competence and provide their feedback early on. In addition, the projects should be guided by visions rather than detailed instructions and specifications (Karlsson & Ahlström, 1996).

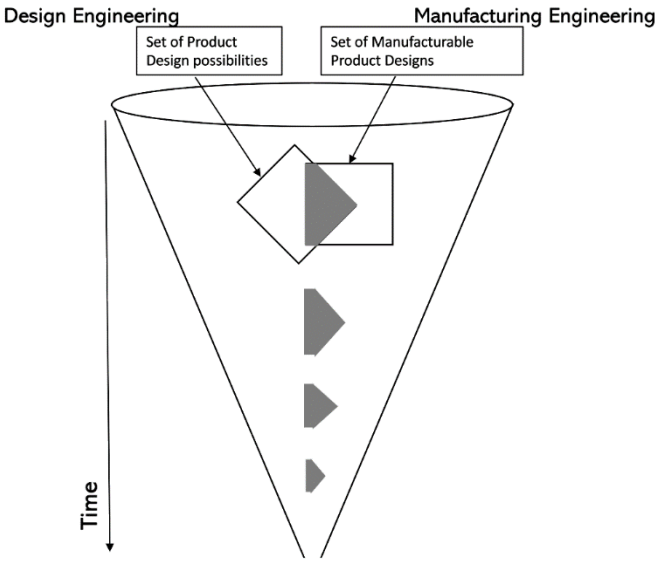

Figure 5. A development funnel adapted from Sobek et al. (1999).

Another highly influential interpretation of lean PD is provided by Liker and Morgan (2006). In this article, a framework for lean PD is presented which builds on the three dimensions of *people*, *process*, and *tools & techniques*. By viewing product development as a process, it can be subject to standardization and elimination of waste. To eliminate waste, a clear definition of what customers perceive as valuable must be established (León & Farris, 2011). In addition, Liker and Morgan (2006) state that the development process should be frontloaded, which means that many ideas should be considered in the early phases of development. In the people dimension of the framework, Liker and Morgan (2006) include the need for constant learning, involvement of suppliers, and the utilization of cross-functional teams. The tools & techniques dimension emphasizes the need to utilize technical solutions and to adapt these to the people, and not the other way around. In addition, the authors describe the benefits of utilizing tools for visual management and communication, and tools for standardization.

In a case study by Helander et al. (2015), the effects from the usage of lean PD were assessed on several projects. It was shown that lean PD contributed with several benefits like increased quality and better communication. However, the focus on streamlining and waste reduction was shown to lead to a decrease in creativity. The reason for this was shown to be because the slack in the projects was decreased when the process became more efficient, and previously, ideas and improvements were often established during this slack time. To avoid this, Helander et al. (2015) therefore, recommends that time is allocated for creative activities where new ideas and innovations are allowed to emerge. In line with this, Von Würtemberg et al. (2011) describe that the implementation of lean PD frequently leads to lower costs and decreased time to develop. However, better products are not necessarily developed through lean PD and the increase in value creation is often not achieved.

2.1.3 Agile

The term *agile* has its origin in the agile manifesto, which was formulated by a group of independent thinkers working with software development (Beck et al., 2001). They created the manifesto with the aim of highlighting their argument that there is a need to be more adaptive

in the new era of e-business and software development. The agile manifesto advocates four main principles for how engineering work should be conducted. These are as follows: *Individuals and interactions over processes and tools*; *Working software over comprehensive documentation*; *Customer collaboration over contract negotiation*; and *Responding to change over following a plan* (Beck et al., 2001). Nonaka and Takeuchi (1986) present similar arguments by emphasizing the importance of agility through flexibility and speed in new product development. Strengths of the agile method for innovation are described by Rigby et al. (2016) as significantly improved quality and productivity in the development of software. The old sequential way of conducting development work is considered insufficient in today's rapidly changing market environment. Therefore, Nonaka and Takeuchi (1986) argue that the agile methodology concept of "scrum" should be adopted. Derived from the rugby term with the same name, the authors describe that this concept advocates the importance of overlapping development phases, project teams that are self-organized, and that learnings need to be transferred throughout the organization.

Agile product development also refers to the way of conducting projects that, in contrast to waterfall, is advocating an iterative process. Instead of defining clear gates, that once passed through there is no possibility of changing what has been previously decided and developed, agile methodology allows the development team to iteratively review and adapt the product and project (Thesing et al., 2021). In Figure 6 below, the difference between sequential and iterative, overlapping phases is visualized.

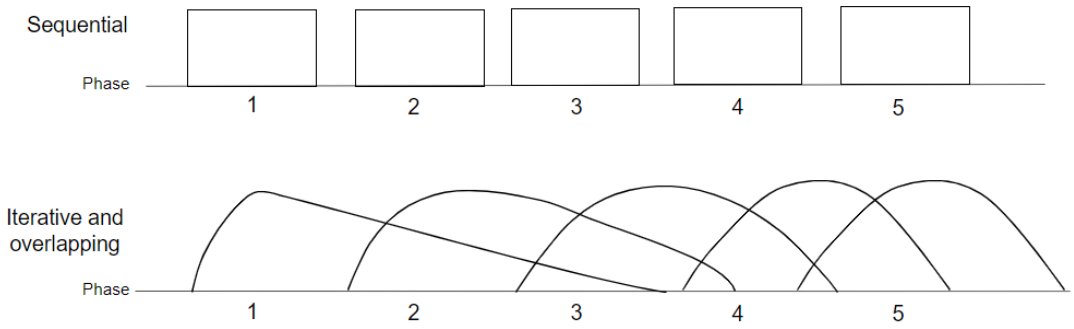

Figure 6. Sequential vs overlapping phases adapted from Nonaka and Takeuchi (1986).

As previously stated, agile and scrum have their origin in software development, and this is where it is most often applied. Critics have therefore raised concern about whether the agile product development process is possible to apply in a hardware development setting. Conboy (2009) argues that agile methods have conceptual scarcities regarding lack of clarity, theoretical foundation, and applicability outside of systems development. However, Srivastava et al. (2017) argue that it is not limited to this area of usage. Instead, they have the opinion that the process can be applied to any field if adapted in a suitable way.

2.2 Communication

Communication is a broad and multidisciplinary topic that contains many theories and models. Depending on the context and situation, different modes of communication are appropriate. In its purest form, however, communication is described by Kliem (2007) as a process that occurs between two or more individuals and in which information is transferred between the

individuals involved. Zulch (2014) extends the meaning of communication by including the process of interpreting the information which has been received during the process of communication. Frequently, the topic of communication is separated into verbal and nonverbal communication. Verbal communication consists of spoken and written words whereas examples of nonverbal communication are visualizations, facial expressions, body language, eye gaze, and similar (Jones & LeBaron, 2002). These two types of communication can be applied in isolation, however, they are often used simultaneously, for example during a discussion (Key, 2011).

Communication plays a vital role in most settings during which several individuals are supposed to collaborate toward a common goal Zulch (2014). For new product development projects, Sicotte and Delerue (2021) state that communication and information sharing, both within the project team and with external actors largely affect the project performance metrics. According to Ramsing (2009), there is a perception that as many as 95% of all problems that occur during collaborations are due to a lack of communication or incorrectly conducted communication. The reason communication frequently fails is because it is a complex task. Communication is highly influenced by the current situation and context, by the individuals involved, and by their perceptions of reality. Hence, it must be continuously adapted to be successful (Kliem, 2007). Moreover, Pickering and Garrod (2014) emphasize aligning the way of communicating, in terms of language usage and intention of information sharing.

2.2.1 The communication process

A frequently adopted model which is helpful for understanding the main elements and mechanisms of communication is *the communication process.* With the deepened understanding of communication, which this model aims to provide, the users can potentially be more successful when both communicating and receiving communication (Kliem, 2007). In its most basic form, the communication process can be viewed as consisting of three elements, the sender, the receiver, and the medium, see Figure 7.

The sender is the individual who initiates the process of communication and does so by first coding the information which is about to be communicated. The act of coding is the process during which the sender decides how the information should be formulated, which words should be used, and which gestures and symbols should be applied (Lunenburg, 2010). Thereafter, the information is distributed through the medium, which is the communication channel used for the communication process. There are many choices of communication channels, and different channels are appropriate depending on the specific situation. Examples are emails, text messages, face-to-face conversations, and telephone calls to mention a few (Kliem, 2007). Once the information has passed through the medium and been received by the receiver, it is decoded. During the decoding process, the receiver unpacks the information and interprets the meaning of the information. This activity plays a vital part in the process and is highly subjective. Individual beliefs and previous experiences affect how each individual interprets the information (Lunenburg, 2010). For the sender to be able to code the information in a way that the receiver interprets it correctly, the sender must be able to understand the perspective of the receiver (Zulch, 2014).

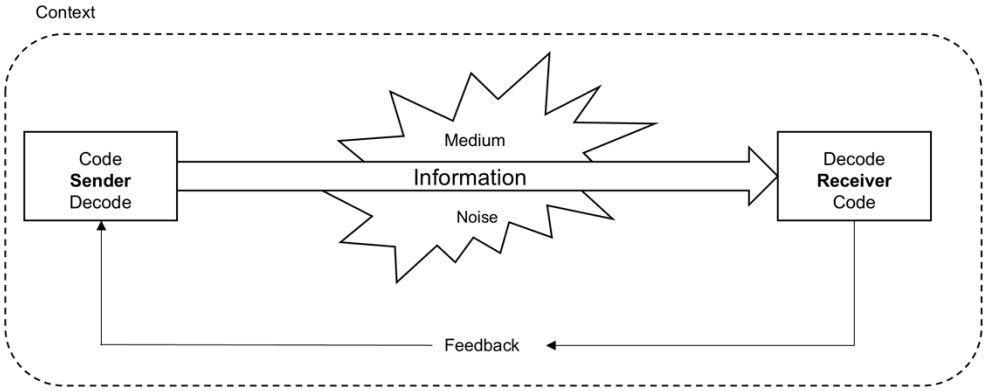

Figure 7. The communication process, adapted from Lunenburg (2010).

As is shown in Figure 7, the communication process can have a feedback loop in which the receiver replies and reacts to the information received. Feedback is an important part since it can be used as a way of ensuring that the information was interpreted correctly by the receiver. By doing this, misinterpretations can be corrected, and the risk of errors and problems is decreased (Zulch, 2014). Communication in which feedback is not present is often referred to as one-way communication, and communication in which feedback is utilized is referred to as two-way communication (Lunenburg, 2010). In addition, two-way communication can include an even higher level of interaction if the communication occurs through a discussion. In this case, the role of sender and receiver is continuously changing and both feedback and information are transmitted both ways (Kliem, 2007). When the information is transmitted through the medium, there is a risk that the information is introduced to noise. When affected by noise, the information risks being distorted, and the intended meaning might become altered. There are many types of noise, and the noise can be induced from both the medium used for communication and from the subjective characteristics of the receiver. Examples of noise are attitudes, emotions, lack of understanding of the language used, and interruptions and delays in the medium (Lunenburg, 2010).

2.2.2 Project Communication

As described in subsection 2.2 *Communication*, general communication can be described as transferring and interpreting information between different individuals. Project communication is the application of communications theory in projects, however, the literature on this topic is quite limited (Samáková et al., 2013). Despite this, some more specific definitions can be formulated. Nyandongo and Davids (2020) state that project communication can be considered as all interactions within a project. This view is shared with Ramsing (2009), who further argues that this definition is applicable both internally in the organization and externally with stakeholders such as suppliers or consultants. In addition to the characteristics shared with organizational communication, Wang and Hu (2012) also adds the aspects of flexibility and dynamics to project communication. Muszyńska (2016) defines a technical approach to project communication as "right information to right person at the right time". Berggreen and Kampf (2015) are aware of this view, but they are however a bit skeptical of this unilateral technical definition of project communication. Instead, they argue that project communication is a socio-technical system, where relations, discussions, documents, and tools need to be considered in combination with each other. Hence, it is a perspective that also puts great value on the social

aspects of the system and, thereby, it is a more relations-based perspective (Berggreen & Kampf, 2015).

Ramsing (2009) describes that there are different ways and different channels of communication in projects. Especially focusing on internal project communication, this can be divided into written and interpersonal communication. Written includes data, documentation, information, IT, and project management systems. Furthermore, diving even deeper into interpersonal communication, this consists of both scheduled and non-scheduled communication (Ramsing, 2009). In contrast, Müller (2003) describes more thoroughly the external project communication, i.e., communication that goes beyond the organizational boundaries. Here, the importance of the three aspects of communication are emphasized, namely *frequency*, *media*, and *contents*. Frequency is how often communication occurs, for example, daily, weekly, or at milestones. Communication media relates to in what way communication is conducted, which could be written, verbally, or face-to-face. The contents of the communication include status updates, issues, next steps, analysis, or other types of content. By considering these aspects and applying routine-based communication, both the social and technical aspects can be improved, in the end implying higher project success (Müller, 2003).

2.2.3 Barriers to project communication

In a study on project communication in global new product development projects, Lohikoski et al. (2015) present a list of barriers to communication that frequently occurs, see Table 2. They describe that face-to-face discussion is the richest method for communicating since it allows for a simultaneous combination of verbal and nonverbal communication. When collaborating in a virtual environment the nonverbal aspect is more limited, thus, communication becomes more difficult. In addition, they explain that virtual project communication is more prone to be distracted and distorted by noise. The noise can be caused by many things, for example, different levels of understanding in the language used for communication, and technical issues causing delays.

In an article on project communication in engineering projects, Galli (2020) has summarized some additional frequently identified barriers and difficulties when communicating in projects, see the lower part of Table 2. To begin with, project communication must be carefully adjusted for the specific receivers of the information that is being communicated. Both the content and the phrasing of the information must be adjusted to the receivers. When people receive information that they consider irrelevant, they experience that their time is being wasted. Achieving the appropriate frequency and timing of communication is another challenging task. Too little communication will lead to misunderstandings and too frequent communication will waste valuable time. In addition, choosing the best form of communication and communication channel can be difficult. Some information is more efficiently spread in written form, some as pictures and symbols or as charts. Sometimes face-to-face communication during meetings is required and for other matters, distributing a written document might be more efficient (Galli, 2020).

Table 2. Barriers to project communication by Lohikoski et al. (2015) and Galli (2020).

#	**Barriers**
Lohikoski et al. (2015)	
L1	Lack of trust
L2	Unresolved conflicts
L3	Excessive use of email
L4	Communication content ambiguity
L5	Unclear actions needed due to use of mass email
L6	Lack of shared goals
L7	Cultural differences
L8	Lack of team building
L9	Power asymmetry
L10	Egocentrism
L11	Insufficient language knowledge
L12	Long and unstructured meetings
L13	Insufficient technical knowledge
L14	Technical problems
L15	Document access difficulties
L16	Time zone differences
L17	Communication tools not used
Galli (2020)	
L18	Lack of customized communication
L19	Differences in preferred communication frequency
L20	Differences in preferred communication channels

2.3 Visualization

It has been proven that the human brain is better and faster at understanding and interpreting information that is displayed and transmitted visually compared to both speech and text. In addition, we can process a larger amount of information if it is presented as a visualization compared to any other format. These facts are utilized in the lean concepts of visual management and visual planning to provide benefits to projects and processes (Tjell & Bosch-Sijtsema, 2015). Visual management has been described as a management system that aims to enhance the performance of an organization by utilizing visual means of communication for a wide set of applications. Examples of applications range from communicating visions and goals to visual representations in a production system with the aim of providing a quick overview of the status (Tezel et al., 2016). According to Pedo et al. (2020), depending on their aim, methods for visual management can be divided into methods for communicating one to one, one to many, or many to many.

Closely related to visual management is the concept of visual planning, which can be viewed as one of several methodologies to achieve the more holistic concept of visual management (Lindlöf, 2014). Visual planning is frequently applied in lean PD as a means of increasing the efficiency of the product development process (Stenholm et al., 2016). The method can either be applied in a traditional setting, where physical tools and artifacts are used, or in a digital

environment where software is utilized to enhance and ease the visualization as well as enable remote collaboration (Stenholm et al., 2016).

2.3.1 Visual planning

Visual planning provides a project with project planning and communication methodology, both in a visual format. The planning part of visual planning is achieved and visualized on a board, see Figure 8. On the board, colored notes representing deliverables, tasks, and other activities are placed on rows corresponding to the responsible person or function. The columns represent when activities should be finished (Jansson et al., 2016). This way, the progress of the project work is visualized and can be quickly grasped (Lindlöf & Söderberg, 2011). According to Stenholm et al. (2016), closely related to visual planning boards are Kanban boards. These, however, are more adapted to agile projects and instead of a timeline on the columns, sprints or phases are used. The second component of visual planning is the meeting. These meetings are short meetings, preferably held as stand-up meetings in the morning. The meeting revolves around the visual board and some of the activities which can be conducted are updating the board, planning for the next tasks, solving problems that have emerged, and doing prioritizations (Stenholm et al., 2016). The preferred frequency of these meetings varies depending on the project at hand, but according to Lindlöf and Söderberg (2011), having two meetings each week is the most common and there should be at least one meeting each week.

Biazzo et al. (2020) has synthesized the current knowledge on visual planning into five main principles. These are *work visualization*, *decentralized planning*, *continuous collaboration*, *transparency of information*, and *simplicity*. Work visualization is about ensuring that all project planning and progress are visual for the members of the team in the project. Decentralized planning relates to the importance of empowering the team members, making them feel ownership of the project and feel responsible for the outcome. For continuous collaboration to succeed, frequent teamwork is a necessity, and a perception of responsibility is of significant importance. Transparency of information refers to the spreading of knowledge and information, where all project members should have access to the same information, which could be eased by the usage of post-its and posters. Simplicity is achieved through the replacement of traditional and too advanced techniques, and instead using simple posters and post-it notes as a way of increasing clarity and straightforwardness for the status of the project (Biazzo et al., 2020).

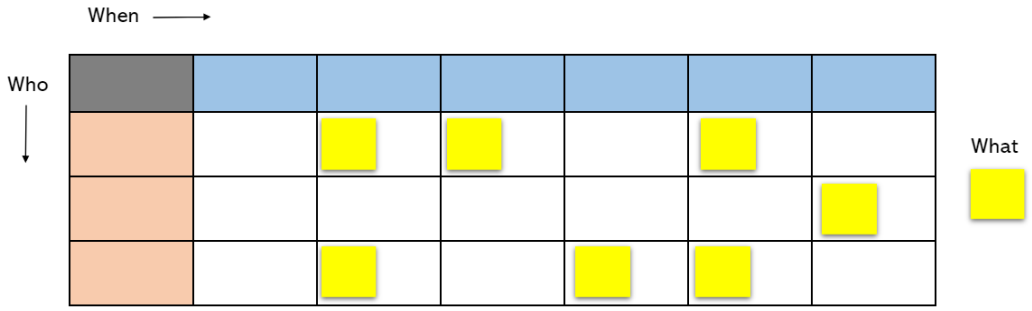

Figure 8. Visual planning board, figure adapted from Stenholm et al. (2016).

According to Hines et al. (2006), visual planning brings transparency into both project planning and execution since the board shows the responsibilities of each individual or function. In

addition, when combined with the board meetings where discussions occur, visual planning increases the motivation of the team. Lindlöf (2014) extends the discussion regarding the benefits of transparency and states that it decreases uncertainty for the team members. Visualization of the activities in the project leads to a better understanding of the cross-functional dependencies, hence, the process can potentially be less mechanistic (Jansson et al., 2016). According to Biazzo et al. (2020), the overall aim of utilizing visual planning is to increase the efficiency of the project by enhancing planning and communication. Proof that visual planning does increase project performance is provided by Xiong et al. (2021), who conducted a case study showing that visual planning had a positive impact on R&D projects' Key Performance Indicators. An additional aspect that follows the usage of visual planning is that the engineers become more involved in the process of making decisions, hence, teams are empowered, and decisions are decentralized (Lindlöf & Söderberg, 2011).

2.3.2 Digital visual planning

Digital visual planning distinguishes from visual planning by applying its concepts but in a virtual environment. Instead of using physical artifacts, such as boards with notes, different types of software can be used to recreate a corresponding setting. Most prominently, it is used by globally dispersed teams, where the distance between the team members does not allow them to work with physical visual planning (Lindlöf & Söderberg, 2011). By combining software that provides a visual planning board with a service for video calls, both main elements of visual planning can be achieved remotely (Stenholm et al., 2016). Furthermore, Pedo et al. (2020) have identified seven aspects that should be considered for digital visual planning systems to be successful. These are *simplicity of functioning, information standardization, autonomy to plan and control, right amount of information available, easy information accessibility, flexibility,* and *information traceability*.

Digital visual planning can provide benefits in terms of the possibility to collaborate remotely and a more efficient sharing of information. However, according to Stenholm et al. (2016), the digitalization of visual planning risks reducing the amount and frequency of communication between team members. Furthermore, Lindlöf (2014) argues that face-to-face meetings are very important since these provide the richest form of communication, compared to communicating through IT systems and documents. In addition, in-person meetings are synchronous, meaning that there is a possibility for the receiver of the information to give instant reaction and feedback, whereas some of this richness is lost when conducting it virtually (Lindlöf, 2014). Stenholm et al. (2016) point out the risk that too much attention is given to the technical aspects of the software when using digital visual planning, and that the cost is higher compared to using physical boards. On the other hand, Jansson et al. (2016) describe how the storage and sharing of information are hindered by physical boards. Consequently, digital tools can address these challenges, by offering more space for notes, easy storing of information, and the possibility to access information independently of geographical location. Furthermore, Brady et al. (2018) describe how digital management systems can enhance the information flow and the transparency in planning and control activities within a project.

2.4 Change management

Organizations consist of people, and whenever a change is conducted in an organization, these people are affected. Organizational changes can be anything from enormous restructuring projects to the implementation of a new working method in an isolated process. Since these changes always affect the individuals in the organization, managing the change while adhering to the perspectives of the individuals who are affected is particularly important (Strebel, 1996). Managing change is a challenging task, and according to Thomas and Hardy (2011), many organizational change initiatives fail to deliver according to their goals. Beer and Nohria (2000) state that as many as 70% of all change initiatives fail. A failed organizational change could either occur if the objectives are not met or if the change is diminished after a while and the way of working is changed back to the old way.

2.4.1 Resistance to change

Frequently, the reason for these failures in organizational change is pointed out to be due to the phenomena of resistance to change. Resistance has usually been defined as a state during which the individuals in the organization oppose the change because they consider that it in some way will lead to a deterioration of their working conditions or because they are unwilling to do the additional work needed to implement the change (Thomas & Hardy, 2011). Hence, the individuals affected by the change have previously frequently been blamed for resisting change and thus causing the change to fail. However, more contemporary research has started viewing resistance to change in another way. Ford and Ford (2010) admit that resistance or unwillingness to change can sometimes be irrational and unjustified. However, they emphasize that resistance or unwillingness to change frequently occurs because of an important reason. The people affected by a change are often experts in the process where the change is conducted and the reason they react with resistance is that they know that the change is not suitable. By listening to and discussing with these people, the leaders of the change can gain valuable insights which can be used as inputs for altering the strategy of the change. In this way, Ford and Ford (2010) explain that there are two benefits to be made, the change can become better, and the individuals affected will be more involved and potentially more motivated to help. Thomas and Hardy (2011) share a similar view on the topic of resistance to change and suggest that resistance should be viewed as something positive and an opportunity for feedback and improvement instead of a hindrance.

2.5 Activity theory

The Activity theory is a theoretical framework that can be utilized to analyze activities that involve interactions between humans. It has its origins in psychology, but the usage has spread to other branches of science as well (Engeström, 1999). It can be adopted as a theoretical lens when deductively analyzing empirical data in qualitative studies (Hashim & Jones, 2007). In this theory, an activity is loosely defined as a phenomenon that consists of both the actions performed by individuals, as well as the context in which these actions occur. Since several dimensions and aspects are considered in this theory and not only the actions themselves, the theory is considered effective for understanding the subjective reality of humans involved in the activities of interest (Duignan et al., 2006). The Activity theory framework, which is visualized in Figure 9, consists of several elements. These elements together describe the activity and its context, and this representation is termed Activity system (Boer et al., 2002).

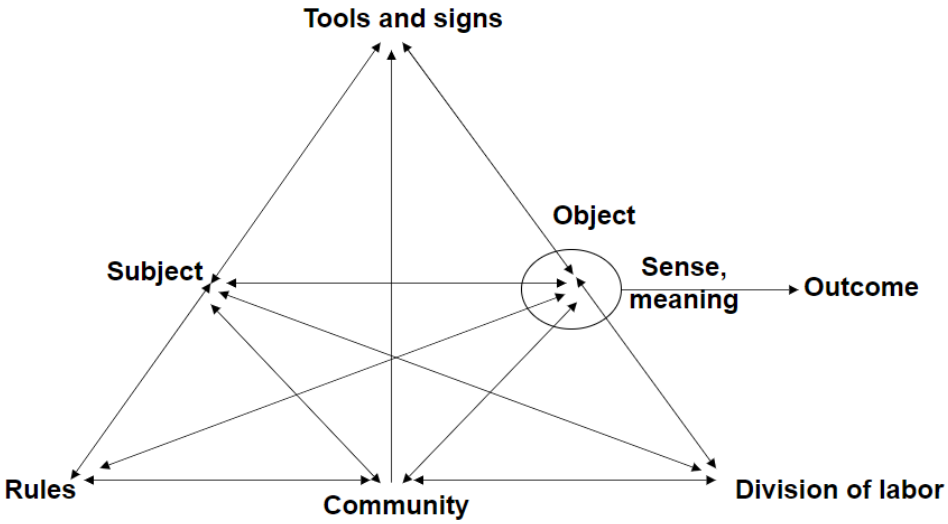

Figure 9. Activity theory adapted from Engeström (2001).

The *subject* is the individual or group of individuals that are being studied, for example, a worker or a project team and, therefore, the subject is the point of view of the study. The *object* corresponds to the activity or phenomena that is being studied with the aim of reaching a certain *outcome*. The *tools and signs* are artifacts used to accomplish the activity, in other words, to affect the object and, hence, also the outcome. Tools and signs can, for example, be software, work methods, and other aids. *Rules* are social norms that affect the behavior of the individuals that are being studied. *Community* corresponds to the larger group that is being affected by the individuals in the study. The community can therefore be seen as the stakeholders which are affected by, or interested in, the activity that is studied. *Division of labor* describes how actions are distributed between the individuals of the study and the distribution of power (Hashim & Jones, 2007). As can be seen by the arrows in Figure 9, the different elements of the Activity theory are related in different ways, and some affect each other. As an example, *rules* and *subject* are connected with a two-dimensional arrow. This represents the fact that the subject is affected by rules like social norms, and it also contributes to creating these norms. When utilizing Activity theory for analysis, one can examine to which extent, and in which way the subject is affected by norms, and how the subject affects existing norms (Boer et al., 2002).

3. Method

In the following chapter, the method used in the study is presented. First, the research strategy and approach are outlined. Then, the process of the research, which is based on the DRM framework by Blessing and Chakrabarti (2009), is described. Following, the sampling strategy and how data collection and data analysis was performed are presented. Finally, the quality criteria and the ethical, environmental, and societal aspects considered during the study are presented.

3.1 Research Strategy & Approach

The research strategy chosen for this study is of a qualitative character. This branch of research often emphasizes the use of an inductive approach where theory is generated out of the specific research setting (Bell et al., 2019). However, collected empirical data from this study also needed to be complemented with general rules from existing theory, and this combined approach to research corresponds to an abductive approach (Bell et al., 2019). The abductive approach implies that the researchers of this study have shifted between analyzing the empirical data in an inductive and a deductive way. The goal of induction was to identify barriers to efficient project communication based on empirical data, whereas the goal of deduction was to use existing frameworks and theories of barriers to efficient project communication to compare with the inductively established findings. The abductive approach was considered useful since it allows for inductive findings to be combined with the deductive approach of utilizing existing theory to gain knowledge on relevant topics (Dubois & Gadde, 1999). Furthermore, this was realized by utilizing both Activity theory which is a deductive method, and Thematic analysis which is an inductive method.

A qualitative research strategy was deemed suitable since the research was based on a multiple case study where a limited number of people had extensive knowledge and insights in each project studied. These people were involved through semi-structured interviews and observations of the case projects were carried out. Another reason why a qualitative strategy was chosen was because the projects included did not quantitatively measure their performance with any metrics. Since the researchers were part of implementing the digital visual planning software that was being evaluated and thereby conducting interventions, this study included elements of action research as well. This combination of a multiple case study and action research is something that is advocated by Halecker (2015), who states that this combination can potentially provide the benefits of both methods. By combining these, contributions to research theory can be achieved, as well as contributions to the case company. The reason a multiple case study was considered suitable was the fact that the phenomenon, which was three different projects, were studied in their unique contexts (Yin, 2004). This allowed the digital visual planning software to be applied in the natural setting of the studied projects, and to be compared with the existing tools used in the same settings. As an implication, this led to the advantages of more accurate findings compared to only conducting a theoretical analysis of the software of the study.

3.2 Research Process

On an overarching level, the research process of this study could be seen as a combination of a prescriptive and a descriptive approach, in which the researchers have alternated according to

Figure 10. This approach is adapted from the DRM framework by Blessing and Chakrabarti (2009), which consists of the four phases *Research clarification*, *Descriptive I*, *Prescriptive*, and *Descriptive II*. *Research clarification* can be considered a pre-phase, which involved the literature review and served as the basis for defining the goals of the research. *Descriptive I* is referred to as the initial phase. This phase was highly related to the first research question, which aimed at uncovering the existing barriers to efficient project communication. When the current situation was understood, the *Prescriptive* phase began where development was conducted. During this phase, the digital visual planning software was adapted and implemented in the case projects. The concluding *Descriptive II* phase, also known as the post phase, contained an analysis and evaluation of the effect of the usage of the software. This was done to establish findings and answer the second research question regarding whether digital visual planning software could be used to address the barriers to efficient project communication.

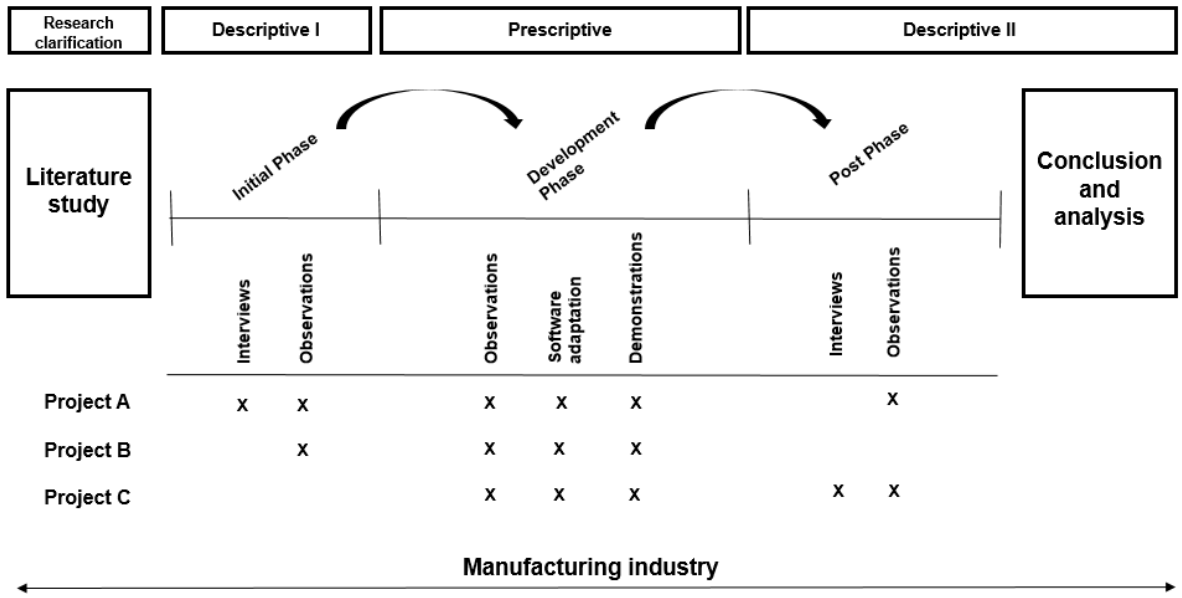

Figure 10. Detailed visualization of the research process.

Blessing and Chakrabarti (2009) describe that iterations between the phases are common in these types of research projects. Even though it is not evident from Figure 10, so has also been the case in this research. As an example, although most of the literature study was conducted early in the research process during the research clarification phase, literature has been reviewed continuously in iterations throughout the study. The reason for this is that literature has been used both to build a solid foundation for the study and to learn more about aspects and topics which have emerged throughout the study. In addition, during the prescriptive phase, several rounds of software adaptations to each specific case project were conducted. Each round of adaptation was followed by a demonstration, during which the project teams could give their feedback as input for further adaptation. Furthermore, the participants of the study were educated in the usage of the software by the researchers during this phase.

3.3 Sampling

First, suitable projects were identified and approached, and the owners of the projects were asked if they wanted the projects to be included in the study. Once suitable projects were identified, and agreements on inclusion in the study had been made, the next step was to establish the sample of individuals to participate in each study. For this, *purposeful sampling* was utilized. Purposeful sampling is described by Palinkas et al. (2015) as a way of establishing a sample by including the individuals who are the most knowledgeable and the most affected and involved in the object of study. This sampling method was considered suitable for this study since it increased the understanding of the projects that were being studied. Furthermore, since no statistical calculations were conducted, random sampling was not needed. Both team members of the projects and project managers were included in the study so that several perspectives were analyzed.

The size of the sample for this study, in other words, the number of participants included, was dependent on the size of the project teams of the case projects. According to Bell et al. (2019), there is no minimum sample size when conducting a qualitative study. Instead, the empirical saturation is more affected by the richness of the data rather than the number of participants. However, to establish a sufficient understanding of the case projects and to include several perspectives, the researchers strived to include all members of each project and the project managers of all projects. All members of projects A and project C were included in the study as participants. However, in project B, all members of the project were represented during observations but not all members were available for interviews.

3.4 Data Collection

Three different methods of data collection were used to gather qualitative data for this study. Empirical data was collected using participant observations and semi-structured interviews. In addition, qualitative secondary data was collected through literature reviews.

3.4.1 Literature Review

As described earlier, literature was reviewed throughout the entire research process. The reason was to ensure constant learning and improvement throughout the process. Another reason was to enable the ability to adapt the literature searches depending on findings from the empirical data. Search terms considered relevant and that were included in the literature reviews were "*project management", "communication", "project communication" "Stage-gate", "lean product development", "agile product development", "visualization", "visual planning", "digital visual planning", "change management",* and *"resistance to change".*

During the literature review, the searches were limited to searches in title, abstract, and keywords of the different literature. In addition, documents included in the searches were limited to articles, books, book chapters, and conference proceedings. The reason for this was both to limit the amount of material to assess, as well as to ensure that the included literature was of sufficient quality. When searching for literature, the scientific publishing database Scopus was used. The method for reviewing literature varied throughout the process. In addition to searches in Scopus, snowballing was utilized. Applied to a literature review, snowballing is described by Bell et al. (2019) as the act of studying the references of relevant literature. This is known as *backward snowballing*. Another type of snowballing, which is conducted by

studying literature that cites relevant literature, is referred to as *forward snowballing* (Wohlin et al., 2020). By doing this type of review, additional literature, which was not found in searches, could be identified.

3.4.2 Observations and demonstrations

During the study, participant observations were conducted. The researchers participated during meetings, workshops, and field trips in the projects, acting as passive participants by taking notes. These notes together with written summaries done by the researchers after each observation acted as empirical data from the observations. However, by applying elements of action research, the researchers did after providing education on the digital visual planning software also observe the users in their usage of the software. According to Bell et al. (2019), participant observations allow the researchers to keep an open mind about what knowledge needs to be gained from a case study. Consequently, it helps to formulate the frameworks and theories out of the data. In addition, Kawulich (2005) states that participant observations are useful to gain knowledge that may not be verbally communicated from participants during interviews. In total, 13 observations were conducted during the study, and information regarding these can be found in Table 3.

Table 3. Information regarding participant observations.

Observations	Type of observation	Location	Duration (minutes)	Date
A1	Meeting	Online	40	2022-02-16
A2	Meeting	Online	45	2022-02-17
A3	Meeting	On site	60	2022-02-28
A4	Workshop	On site	420	2022-03-02
A5	Workshop	On site	330	2022-03-17
A6	Meeting	Online	30	2022-03-30
A7	Meeting	Online	60	2022-04-01
A8	Meeting	Online	50	2022-04-05
B1	Workshop	Online	60	2022-02-02
B2	Meeting	Online	30	2022-02-04
B3	Meeting	Online	50	2022-02-08
B4	Meeting	Online	60	2022-04-13
C1	Workshop	Online	60	2022-04-25

In addition to the observations, the researchers conducted demonstrations of the software on the three case projects, see Table 4. When the projects had agreed to participate in the study, the demonstrations were used as an opportunity to receive important feedback, which could be used to further adapt the layout of the software to the specific projects. During the demonstrations, the researchers showed the software and taught the participants how to use it, and the project members got the opportunity to ask questions and share their opinions. Demonstrations were held until the project members considered that the planning board in the software had been adapted enough to suit their project. In project A, two demonstrations were

conducted, in project B, three demonstrations were conducted and in project C, two demonstrations were conducted.

Table 4. Information regarding demonstrations conducted.

Demonstration	Location	Duration (minutes)	Date
Demonstration A1	On site	120	2022-02-18
Demonstration A2	On site	90	2022-03-09
Demonstration B1	Online	60	2022-02-2
Demonstration B2	Online	55	2022-02-07
Demonstration B3	Online	60	2022-03-01
Demonstration C1	Online	60	2022-03-11
Demonstration C2	Online	60	2022-03-28

3.4.3 Qualitative Interviews

In addition to participant observations, empirical data was collected using semi-structured qualitative interviews. This type of interview was considered suitable since, according to Bell et al. (2019), it is flexible, yet standardized, since the interviews revolve around certain themes. This method allows for unexpected findings to emerge because participants are allowed to speak freely about the chosen topics. Moreover, the interviewer has the possibility to adjust the interview depending on how it develops. A strength of the semi-structured interview that was considered useful in this specific study was that since it has some degree of standardization, it can be used to compare answers from different participants (Carruthers, 1990). This implied that the differences in opinions and interpretations between different members of the teams in the case projects could be uncovered and analyzed. In addition, this enabled the different case projects to be compared to each other.

To aid the researchers during the interviews, interview guides were established. The interview guides were based on themes identified in relevant literature and on aspects found during observations. Similar interview guides were used for the three different projects to allow for comparisons between them. Due to this, the reasons behind different opinions were easier to understand, which was helpful when identifying the barriers and addressing them in the conclusions. In total, 12 semi-structured interviews were conducted, and interviews were held with members of all three case projects. All interviews were recorded and transcribed with the aim of simplifying the data analysis. For more information, see Table 5, where the letter in front of the interview number indicates which of the three case projects the interviewee belongs to.

Table 5. Information regarding interviews.

Interview	Position	Type of interview	Duration	Date
A1	Project member	Semi-structured	43	2022-02-23
A2	Project leader	Semi-structured	48	2022-02-24
A3	Project leader	Semi-structured	49	2022-02-24
A4	Project leader	Semi-structured	45	2022-02-24
A5	Project member	Semi-structured	48	2022-04-07
A6	Project member	Semi-structured	34	2022-04-09
A7	Project member	Semi-structured	31	2022-04-11
B1	Project member	Semi-structured	28	2022-04-13
B2	Project leader	Semi-structured	32	2022-04-27
B3	Project member	Semi-structured	30	2022-04-27
C1	Project leader	Semi-structured	32	2022-04-06
C2	Project member	Semi-structured	43	2022-04-06

3.5 Data Analysis

Thematic analysis was chosen as the method to use for conducting data analysis on the empirical data that was collected during the study. In addition, two theoretical frameworks regarding barriers to efficient communication were utilized for comparison with the findings from the thematic analysis. This combination of analysis methods was a way of realizing the abductive approach of this study since thematic analysis is an inductive method of analysis and using established frameworks is a deductive method (Bell et al., 2019). Furthermore, the theoretical framework *Activity theory* was used to structure the empirical data before analyzing it. By using this framework, the aim was to ensure that no important aspects of the empirical data were missed for the following analysis.

The reason Activity theory was considered useful for structuring the empirical data was because it can be utilized as a theoretical framework when analyzing interactions between humans, which is what occurs in projects. In addition, the use of artifacts and tools and the impact of these on human interactions are emphasized by Hashim and Jones (2007). The Activity theory framework, which is visualized in Figure 9, consists of several elements. The subject corresponded to the project teams in this case study. The object is the activity of communicating and sharing information in the project. Tools and signs are artifacts used for accomplishing this, in this case, the studied software and other methods and channels. Rules are social norms, and in this study, it can be different organizational belongings and different expectations that affect the behavior of the individuals. Community corresponds to the larger group that was being affected by the individuals in the study, i.e., the case projects, and their stakeholders. Division of labor corresponds to the hierarchy and the way that work is distributed in the case projects.

Thematic analysis is a method for conducting analysis of qualitative data. The reason it was considered suitable for this study was that it is a flexible method that can be used in a wide range of research areas. In addition, it is considered able to efficiently handle large amounts of qualitative data in different formats, which was useful since data from both observations and

semi-structured interviews were analyzed (Bell et al., 2019). To minimize the impact of subjectiveness during the thematic analysis, a guide by Nowell et al. (2017) was followed. This guide contains six steps meant to help the researchers, see Figure 11. The first step was to structure and become familiar with the data. In the second step, initial coding was conducted by highlighting interesting aspects of the data. Step three was to identify themes in the initial codes, and the fourth step was to review these themes by once again reviewing the raw data. Step five was to define and name the themes that have been identified and reviewed, and the last step was to write up the findings from the thematic analysis.

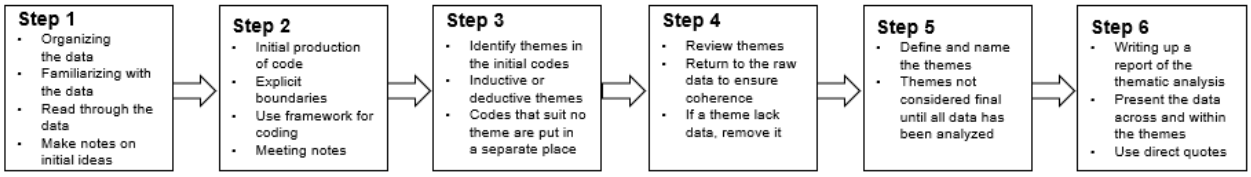

Figure 11. Thematic analysis process adapted from Nowell et al. (2017).

3.6 Validation Criteria

When conducting a research study, Isaksson et al. (2020) describe the importance of validating the research and states that it is important to focus on what to validate. Therefore, when designing the research method for this study, measures were taken to ensure that the validity of the research was sufficient. To guide this work and focus on the most important aspects, the set of validation criteria known as trustworthiness was used. This consists of four dimensions that are important to consider when designing a research method, namely *credibility*, *transferability*, *dependability*, and *confirmability* (Lincoln & Guba, 1985).

Credibility is about to which degree the result of the study reflects reality, hence, it is dependent on the researcher's ability to understand and interpret the reality of the participants of the study. An action that has been taken to increase the credibility of the study is triangulation. Triangulation was achieved by verifying interpretations from interviews with observations, or vice versa. In addition, the literature review was used to validate the connection to previous research. Since the researchers have prior experience within the case company, this was considered to increase the possibility of a greater understanding of the context, hence, increasing credibility further. Alvesson (2003) describes risks when conducting semi-structured interviews which were used in this study. Participants risk being influenced by the interviewers, and company norms and culture risk affect the way they answer questions. To mitigate these risks, the participants were granted anonymity to ensure that they felt comfortable revealing their true opinions.

Transferability describes to what extent the results of a study can be generalized to other contexts. Measures taken to increase the ability to generalize the results are that the research process was spelled out in detail and the context in terms of the industry, case companies, and case projects were described as detailed as allowed. In addition, since the case company Volvo Group which the study is conducted on behalf of is operating in the manufacturing industry, similar contexts are likely to exist. Thus, results might be generalizable to these. However, an important note is that the research is of a qualitative nature, and this type of research has

according to Bell et al. (2019) a limited possibility of generalizing the findings. Therefore, any generalizations of the results of this study must be done carefully.

Dependability is about how transparent the researchers are regarding the research method and research process. To ensure proper dependability, the problem formulation was clearly stated, fieldwork notes and transcripts were saved until the end of the research, and data analysis procedures were described.

Confirmability addresses the need to minimize the subjectiveness induced by the researchers. As stated by Bell et al. (2019), it is difficult to completely avoid all kinds of subjectivity when conducting qualitative research, however, some measures were taken to decrease subjectivity. The established method of thematic analysis was used for data analysis and a guide was followed to make sure that the method was used correctly. Since this study was subject to opposition from peers, which gave valuable feedback, this strengthened the confirmability of the research even further (Bell et al., 2019). Furthermore, the analysis of the empirical data was conducted by both researchers independently. The results of the analysis were then compared, with the aim of uncovering and discussing potential differences and establishing consensus.

3.7 Ethical Considerations

To ensure an ethical approach during the research study, the four most prominent aspects that need to be avoided during a research study according to Bell et al. (2019) were taken into consideration. These are *harm to participants, lack of informed consent, invasion of privacy*, and *deception*.

Harm to participants includes several different perspectives, of which some are physical harm, stress, and harm to future career possibilities. By ensuring that the interviews were conducted in a safe environment, that interviewees were provided with several alternative interview timeslots to choose from, and by ensuring anonymity of their answers, the risk of harm has been minimized in this case study.

To avoid a lack of informed consent, the participants were informed before each interview about their rights. This included communicating that they had the right to not accept the interviews to be transcribed, recorded, nor saved to the end of the project. In addition, participants were given the right to turn down specific questions if they did not feel comfortable answering them.

When conducting the interviews, it was of significant importance not to invade the participants' *privacy*. This relates to avoidance of harm and anonymity, where no information should be possible to backtrack to one specific interviewee, and the information should not risk falling into unauthorized possession. By storing information safely with access rights strictly controlled, invasion of privacy could be avoided.

Deception relates to the importance of not misleading the participants by not being open and honest about the purpose of the study. In all observations and interviews, the researchers had an overt role, meaning that they revealed and were open to the project participants that the observations and interviews were part of a research project. By ensuring total transparency, there might be a risk that all relevant information would not be shared by the participants.

However, this was a risk worth taking since ethical aspects were considered more important than the quality of the research.

3.8 Societal and Ecological Considerations

During the design of the research method for this study, several actions have been taken to minimize negative impacts on ecological and societal aspects. To minimize the ecological impact of this research, most of the study was conducted virtually through the aid of digital platforms such as Microsoft Teams, Zoom, and telephone calls. In addition, the software that was implemented contributed to a reduction in the need for traveling, both during the study and in the aftermath, since it is web-based. It also replaced the usage of paper, whiteboards, and other consumables. However, since it is web-based, the software consumes energy in the form of electricity. Both for running the servers by the service provider and for using the tool by the case company. For the societal aspects, since the study was conducted during parts of the Covid-19 pandemic, the researchers acted responsibly and always prioritized the health of all participants of the project above the quality of the results. In addition, the researchers aimed to utilize the time provided by the participants in the best way possible to reduce the risk of them being overloaded. A potential positive impact that could be seen as an implication of the implementation of the software is that the project leaders can be relieved of some of their burdens, hence, decreasing their risk of stress-related health issues.

4. Results

In this chapter, the empirical data which has been collected during this study is presented. The data has been obtained through interviews, observations, and feedback from actions conducted by the researchers. The data originates from the three different projects included in this study, project A, project B, and project C, and have been structured according to the seven categories of the Activity theory described in section 2.5 Activity theory and visualized in Figure 9. The interviewees and the observations are named based on which project they belong to. Hence, as an example, interviewee A1 is the first interviewee and is a member of project A.

4.1 Subject

The *subject* in Activity theory is the individual or group of individuals that is being studied. Therefore, these peoples' perspective is the point of view that is adopted.

Project A:

According to interviewee A2, the members of project A originate from different organizations and are collaborating toward a common goal defined by the project. In addition to this, the members have different roles, some have a leadership position, and some are regular project members. The organizations included are different industrial manufacturing companies as well as a university. The fact that the members have different backgrounds is, according to interviewee A3, sometimes challenging since different individuals have different perspectives and expectations on the project.

"*I think that the toughest challenge of this project [project A] is that different companies have different expectations on the project"* - interviewee A3.

This view is shared by interviewee A2, who emphasized that the different organizational backgrounds create a challenge since the prior knowledge and experience of these types of projects differs, as well as the understanding of what a demonstrator could look like. A demonstrator could, according to observation A4, be a way of working or a tool that shows a proof-of-concept and proof-of value that fulfills the aim of project A. Hence, one or several demonstrators are the deliverables of project A.

Interviewee A1, which is a project member with a background in one of the manufacturing companies, held the opinion that there is currently some ambiguity regarding the responsibilities of both the interviewee self and the other members of the project as well. In addition, the interviewee stated that the tasks of the project do not need to be scheduled hour by hour, but more clarity is needed.

"I do not think they [project members] are aware of their responsibilities at the moment." - interviewee A1.

One of the participants with a project leader position, interviewee A2, stated that since project A aims at creating new and innovative solutions, a long horizon and a less rigid and defined structure of planning is a necessity. However, interviewee A6 from one of the manufacturing companies held the opinion that project A is too vaguely defined and that this leads to confusion

regarding what needs to be done, which slows down the project. A similar view was expressed during observation A1 by a member of another of the manufacturing companies.

Project B:

According to interviewee B3, project B is a development project in which products are adjusted to be able to be mass produced. In this project, the individuals in the project team are all from the same organization and with similar backgrounds. However, they have different roles, including management, project management officers (PMO), project coordinator, and development engineers. The goals are clearly defined from the beginning and from observation B3, it was identified that a process similar to the Stage-gate methodology is applied for managing the project. From observation B1, it was uncovered that the members of project B had several reasons for wanting to participate in this study and the goals were shared by all the members. Some of the reasons were to make the work more efficient, communication more intuitive and to increase the level of digitalization.

Project C:

The members of project C are from the same company and are working in the same department. However, their tasks require cross-functional collaboration, hence they communicate regularly with other functions of the company. The project members work with software, more specifically with changes to parts of the company website regarding product configuration options. This implies that the members communicate with both software developers as well as functions connected to the production of the physical products. Their work has, therefore, a direct impact on the customer experience when ordering their products. Interviewee C2 explained that they have used the Yolean software daily for around five years.

"The department started using Yolean when I started working here five years ago. Ever since then, we have used it every day. We use it for keeping track of all our productions and the daily management" - interviewee C2

Interviewee C1 has a leadership role and interviewee C2 is a project member. Both have several years of experience within the company, and therefore possess knowledge of how other departments conduct work without the Yolean software.

4.2 Community

The *community* is the people and stakeholders around the studied situation that are being affected by the activities and individuals in the study.

Project A:

Project A has a rather extensive community of actors and stakeholders with an interest in the outcome of the project. As stated by interviewee A3, the different organizations which are represented by the members in the project are important stakeholders.

"*Apart from the members of the project, there are many stakeholders in each company which is represented in the project. Me as a leader do not communicate regularly with these, instead we trust that the members of the project forward important information to their organizations"* - interviewee A3.

However, interviewee A1 stated that very few details regarding the progress of the project have been possible to communicate. The reason is that the interviewee considers that the aim is vague, and the project is inefficient with slow progress. In addition, the interviewee described that the organization which the interviewee represents requests information in English, but communication from project A has sometimes been in Swedish. This was also noted during observation A6 which was a status update meeting for the project during which some presented in English, and some in Swedish.

Interviewee A2 described that external actors, which are not part of the project, are interested in the outcome as well. Since project A is a publicly funded research project, it is expected to provide benefits to the entire Swedish manufacturing industry by communicating the findings externally. Therefore, interviewee A2 described that the project has a webpage where information is publicly posted. Interviewee A6, who represents one of the organizations in the project, described the stakeholders similarly by stating that one of the overall goals of the project is to deliver innovations that can help increase the competitiveness of the Swedish manufacturing industry.

"*As I see it, the goal of the project is to make the Swedish industry more competitive by having a digital platform on which communication and collaboration can be conducted in different ways"* - interviewee A6.

The fact that there are members from several organizations in the project leads to some challenges when communicating according to interviewee A3. The interviewee explained that it is sometimes difficult to get a hold of the members since they are spread out geographically. In addition, the interviewee described that some members know each other from previous projects, and some do not. This sometimes leads to a situation where different members are communicated with various levels of formality and members who know each other from before sometimes communicate more frequently. Interviewee A4 added that there have also been some technical issues in the communication channels because of members being from different organizations. One example that was provided by the interviewee is that access to different systems has been troublesome when the system originates on the intranet of a specific company.

"It is a little bit tricky to have like the specific credentials if you are not part of company XX or not part of company YY." - interviewee A4.

Project B:

In project B, the stakeholders are mainly within the same organization. As was explained during observation B1, a lot of communication occurs with individuals working in production and with the R&D function of the organization. In addition, interviewee B1 described how the PMOs, who are responsible for the projects, communicate with several additional functions and their corresponding team leaders to ensure that the activities necessary to reach the milestones are performed. Furthermore, during observation B1, it became evident that the way communication and information sharing is conducted within this plant also affects other plants, since it is part of a larger value chain. According to interviewee B3, the most important stakeholder is the production department, however, other plants in other locations are also involved and part of their work.

Project C:

Interviewees C1 and C2 work cross-functional and collaborate with different functions of the company. In addition, they receive customer feedback from different markets, hence, the end customer of the company is an important stakeholder in their daily work. Interviewee C1 described that they are utilizing the Yolean software when collaborating with one of the other functions involved in their daily work. The interviewee stated that the software provides benefits in terms of easy planning of tasks and activities as well as powerful visualization, which can be displayed during meetings as a basis for discussion. In addition, interviewee C1 described that the usage of Yolean has increased the quality of their deliveries to the stakeholders.

"I believe that we have almost never missed any of our change requests. We have always inserted a post-it in Yolean and been able to follow up on that delivery. We may not always be able to deliver on time, but an activity has never been forgotten" - interviewee C1.

Interviewee C2 described that they are currently not utilizing the Yolean software when communicating with external actors such as consultants and suppliers which are also a part of the community of project C. However, interviewee C1 explained that their intention is to start utilizing Yolean when communicating with these external actors as well. The interviewee hoped that by doing this, a larger share of their work can be planned and communicated in the Yolean software.

4.3 Tools and signs

To enable the necessary activities, *tools and signs* in the form of artefacts can be used. These can for example be software, work methods, and other aids.

Project A:

Interviewee A2 described that communication and planning in project A is managed through the usage of three main channels. These are email, the chat function in Microsoft Teams, and a SharePoint folder for storing documents and data. As was uncovered during the interviews and during observation A3, the preferred communication channel varies between different members of the project. Interviewee A7 preferred using the chat function in Teams and stated that emails are both inefficient and potentially untransparent since people frequently forget to reply to all people in the email list. In addition, the interviewee has experienced that people sometimes are mistakenly removed from the email lists and therefore miss important information. Interviewees A1 and A5 also stated that they prefer the usage of a chat solution rather than emails. Interviewee A4 on the other hand promoted the usage of email and disliked Microsoft Teams.

"A Teams collaboration solution is a substantially better way. Instead of having a lot of returning emails in which people either 'answer all' or do not 'answer all' and so on" - interviewee A7.

Interviewee A3, who is a project leader, explained at the time of the interview that they have not yet utilized any tool for documenting the project plan. The reason was explained to be that the plan was not yet finalized. However, the interviewee added that in previous similar projects,

Word documents and Excel files have been utilized for documenting the project plan, often in a Gantt chart format. The interviewee expressed that a more collaborative solution for documenting and creating the project plan could be beneficial. However, the interviewee also acknowledged the risk that the project leaders will be the only ones utilizing this collaborative software and that it thus would provide no benefits compared to a regular Word document or Excel file.

"I would like to have a tool in which everyone can collaborate simultaneously. However, the difficult part is to make sure that me and the other project leaders are not the only ones using the tool, you must figure out how to make it interactive and how to engage everyone in the tool" -interviewee A3

Interviewee A4 described that some tools for communication and planning are not intuitive and difficult to learn how to use. A similar view was presented by interviewee A3 who added that if the tools are difficult to use, there will be a barrier for the project members to use them and there is a risk that people simply will avoid using them. Interviewee A1 was positive towards the usage of digital tools when communicating but also recognized the risk of technical problems and provided an example of when documents were lost in project A. Interviewee A4 also described some technical problems related to difficulties of providing access to the company-specific platforms for the project members who originate from different organizations.

"Once we lost a lot of documents stored in an online platform... it was really good material but we cannot find any more, it has disappeared." - interviewee A1

During some of the interviews, it was discovered that with the usage of digital collaborative tools comes the question regarding cyber security. Interviewee A6 described that the company which the interviewee is representing is supporting the sharing of data with other actors in the value chain. However, the interviewee pointed out that there is some data that is connected to competitive advantages which the company is more restrictive about sharing. Interviewee A7 from another company in the value chain also expressed a willingness to share data but restrictiveness towards which data is shared and to whom and pointed out the risk if confidential data falls into the wrong hands.

Project B:

During observation B3, the project members described that their main channels for communication are Microsoft Teams and emails. Microsoft Teams is used both as a chat function for daily communication, as well as the platform used for digital meetings. Email is still a common tool for contacting people and sending documents. However, SharePoint is the document handling server where most documents are stored. Here, the Excel files associated with the project planning are located. It is also through SharePoint that the OneNote can be accessed, which is used for meeting minutes and with a page for each week stating the required deliverables and activities of the project. According to interviewee B1, these tools are for managing the project and for conducting communication, other digital tools are used as well but those tools are technical tools used in the actual development work. The interviewee stated that the current configuration of tools and documents for managing the project is not

transparent. The interviewee, who is a project member, lacked access to some of the important documents which were instead only shown during meetings. Another issue brought up by the interviewee was the difficulty in collaborating in the current configuration of tools. Partly because of lack of access and partly because the documents are unintuitive and difficult to understand. Interviewee B2 stated that the current configuration with several tools and repositories is not intuitive, nor efficient, and that they seek a solution that consists of only one tool.

"*Today we have many tools and files for managing the projects, it is a bit messy and therefore, every PMO manages their projects in their own way. We would like to find one tool which can be used by everyone and replace the other tools."* - interviewee B2

Project C:

In project C, when working with departments and external actors which do not use the Yolean software, project plans are planned in Excel files. These files are either stored in SharePoint or on separate computers. The files are often emailed from one person to another. Interviewee C1 stated that this is one of the challenges with using email for sending documents, that sometimes the documents then disappear and that emails need to be sent each time the project plan has been revised.

"Emails are often used. And it is often there that it fails, when you email someone and then it [the document] disappears." - interviewee C1

By using Yolean, interviewee C1 expressed that the number of emails is decreasing and that this leads to less stress. Interviewee C2 does not completely agree, since a lot of emails are still used for communicating with other departments within the company. However, interviewee C2 agrees that an expansion of the usage of Yolean to other teams could imply this reduction in number of emails. One problem that was mentioned by interviewee C2 is that one of the actors who is collaborating closely with the team is unwilling to use the Yolean software and prefers email and regular meetings instead.

"I would definitely say that Yolean reduces the amount of emails." - interviewee C1

Yolean is used, as previously described, to manage the planning of tasks and communicate what activities should be conducted and by whom. Both interviewees C1 and C2 highlighted how simple the software is to use. Because of this simplicity, interviewee C2 expressed that the threshold to learn Yolean is very low.

"The threshold to start using Yolean is very low. You do not need to familiarize yourself with the software, everything is very simple." - interviewee C2

Another benefit, according to interviewee C1, is that Yolean has easy accessibility. As long as you have an email address, you can add new users that need to have access to the information in Yolean. Thereby, even people that are used to other systems can easily be invited to the board.

4.4 Rules

Social norms that affect the behaviors of the individuals in the study can be defined as *rules*.

Project A:

During interview A3, the interviewee spoke about the importance of all project members receiving the same information and that they also interpret the information similarly. However, the interviewee also stated that this can be challenging and especially in the case of project A where the project members are geographically spread on different companies with different expectations. Different project members have described different preferred frequencies of communication in the project. Interviewee A1 does not want to have any regular meetings and wants to use a chat service to communicate when there is a need.

"I am not after any regular meetings, I really want to avoid that. I want us to have an ongoing dialogue, I would like to have a Teams chat that we can discuss directly in" - interviewee A1

Interviewee A6 has a similar view but would rather use telephone calls to get instant answers to questions that arise. Interviewee A4 on the other hand prefers more regular and frequent occasions for communication, for example, meetings, either face-to-face or online. Interviewee A2 described that a large and important task is to ensure that all the members of the project get to know each other. Connected to this, the interviewee emphasized the need to establish a sense of trust between the members of the project, since a large part of the project is about collaboration and sharing of data between companies in the value chain. Trust is something that was also brought up by interviewee A4 who states that as trust is built, communication is improved.

"I think that it is a matter of time, that people will get to know each other, and get to trust each other, and understand each other. So, I think with time, communication will become better" - interviewee A4.

Interviewee A5 also acknowledged the fact that several project members do not know each other from previously makes communication more difficult. The interviewee stated that it is sometimes unclear how a certain project member should be approached, if questions should be directed directly to members in separate communication channels or if communication should pass through project management. Interviewee A3, who has a leadership role, also acknowledged that there are some uncertainties regarding how communication with members in the project should be conducted.

"*I think it is a bit difficult, it is not so easy to contact the company representatives for every single little detail in between meetings. It is most often done by email. It does not feel natural to check every detail"* - interviewee A3.

Interviewee A1 described that it is sometimes difficult to access information connected to the project and its progress. The interviewee experiences that information is not transparent enough and that the interviewee lacks access to platforms that are used in the project. Interviewees A2, A3, and A4 who are project leaders shared the same opinion, that information is not transparent enough. However, interviewee A2 explained that measures are taken to increase transparency, and an example of this is that meetings are recorded so that people that miss a meeting can still receive the same information.

"I think it's not transparent for them. For me it is quite transparent because I am the leader" - interviewee A4.

Project B:

From interview B3, it was expressed that the frequency for project meetings is generally once every week. During these meetings, the PMO reports the status of the project to higher instances. In addition, observation B4 indicated that the PMO has continuous contact with the team leaders in the relevant functions. These team leaders respond to the PMOs to ensure that all necessary activities are conducted to reach the milestones of the project in time.

Project C:

According to interviewee C2, the members of project C utilize the Yolean software daily and they update the board once a new activity is demanded of the team. In addition to this, the team has daily meetings during which they use the Yolean board as the topic for discussion. The main objective for these daily meetings is according to interviewee C1 to plan for and discuss the upcoming two weeks of the project. In addition to the daily meetings during which decisions regarding the short-term planning are conducted, the team also has weekly meetings. Interviewee C1 described that during the weekly meetings, a more long-term plan is discussed and activities and deliverables for the upcoming quarter are discussed. Both interviewee C1 and interviewee C2 described that they like this set-up and the frequency of the meetings, however, they both express a wish that more people would utilize Yolean so that they could scale up the benefits that they experience from using the software.

4.5 Division of labor

The way that activities and actions are divided between the individuals of the study can be referred to as *division of labor*.

Project A:

From interview A3, it was described that decisions in the project are built upon a common consensus, where all project members need to be aware of the next activities to be conducted and that everyone needs to agree on who should do it. This view was shared by interviewee A4, who stated that there is no hierarchy in the communication in the project.

"It is a lot about building consensus." - interviewee A3

In contrast, interviewee A1 expressed a concern that a hierarchy does exist, and that it is very informal. On the same note, according to interviewee A5, there is an ambiguity in who takes the leadership role, even if there is a designated one. Interviewee A1 further described how some project members take up more space and, thereby, steer the project into those activities that are of special interest to them.

"There is a hierarchy, and it is very informal... then strong characters drive the progress" - interviewee A1

The project members are, based on the description from interviewee A1, not aware of their responsibilities at the moment. Interviewees A1, A5, and A7 stated that their roles and responsibilities are quite ambiguous.

"It is a bit unclear what my role is. I actually don't have a formal role." - interviewee A7

Interviewee A2 expressed an understanding that the current challenge is related to communicating when things are supposed to occur. That information distributed is perceived as indented is not something that can be expected. Therefore, even more communication is, according to interviewee A2, a necessity.

Project B:

During observation B3, it was clear that the project execution process was formalized and well defined. Many projects are run simultaneously, and the project organization is thorough and well-defined. Interviewee B1 described a clear hierarchy for how the projects are managed. PMOs manage several projects at a time, and in each project, there are leaders who are representatives from the different functions conducting the development work. The PMOs communicate with these functional leaders, who in turn communicate with their members regarding what they should do. Hence, the PMOs have the highest authority and are responsible for making the decisions in the projects.

"Normally the PMO does not have contact with the members of the team, only with the leaders of the functions" - interviewee B1

Interviewee B1 described that because of the hierarchy in the communication, the functional leaders interpret the information provided by the PMO before it is transmitted down to the members. The interviewee recalled once when a leader misinterpreted the information from the PMO. The PMO then chose to bypass the hierarchy and speak directly to the members of the project to ensure that the misinterpretation was corrected.

In the Stage-gate process methodology applied, interviewee B3 described that to pass a gate and move on to the next phase in the project, a set of predefined criteria must be fulfilled. During a gate-meeting, the project is assessed, and a steering committee is responsible for giving a go or no-go decision for each project. The interviewee further added that even though the project execution process is clearly defined, there are sometimes some difficulties retaining the information needed. This is explained to be due to the lack of transparency and difficulty in collaborating in the tools and documents used to manage the projects.

Project C:

The division of labor is, according to interviewee C1, relatively even within the team. Interviewee C1, which has a project leader position, is the manager for interviewee C2. Regardless, they share the same issues and help each other out with solving the problems by dividing the different tasks to be solved between them both. Furthermore, they take turns being responsible that all necessary activities are added to the Yolean board. This responsibility they switch on a weekly basis.

"One person is always the 'week-manager', who is responsible for all the incoming deliverables. This person we switch every week." - interviewee C1

Since they have their own rows in Yolean, interviewee C2 described that all activities can be addressed to a specific person, which improves the clarity of who is responsible for each activity. If some activities are hard to solve, it is also easy to reassign the work to another person.

"We always put the notes that we are responsible for on our own row. That makes it pretty simple for us to know what we are responsible for." - interviewee C1

The Yolean software is stated by interviewee C1 to be very collaborative. Since all team members have access to the planning board and can interact with the changes made by other people, it is easy to follow who is in charge of what. In addition, it eases the understanding of whom to contact when more information is necessary. In addition, since the software utilizes visualization to a large extent, it is easy to get a quick understanding of how much work each team member has each day, which is beneficial since the tasks can easily be more balanced according to interviewee C2. Furthermore, the interviewee stated that less emails also resulted in less stress of searching for information in unstructured email threads.

4.6 Outcome

The *outcome* is the final goal that is desired from conducting all activities.

Project A:

During observation A5, leaders of project A communicated that the main goal regarding the outcome of the project is to strengthen the competitiveness of the Swedish industry. This is aimed to be achieved by improving the quality assurance and root cause analysis process in the companies included in the project through new innovations in the shape of demonstrators. This statement was also expressed during an interview with interviewee A6. The way that this ought to be achieved was explained to be through digitalization and cross-organizational collaborations. Interviewee A2 described that the goals are clear and that there is already a plan for how to get there.

"We have started to work with activities in each value chain, so we do have concrete goals that we already have formulated on the agenda." - interviewee A2

In contrast, interviewees A1, A5, and A7 expressed that the goals of the project are still unclear. They stated that they do not really know where they are in the project and what should come out of it.

"What is tricky in the project is that the goals are diffuse." - interviewee A5

Interviewee A1 stated that the implementation of the Yolean software is aimed at increasing the efficiency of project A by, for example, reducing the number of meetings in the project. Through observation A7, additional insights were that further functionality in terms of the ability to collaborate with several actors from different organizations was demanded by project members. Furthermore, the ability to visualize the project status and project plan was considered useful.

Project B:

During demonstration B1 and demonstration B2, workshops were conducted during which the project members of project B explained their way of working and their needs on a collaborative project management tool. The overarching methodology applied in the project was explained as a Stage-gate methodology consisting of different phases followed by gates. The project members investigate and evaluate several different collaborative project management software and Yolean is one of them. During the workshops, the project members explained that there are many reasons why they want to implement such a software. The existing solution for managing the projects consists of many different repositories and documents used in combination. Interviewee B3 explained that by implementing a new software, they aim to reduce this complexity and increase the quality of the output by minimizing the risk of activities being forgotten. One of the project members described that the current way of working is highly unintuitive and difficult for new team members to grasp. By reducing the complexity, they also hope to decrease the time needed for administrative tasks connected to the project planning and communication, and thereby free up more time for actual development work. In addition, the implementation of a software like Yolean was considered a possible step in the company's digital transformation journey with more interactive and transparent communication.

Project C:

In project C, the outcome to strive for was to improve the efficiency in communication and planning, reduce the time needed to complete the milestones, and ensure that no deliverables are forgotten. By using Yolean, interviewee C1 stated that the management of planning becomes much easier to handle. Furthermore, the interviewee described how it helps to ease backtracking of what actions have been taken, which decreases the time spent on going through emails, and thereby in the end improves efficiency.

"I would absolutely say that Yolean helps to make the work more efficient. If someone asks me 'have we completed this change request?', then I can easily backtrack in the Yolean board and check that it is already revised." - interviewee C1

Interviewee C2 described that the Yolean software helps to achieve greater transparency in communication. The simplicity of the software is stated to be the key to this, and that it allows for other people to easily keep track of what work should be conducted.

"I would say that information and communication become transparent with Yolean. And I believe that the key is that it is so simple. Since we write in the time plan exactly what needs to be done at each larger deliverable, it becomes very clear and easy to follow for everyone that is affected." - interviewee C2

4.7 Object

The o*bject* is the activities and phenomena that are being conducted and studied to reach the desired outcome.

Project A:

Interviewee A6 described that there are different perspectives on the aim of project A and what activities should be conducted within the project. The interviewee wants to formulate a way of

working to improve the traceability of quality issues related to a product. Interviewees A3 and A4 mentioned similar activities, but also added activities to improve root cause analysis. In contrast, interviewees A5 and A7 emphasized the importance of performing digital maturity assessments in their manufacturing plants as the most important activity. Here, interviewee A5 described that these different views of the object of project A hinder communication and reasons for why to collaborate.

"You don't know why you should collaborate with some parties. What is the purpose in the project for this collaboration? Do we have common interests?" - interviewee A5

Interviewees A2, A3, and A4 expressed an understanding of this reasoning and stated that the different expectations from each member are the biggest challenge. However, interviewee A4 is convinced that finding the common goals to work towards will improve project communication and collaboration.

"I think that once we have defined a common goal that everyone agrees upon, it will make communication easier in a way" - interviewee A4

In addition to members having different goals and expectations on project A, some members have stated that they are unaware of which activities need to be conducted to reach the goal of the project. Interviewee A7 described that the interviewee has no knowledge of the plan of the project, especially regarding when activities should be performed. This view is shared by interviewee A1 who in addition also stated that the wanted outcome of the activities is unclear.

"We do not know what we should do, we do not know when we should do it, we do not know what we should deliver. So many challenges." - interviewee A1

Furthermore, interviewee A5 expressed the concern that it is not clear when things should occur and whom to communicate with to ensure the progress of project A. The concern regarding the ambiguity of communication content was also highlighted by interviewee A1, who stated that activities are conducted, but it is not always clear what came out of them.

"But right now, the challenge is that I don't know what I should communicate and to whom" - interviewee A5

Both interviewees A4 and A6 expressed that there is a lack of visualization of the progress in the project and that it is done in an inconsistent way. As a result, interviewee A6 stated that it is hard to understand where they are in the project time plan. Written text is used according to interviewee A4, but no graphics or other forms of visualization.

"I would say that the visualization is not conducted in a good way. Each time it is done differently, so it's not possible to tell where we are in our progress." - interviewee A6

Due to the above-mentioned challenges connected to communication within project A, the project members sought a more collaborative solution for managing communication. Therefore, it was decided that the software Yolean should be implemented and tested in the project and the researchers of this study were given the task to conduct the implementation. The first demonstration, demonstration A1, was held with the aim of showing the software and its functionalities. In addition, during this demonstration, the members of project A were asked to

provide their demands for a digital visual planning software for communication and planning. The researchers took this feedback into account and presented an adapted layout during demonstration A2, see Figure 12. This version was, according to the project members, considered usable for project A, and was thus implemented.

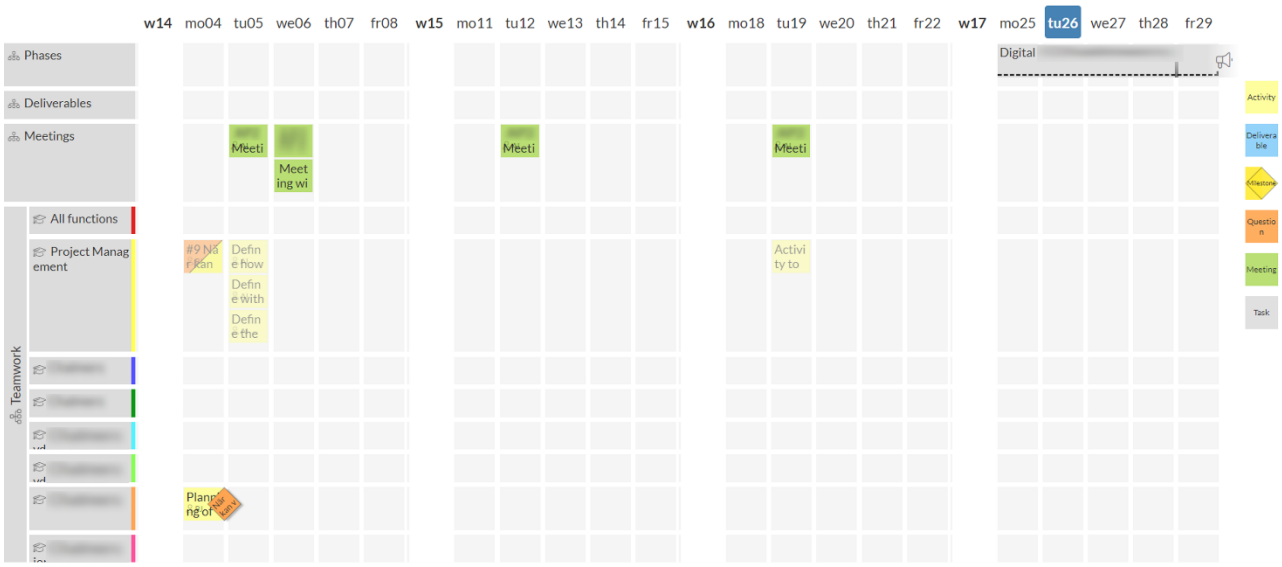

Figure 12. Yolean board adapted to project A.

Project B:

In project B, during demonstration B1, it was discovered that the aim of the project members to participate in the study was to explore how the current methodology used for project management can be revised and improved. Furthermore, this was to be done by implementing a project management software. As a part of this, the project members wanted to improve the structure of how the progress of project B was documented and visualized. From observation B2, the current way of working in project B was mapped.

The structure for managing the project was explained by interviewee B3 to consist of four different components used in combination, as shown in Figure 13. In a standardized and non-project specific Excel file, all stages and their corresponding gates are listed, and instructions for each stage and each gate review are included in this document. A high-level time plan, similar to a Gantt chart, in which the phases and gates are included is documented in another Excel file. In a OneNote document, a more short-term planning is conducted by creating bullet-point lists of activities to be performed together with information regarding the individual or function responsible for each activity. These three documents, together with other resources and files used in project B, are stored in a SharePoint repository. As can be seen by the arrows in Figure 13, although each document and Excel file are separate, they depend somehow on each other. Therefore, changes in one document imply the need for manual changes to other documents. In addition, the project members need to go through all these documents on a regular basis to stay updated on the progress of the project.

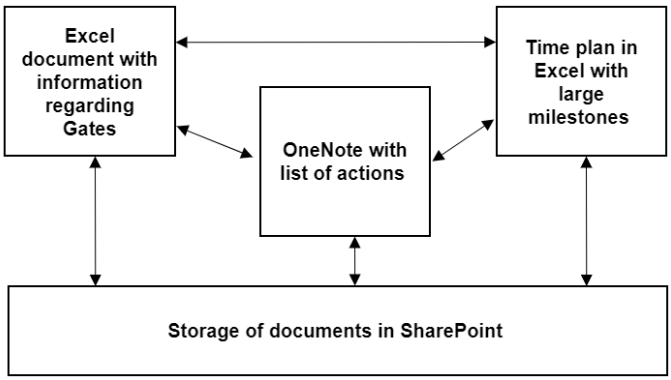

Figure 13. Structure of previous way of managing project B.

The solution proposed by the researchers of this study consist of a project management structure with two instead of four components, see Figure 14. One component is the Yolean software which has been adapted to include the list of actions, the time plan, and the information regarding the gates. The second component is the solution for storing project-specific documents and other resources in SharePoint, similar to the existing solution. Because of the reduction of components, the number of dependencies is reduced. Therefore, less administrative work of updating different documents is needed and the users are offered a quick overview of the entire project. In the Yolean software, by utilizing different views and levels of displaying, both short-term daily planning and long-term planning can be included.

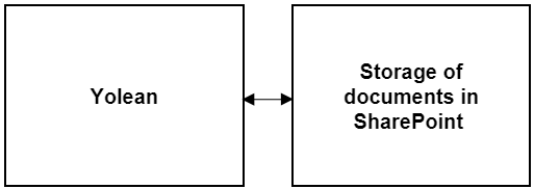

Figure 14. Suggested structure for managing project B.

During demonstration B1, the Yolean software was presented and input for how a desired board could look was communicated by the members of project B. Based on this input, a first draft of a Yolean board was developed. Through demonstration B2, it became apparent that the Yolean board needed some further adaptations to suit their needs. During this demonstration, it was emphasized that the Yolean software should be adapted to appear as similar to the previous systems as possible to reduce the need to relearn. Consequently, a specific layout for visualizing the deliverables of the project was requested. After further adaptations, demonstration B3 was conducted where a suitable board, including the sought-after functions and corresponding layouts, was presented, see Figure 15. The Yolean board was, according to the members of project B, considered satisfactory and included the necessary components and was, therefore, ready to be tested in a real development project.

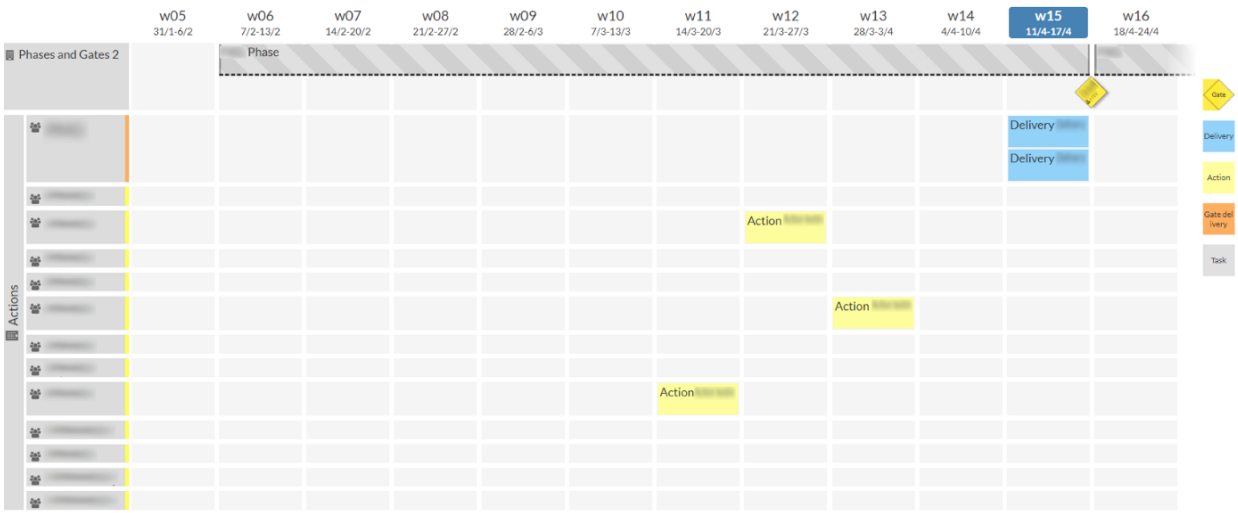

Figure 15. Yolean board adapted for project B.

Project C:

In project C, the members work with handling incoming change requests for the management of the company's product configurator used by their customers. Interviewee C1 described that they use the Yolean software daily to manage the planning of activities and communicate what tasks need to be conducted to reach their deliverables. Yolean thereby helps to ensure that all activities are assigned to a person and allows the project members to follow up on them which minimizes the risk of forgetting an activity.

"We use Yolean to create notes for all incoming incidents. Then I also have a specific row for my daily work." - Interviewee C1

Before the study, the members of project C had used an older version of the Yolean software, which was now in need of being replaced. During the study, the researchers conducted two demonstrations, demonstration C1, and demonstration C2. During these, the researchers showed how the updated version of Yolean works and showed which functions are available. In addition, with the aid of observation C1 where feedback on functionality was received, the researchers have between the demonstrations made adaptations to the board to better suit the needs of the members in project C. In addition, the researchers have aided the members of project C in transferring to the new version of the Yolean software. In Figure 16, the anonymized version of the Yolean board for project C is visualized.

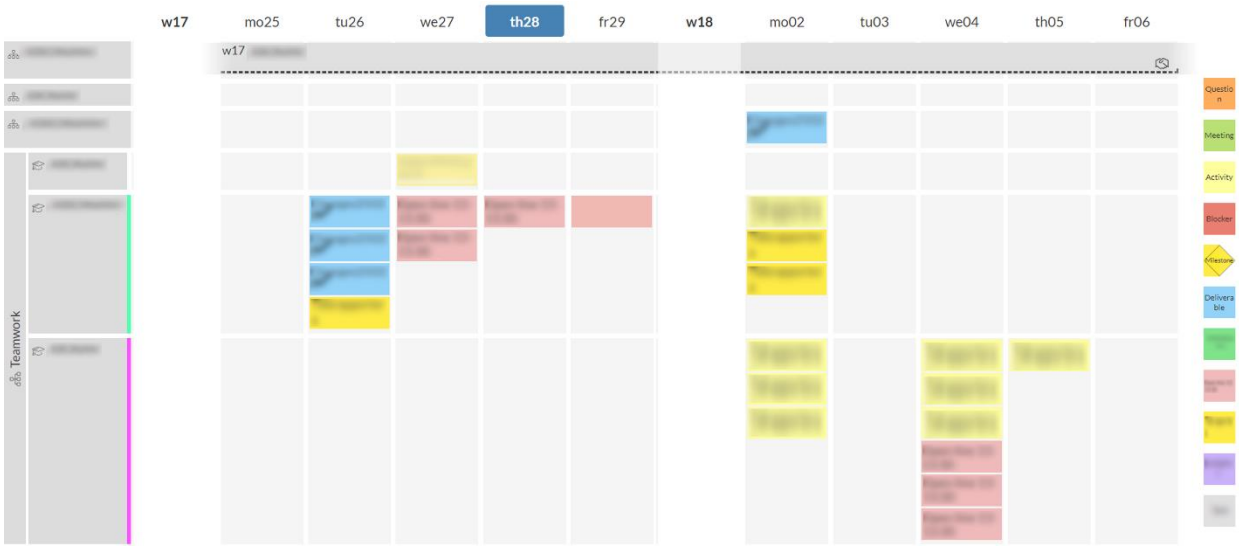

Figure 16. Yolean board adapted for project C.

Interviewee C1 described that the usage of Yolean in project C is mainly internal within the team. However, interviewee C2 expressed the benefit of using Yolean also with external actors, since this enables a common platform for communication and information sharing. Interviewee C1 also described the ambition of starting a testbed for adopting Yolean in collaboration with external actors.

> *"I'm thinking that with the new version [of Yolean] that you showed us, I believe we would like to test it together with web developers, back office, and maybe also other suppliers."* - interviewee C1

By spreading the usage of Yolean, interviewee C1 hopes to reduce the need for different systems and software. Thereby, the interviewee believes that the work could become more efficient with less time needed for administrative tasks.

5. Analysis and discussion

In this chapter, the findings from the thematic analysis conducted on the empirical data of the study are presented. In addition, these findings are discussed, and the chapter thus lays the foundation for later answering the two research questions of the study. To do this, the barriers to efficient communication are presented. In addition, which of the barriers that can be addressed by digital visual planning software is examined and discussed.

5.1 Barriers to efficient project communication

From a thematic analysis based on interviews and observations conducted on the case projects of this study, several barriers to efficient project communication were identified. As a result from the literature review on the studies by Lohikoski et al. (2015) and Galli (2020), who conducted their studies in similar contexts, additional barriers were identified. All the identified barriers from both the literature review and the empirical data are summarized in Table 6. In total, 27 barriers could be found, and 16 of these appeared both in the literature and in the empirical data. Furthermore, seven barriers identified from the empirical data had no equivalent in the literature that was studied. However, it should be noted that this literature review was narrow, and the reason for this was to find articles with as similar contexts to the case projects as possible. Therefore, if broadening the search, these barriers might be found. During the thematic analysis of the barriers, they were thematically categorized to form a structure for further analysis. The categories are visualized in Table 6 by the orange rows.

Table 6. The identified barriers, structured according to the categories.

Barrier	**Stated in literature**	**Captured in the study**	**Literature source**
Attitude			
Egocentrism	**x**	**x**	Lohikoski et al (2015)
Lack of trust	**x**	**x**	Lohikoski et al (2015)
Unwillingness to share information	-	**x**	-
Ambiguity			
Unclear actions needed due to use of mass email	**x**	Not applicable	Lohikoski et al (2015)
Communication content ambiguity	**x**	**x**	Lohikoski et al (2015)
Power asymmetry	**x**	**x**	Lohikoski et al (2015)
Unclear responsibilities	-	**x**	-
Lack of transparency in communication	-	**x**	-
Long and unstructured meetings	**x**	**x**	Lohikoski et al (2015)
Social			
Social aspects	-	**x**	-
Cultural differences	**x**	**x**	Lohikoski et al (2015)
Insufficient language knowledge	**x**	**x**	Lohikoski et al (2015)
Unresolved conflicts	**x**	Not applicable	Lohikoski et al (2015)
Lack of team building	**x**	Not applicable	Lohikoski et al (2015)

Technical			
Insufficient technical knowledge	**x**	**x**	Lohikoski et al (2015)
Technical problems	**x**	**x**	Lohikoski et al (2015)
Document access difficulties	**x**	**x**	Lohikoski et al (2015)
Subjectivity			
Lack of customized communication	**x**	**x**	Galli (2020)
Lack of shared goals	**x**	**x**	Lohikoski et al (2015)
Differences in preferred communication frequency	**x**	**x**	Galli (2020)
Insufficiency in peoples' availability	-	**x**	-
Differences in preferred communication channels	**x**	**x**	Galli (2020)
Time zone differences	**x**	Not applicable	Lohikoski et al (2015)
Tools			
Communication tools not used	**x**	**x**	Lohikoski et al (2015)
Excessive use of email	**x**	**x**	Lohikoski et al (2015)
Security			
Cyber security	-	**x**	-
Data confidentiality	-	**x**	-

Four of the barriers found in the literature by Lohikoski et al. (2015) and Galli (2020) could not be discerned from the empirical data, and there could be several reasons for this. The contexts of the two studies are similar to this study since they are conducted on development projects in engineering settings. However, different organizations and different products lead to differences in how projects are managed and, thus, how communication is conducted. This fact was identified during the study. Project B was managed in a way similar to the Stage-gate methodology developed by Cooper (1990), and project A was less structured with an emphasis on innovativeness, hence, with some similarities to the agile methodology.

Furthermore, the composition of the specific project team is likely to play a vital role in which barriers are affecting the communication process. Some of the barriers, for example *unresolved conflicts* and *lack of teambuilding* presented by Lohikoski et al. (2015), are affected by if the project members know each other from previously or not. In project B, the project members worked together regularly and had also done this previously. In project A, however, some of the members had not met before since they were from different organizations. Despite this fact, the barriers of *unresolved conflicts* and *lack of teambuilding* were not identified in any of the case projects. This could be a result of project management providing opportunities for the members to get to know each other and ensure a favorable group dynamic. An example of this is provided by the project leader interviewee A2 who spoke about the necessity of making sure that the project members got to know each other. During the observations of project A, the researchers identified several occasions when the project members met face-to-face which provided opportunities for the project members to socialize and get to know each other.

Another barrier that was not encountered in the study was *unclear actions needed due to use of mass email*. The simple reason this barrier was not encountered in any of the case projects is

that this way of communication was not utilized. When emails were sent, questions and responsibilities were directed towards specific individuals when needed. However, some confusion regarding responsibilities and actions was still identified in project A.

5.2 Analysis of barriers to efficient project communication

The barriers that were identified from the empirical data are listed in Table 7. Hence, the barriers that are only mentioned in the literature frameworks of previous research are excluded in this table. Furthermore, the corresponding interviewees who mentioned each barrier are stated. The thematically established categories of barriers described earlier form the structure for the following analysis of the barriers.

Table 7. Empirically identified barriers to efficient project communication.

Barrier	**Empirical source**
Attitude	
Egocentrism	A1, A3, A5, A6, A7
Lack of trust	A2, A3, A4
Unwillingness to share information	A4, A5
Ambiguity	
Communication content ambiguity	A1, A2, A3, A4, A5, A6, A7, B1, B2
Power asymmetry	A1, A3, A4, A5
Unclear responsibilities	A1, A3, A5, A7, B3
Lack of transparency in communication	A1, A2, A3, A4, A5, A7, B1, B2
Long and unstructured meetings	A1, A6, A7
Social	
Social aspects	A1, A3, A5
Cultural differences	A1, A4
Insufficient language knowledge	A1, Observation A6
Technical	
Insufficient technical knowledge	A3, A4
Technical problems	A1, A4
Document access difficulties	A1, A4, A5, A7, B1, B2
Subjectivity	
Lack of customized communication	A6, A7
Lack of shared goals	A1, A2, A3, A4, A5, A6, A7
Differences in preferred communication frequency	A1, A4, A5, A6, A7
Insufficiency in peoples' availability	A1, A3, A4, A5, A7
Differences in preferred communication channels	A1, A3, A4, A5, A6, A7, B1, B2, C2
Tools	
Communication tools not used	A1, A3, Observation A7, C1, C2
Excessive use of email	A1, A6, A7, C1
Security	
Cyber security	A2, A6, A7, C2
Data confidentiality	A1, A2, A6, C1, B2, B3

5.2.1 Attitude barriers

As mentioned by Lohikoski et al. (2015), *egocentrism* can be considered a barrier that hinders efficient project communication. From the empirical findings, this was found to be an issue in one of the case projects as well. Both interviewees A1 and A5 stated that they try to steer the project into conducting the necessary activities to achieve their own goals. Similarly, interviewees A6 and A7 expressed that there exist different perspectives on the goal of the project and that their focus lies on their own goals rather than the overall goal of the project. There seems to be an awareness that different members have different expectations on the project. However, these disunited expectations appear to not be respected by one another. Although the project has an outspoken goal that will benefit all members of the project, members thus seem to act according to their own interests. Consequently, the egocentric mindset disfavors the communication and collaboration of project A. These tendencies were not present in projects B and C which are internal projects in which all members belong to the same organization. Hence, the composition of members in project A is probably a prominent reason for the disunited perceptions of the project goal.

Lack of trust and *unwillingness to share information* were also highlighted both in literature and in the empirical findings. Interviewee A4 stated that it is sometimes challenging to receive the right information from other parties, even after repeated attempts. Interviewee A5 described that this might be due to the fear of sharing too much information. Especially, it was highlighted that an initiated information flow cannot easily be cut off, and the sharing of information cannot be undone. The reason for the fear of sharing information is probably because the members originate from different organizations. The companies are not competitors, but they might see a risk of sensitive information ending up in the wrong hands when transferred outside the boundaries of the organization. Interviewees A2 and A3 expressed the importance of social trust-building in project A, and that this is something they are working on. As stated by interviewee A4, this will improve over time, the trust will be strengthened, and consequently, the project communication will improve. However, it is a situation that needs a faster solution. Without trust and with an unwillingness to share information, the project will not proceed properly. These barriers were not present in project B nor project C. The reason is probably once again since these are internal projects in which the members are from the same organization.

5.2.2 Ambiguity barriers

In project A, all the seven interviewees expressed, to different extents, their concerns regarding *communication content ambiguity*. Predominantly, it was expressed that the project is not well defined and that there are also *unclear responsibilities* of what activities the different members should conduct. This can also be considered closely related to the barrier *lack of transparency*, which also is an issue in project A. Why this is a problem can be due to the identified *power asymmetry*. Even though there are project leaders, there seems to be an uneven distribution of power. Project members that should not have more power than their equals have excessive influence on decisions and where the project is heading. The project managers thereby lack the power and support that they need to ensure that the project stays on track and progresses as intended. The reason for this is probably that the project leaders belong to another organization than the project members, hence, they do not have the managerial authority which is usually

present in projects conducted internally in an organization. In other words, the project leaders of project A are leaders of the activities and direction of the project, but they lack the mandate to lead the members of the project.

The barrier *lack of transparency* was also noted in project B. Here, interviewee B1 explained that there are restrictions on document access, which limits the possibility to access all information in the project. In addition, interviewee B2 stated that since many tools are used in combination, it can be difficult and time-consuming to find the information needed. Regarding the barrier *long and unstructured meetings*, interviewee A1 had expressed a wish to have a minimum of meetings and to have them only when needed. The interviewee experienced that the meetings in the project were unnecessarily long and frequent and that it was difficult to understand what each meeting resulted in. In line with this, interviewee A7 stated that the project had too frequent meetings. This is an example of the statement by Kliem (2007) that communication must be adjusted to each individual since different people have different needs. However, many of the interviewees of this study have expressed the importance of transparent communication and one could argue that there is a trade-off between communication transparency and personalization. Hence, if adjusting communication to the different individuals, it is important that everyone still gets the opportunity to access the same information.

5.2.3 Social barriers

Since the members of projects B and C have the same native language as their project members, the barrier of *insufficient language knowledge* was not present in these projects. In project A, however, the native language of the members differed, and the different organizations which were represented by the project members had different official languages. Interviewee A1 stated that these differences had caused some challenges, and during observation A6, usage of different languages was observed. Hence, this barrier could be seen to result from two different sources, both deviation from the official language and from insufficient language skills in the official language. Furthermore, one could argue that this barrier can impose serious problems since it acts as noise to the communication process of the project as described by Lunenburg (2010). When affected by noise, the message which is communicated risks being distorted with misinterpretations as a result. This could be one of the reasons for the ambiguity that several members of project A perceived as described earlier.

In project A, some members knew each other from previously and some did not. Interviewee A3 explained that this resulted in various levels of formality and frequency depending on which members communicated with each other. This decreased the transparency of communication, and the project is thus affected by a *social barrier*. In addition, the fact that different cultural backgrounds affect the collaboration and communication in the team was pointed out by interviewee A1. The interviewee perceived that the usage of digital software for communicating and having meetings increased the distance between the project members and made it more difficult to get to know each other. Hence, digital software could lead to, and increase, the difficulties of communicating due to *cultural differences*. In projects B and C, the members had worked together previously and none of these two barriers were identified.

5.2.4 Technical barriers

From the empirical findings in project A, it was discovered that technical barriers are sometimes a concern. Four out of seven interviewees mentioned that they had encountered *document access difficulties*. The main reason for this is most likely because the project members have account credentials from different organizations, and thereby the data cloud services are not compatible with handling this. However, it is not only the technical tools that create these limitations. Observation A5 showed that it is difficult to receive an invitation to the online platform since the owners of the platform are restrictive with who should be granted access. Also in project B, the barrier of *document access difficulties* could be discerned. During observation B4, one of the project members described that the systems used for planning and storing documents were unintuitive and difficult to use. Furthermore, interviewee B1 stated that some project documents were restricted and needed to be requested to be accessible. Hence, the downside of the topic of data security, which is important, seems to be that it limits the users of the information which is protected. None of these problems were identified in project C and the reasons were considered to be both that the members are from the same organization and that the Yolean software that is used is not connected to a specific company intranet.

Moreover, *technical problems* have occurred. Two interviewees in project A mentioned that documents uploaded to an online platform disappeared. In addition, two members of the same project expressed that the technical tools are sometimes too complicated to understand and that it happens that you need to export the data to another system for the users to be familiar with how it works. Therefore, it is also an issue of *insufficient technical knowledge*. It could be that members are unwilling to try new software because they are not willing to learn new technical software. This matter is related to change management, as described by Thomas and Hardy (2011). When changes are about to be implemented, there is often resistance. This is likely an issue in projects B and C as well. In project C, this appeared to be the case when interviewee C1 expressed that a person in a nearby department, who has weekly collaboration with the members of project C, did not want to learn the Yolean software even though it was used at all their meetings. In project B, the members intended to implement the software in their daily project work. However, the implementation process was protracted, and it was decided to only try out the software on a small scale with the help of the researchers. This could be because there exists a resistance to these types of change initiatives in project B and the members are unwilling to go through the learning process that is needed when new software is implemented.

5.2.5 Subjectivity barriers

All seven interviewees in project A expressed a concern that there is a *lack of shared goals* among the project members. The ones representing the companies have a clear vision of the goals to benefit their own company in the best way possible. On the other hand, the academic part sees the overall goal of the project to be to strengthen the competitiveness of the entire Swedish industry. Since the project is not following a predefined structure, it can be argued that agreement upon what should be achieved in the end is of even greater importance. This barrier was not encountered when studying project B and the reason is probably due to the clearly defined goals of the Stage-gate methodology applied in this project. Similarly, this was not encountered in project C either.

Furthermore, there exist barriers regarding *differences in preferred communication channels* and *differences in preferred communication frequency*. Some members of project A prefer using emails, some prefer using Teams, and others prefer using the phone. This creates inconsistency in what channel to use depending on whom to contact. This probably lowers the transparency of the communication, but also creates uncertainty within the team. It might also result in some members losing interest in the project when communication is not conducted in the way they expect it to be. The same issue could also be present due to the different preferred frequencies of communication. If the representatives of the companies prefer higher intensity in communication than what is currently used, they might put their efforts elsewhere. This phenomenon is described by Galli (2020), who states that communicating too seldom leads to ambiguity, and communicating too frequently could be considered as a waste. Also in project C, different opinions regarding which communication channel should be used could be identified since one of the functions collaborating with the project does not want to adopt the Yolean software. Similar issues related to preferred communication channels were identified in project B. Interviewee B2 stated that different PMOs used the set of available tools differently when communicating with their project members and stakeholders. In this project, since a development process similar to the Stage-Gate process described by Cooper (1990) is applied, consistency in which communication channels to use is important to ensure that no important information gets lost. However, it can also be argued that strict rules on how to communicate could hinder creativity. Therefore, a balance where both consistency and creativity can be present is argued to be necessary.

Related to this, it was mentioned by five out of seven interviewees in project A that there is an *insufficiency in peoples' availability*. Interviewee A4 described that all schedules are very often fully booked and that you need to schedule several months in advance. However, this could also be argued to be a result of the low frequency of communication in the project. If a higher frequency had been established, the interest from the company representatives would probably be higher, and they would thereby ensure that more time in their schedules would be available for project A specifically. Also, the *lack of customized communication* is considered a barrier. Here, more personalized information can ensure that the right information is distributed to the right people at the right time, just as described by Muszyńska (2016). However, this could backlash by decreasing the transparency when the information is not accessible to everyone as described previously. These barriers were not encountered in project B and project C.

5.2.6 Tool barriers

The barrier of *communication tools not used* was identified in the empirical data from projects A and C and it was also expressed in the literature. Interviewee A3 described that the interviewee had experienced a risk during previous projects that none of the project members utilize collaborative tools that are implemented. The interviewee gave examples of different tools that had been tried but told that it had only been the interviewee self that utilized them as the project leader. One part of this study was the implementation of the digital visual planning software in project A. During this implementation, the barrier of *communication tools not used* was experienced also by the researchers. To begin with, the members of project A were interested in the tool, but the usage and enthusiasm decreased after some time. During observation A7, it was concluded that the tool could bring several benefits to the project.

However, what caused the limited use was considered to be the fact that the tool imposed an additional system to use and update, and it was not possible to fully integrate it with the existing solution used for managing the project. As discussed previously, the aspect of change management probably also contributed to the lack of usage. Since the researchers joined the project some months after it had already been initiated, the implementation of the tool led to a change in the way of working for the members. Hence, it would probably have been beneficial to implement the tool at the start of the project. In project C, which has utilized the Yolean software for several years, the same tendencies were described by interviewee C1. The interviewee stated that one of the colleagues liked the tool but did not want to use it personally, this person preferred that the others managed the tool and then showed it during meetings.

The barrier of *excessive use of email* was found in the literature and in projects A and C. Three of the members of project A and one of the members of project C talked about this issue. Interviewee A6 stated that the use of email caused inefficient communication and led to a decrease in transparency. Interviewee C2 stated that the more unread emails in the inbox, the greater the perceived barrier to start reading and answering these emails. However, as described earlier, communication is a highly subjective matter, and different individuals have different opinions regarding emails. In project B, this barrier was not identified, however, the members of project B perceived that the usage of several different communication channels was unintuitive and inefficient.

5.2.7 Security barriers

The barriers of *cyber security* and *data confidentiality* were discussed by four out of seven members of project A, by both members of project C and in two out of three interviews in project B. Common to the three projects was that these issues were discussed in connection with occasions when external collaboration was conducted. Hence, security and confidentiality are considered most important and relevant when data is shared outside the boundaries of the organization. The way that *data confidentiality* leads to a barrier to project communication is because it makes project members more restrictive with what information they share when communicating, and this fact was discovered during interview A7. This will naturally negatively affect the collaboration and the transparency of the communication since all members might not receive the same information. Interviewee A1 describes that this is an issue since people are often unnecessarily restrictive and that many times, it is harmless to share more information than people dare to do. When conducting a project which involves external collaboration, it is, thus, probably wise to clearly determine and define which information is sensitive and which is not. Then the project members might be less restrictive due to less uncertainty. The barrier of *cyber security* is a bit broader and applies both to circumstances when communication is conducted externally and when it is only conducted internally in the organization. Hence, the tools used for communication must be secure enough so that the members are comfortable with using them.

5.3 Addressing the barriers with digital visual planning software

With the help of the knowledge gathered during the literature review and insights from the case studies, the researchers assessed whether the identified barriers to efficient project communication could be addressed by digital visual planning through the use of the studied

software. The assessment was conducted by comparing which barriers to efficient project communication were perceived by project C, with the barriers found in projects A and B prior to the implementation of the software. The reason why project C was used as a benchmark is that this project has used the software for several years. To achieve this comparison, similar interview questions were directed to these three projects. In addition, previous research was used to strengthen the analysis. The result of the analysis has been summarized in Figure 17. In this figure, all identified barriers are displayed and grouped according to the previously described categories of barriers. The barriers in green are the ones that are considered addressable with the help of digital visual planning. In total, eight out of the 27 barriers from the categories *ambiguity barriers*, *technical barriers*, and *tool barriers* could be addressed. In the following subheadings, the barriers which can be addressed are discussed further and the motivation to why is presented.

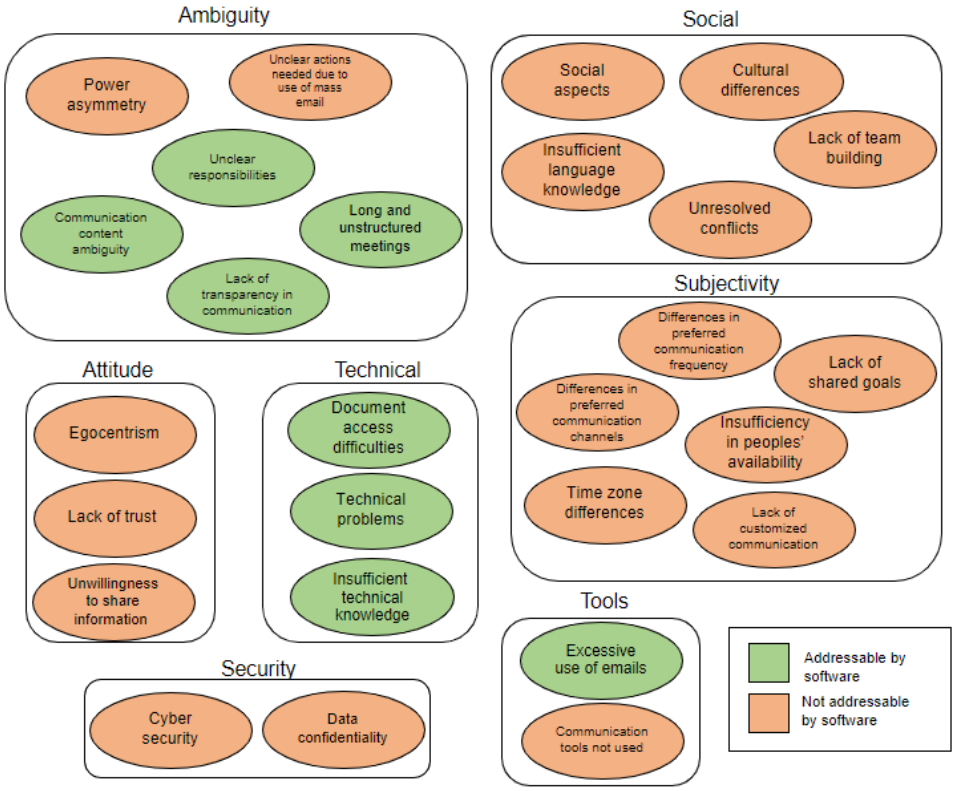

Figure 17. Visualization of barriers addressed by digital visual planning software.

5.3.1 Addressing Ambiguity barriers

The barrier of *communication content ambiguity* was a prominent barrier in project A and was touched upon by all the seven members of the project. The members expressed an ambiguity in terms of unawareness of what activities need to be conducted to make the project progress. However, no signs of this barrier could be found in project C which utilizes Yolean. Interviewee C1 described that the activities to be conducted were placed on the planning board as notes which contained information about the activities and when they should be completed. Both interviewees C1 and C2 posted all their activities on the planning board once they had been received. This way, the board gave the full picture of the project plan immediately, both what had been completed and what needed to be done. In project A, most of the activities were discussed and delegated via email, hence, to grasp the status of the project, the project members

needed to go through several emails and manually synthesize the information. Similarly, as described by interviewee B1, several tools and repositories needed to be used to find the necessary information in project B. Hence, digital visual planning software could be considered able to address the barrier of *communication content ambiguity.*

A barrier mentioned by four out of seven of the interviewees of project A and interviewees of project B was *lack of transparency in communication.* The software seems to be capable of addressing this barrier in multiple ways. The software is designed so that the information on each project board can be accessed and viewed by all the members who have been added to the board. This way, every member can access all information, regardless of if it is directed towards everyone or a specific project member. Interviewee C1 who uses Yolean held the opinion that the communication in project C is in fact transparent. The interviewee added that email is used as well, but to increase the transparency of the communication received via email, the team has a routine of continuously adding information received by email to the planning board. In addition, the software has the functionality of posting questions that can be viewed and answered by all members of the board. This way, the need of using emails is reduced and the risk of information being locked in email threads is decreased. According to Biazzo et al. (2020), one of the cornerstones of visual planning is that information should be transparent, thus, the software contributes with a high degree of transparency.

The barrier of *unclear responsibilities* was identified in project A and was considered a significant barrier to the progress of the project. This problem was not perceived in project C and interviewee C1 stated that each member of project C had their own personal row on the planning board. On these rows, the activities that each member was responsible for conducting were placed as colored notes. Interviewee C2 stated that the visual aspects of these notes made it easy to quickly grasp what should be done as well as the current workload of each member. Therefore, the interviewee considered it easy to conduct rebalancing of the tasks if needed. To increase the awareness of the responsibilities even further, the software has the functionality of sending a notification once an activity is assigned to a specific member. This is in line with the statement by Lindlöf (2014) who explains that the visualization of responsibilities by using rows on the visual planning board decreases the uncertainty for the members and increases the understanding of dependencies. Compared to the approach in project A of dividing the responsibilities via email, the use of digital visual planning with the software is thus considered better at addressing the barrier of *unclear responsibilities.*

Three out of seven members of project A perceived the barrier of *long and unstructured meetings.* As described by Jansson et al. (2016), visual planning consists of two components, the planning board which is equivalent to the Yolean board, and the meeting during which the board is updated. Interviewee C1 described that they utilized this methodology by having short regular meetings during which they used the planning board as a basis for discussion. This way, the planning board offers a structure for the meeting, and the notes on the board form the agenda for the meeting. Digital visual planning could thus be viewed as a solution to address the lack of structure in the meetings. In addition, the software has an automated function for creating meeting minutes, therefore, the time needed for administration is reduced and the meetings can potentially be less time-consuming.

5.3.2 Addressing Technical barriers

Interviewee C2 described that the Yolean software is easy to learn and that the threshold for starting to use the software thereby is low. The interviewee stated that it seems like the need for prior technical knowledge before using the software is lower compared to other digital software that had been used. In line with this, it was expressed by interviewees A3 and A4 that the previous tools for handling communication and information sharing in project A were not so intuitive. Also in project B, the structure that was suggested by the researchers for managing project work in this project, described in Section 4.4, and visualized in Figure 14, implies a lower effort to understand. Furthermore, the planning board can be adapted with different layouts. Thereby, it can be modified to look similar to previous systems. This reduces the need for learning new visualizations of the same information, and consequently lowers the change management barrier of resistance to change. In addition, Yolean builds upon visualization principles, and Tjell and Bosch-Sijtsema (2015) state that it is easier to understand and grasp information that is presented in visual format. Therefore, it can be argued that the barrier of *insufficient technical knowledge* can be addressed by digital visual planning software.

Regarding *technical problems* as a barrier, interviewee C2 stated that Yolean, in contrast to many other software used by the interviewee is always reliable. It has from the interviewee's knowledge never occurred that the software is not working or is down for maintenance. From Lunenburg (2010), it can be understood that any type of noise that is introduced to the communication process implies a risk of altering the information to be communicated with misinterpretations as a consequence. Therefore, technical problems are important aspects to take into consideration, and reliable software could minimize the risk of distorting the information that is communicated in crucial circumstances.

Both in projects A and B, concerns regarding *document access difficulties* were identified. From observation A5, it was discovered that receiving access to all relevant documents for the researchers was not possible. One part of this was due to legal agreements, but it was also dependent on not having account credentials from the same organization. From interviewee B1, it was expressed that not having access to all documents was a concern also in project B. Based on the interviews in project C, the same problems did not seem to be present. This could be because the software is not connected to a specific company intranet, instead, the only thing that is needed to add members is their email address. Thus, the emphasis on transparency in visual planning thereby addresses the barrier of accessibility difficulties through easy adding of new members since the software does not require the users to have the same organizational credentials.

5.3.3 Addressing Tool barriers

In project A, interviewees A5 and A7 expressed that there is an *excessive usage of emails.* Interviewee A7 especially highlighted the need to be able to see the whole information flow and how people respond to questions. By using Yolean to communicate important activities, interviewee C1 stated that the number of emails needed in project C was reduced, both through more transparent communication and by structuring the information in one place. In addition, interviewee C1 described that this led to a sense of less stress. Interviewee C2 on the other hand stated that the usage of the software within one department does not reduce the number of

emails, since communication with other departments is still conducted through emails. However, the interviewee described that if more functions within the company would use Yolean, the use of emails could be reduced even further. Therefore, it is probable that by combining the software with the emails that are still a necessity, fewer redundant emails will be sent. As a result, less time will be needed to search through the inbox to find previously communicated information, and thereby communication can become more efficient. In addition, it was identified during observation A6 that time is wasted on sending emails with status updates and instructions on what needs to be done. By using digital visual planning, the progress in terms of finished activities and remaining activities is visually presented on the planning board for all team members. Hence, there should be less need for emails when using digital visual planning.

5.4 Challenges of implementing digital visual planning software

As was shown in Figure 17, digital visual planning software was shown to be incapable of addressing several of the identified barriers to efficient project communication. However, this fact is not per se a challenge or drawback. Many of the barriers are highly related to organizational and managerial issues and will, therefore, not be able to be addressed by only implementing a new software and methodology. Furthermore, one single tool can naturally not be used to solve all problems and challenges in a project team, thus the inability to address some of the barriers is reasonable.

However, as was shown during the study of the implementation of the software in project A, and during the observations and interviews of project C, some challenges connected to the software itself could be identified. As was stated by interviewee C2, the software has the capability to and would be beneficial to use for collaborating with external actors. However, the interviewee added that there might be some information and data which is sensitive and should thus not be made available to the external actors. Currently in the software, there is no option for doing this. The reason is due to the large focus on transparency of communication in visual planning, all information is made available to all the members of the board. There is one possible walkaround for this challenge and that is to create separate boards and control who has access to which boards. However, when this solution was proposed by the researchers, it was noted by interviewee C2 that this would lead to more administration. In addition, this solution would most probably lead to a decrease in the transparency of communication since information would be separated.

Another identified drawback, which is a bit more general and not specific to the Yolean software and visual planning, is that digital collaborative tools increase the distance between people. There are several dimensions to this aspect. As described by interviewee A1, it makes it more difficult to get to know other people and it might therefore affect the group dynamic in the team. Furthermore, according to Lindlöf (2014), face-to-face discussions and meetings are important since they are the richest form of communication. In addition, this mode of communication allows for instant feedback which reduces the risk of misinterpretations, and could hence, be seen to minimize the risk of experiencing the barrier of *content ambiguity*.

In contexts where changes are about to be implemented, challenges often arise. As described by Thomas and Hardy (2011), the topic of change management becomes apparent in these

circumstances. When a new software or way of working is implemented, project members need to spend time and energy learning the new way of working. This could be perceived as a threshold for the individuals and, thus, a limiting factor in their willingness to devote the time needed to learn. These challenges were expressed by interviewee B2 to be present in project B since it was challenging to convince the PMOs to use one common tool. Yolean has, however, been described by members of project B during observation B3 and by interviewees C1 and C2 to be a highly intuitive tool, but it is still a new tool that needs to be learned before it can be fully utilized. This fact will, according to Strebel (1996), come with the challenge of resistance to change. Some actors will not, because of different reasons, like the change. It could for example be that it is more comfortable to continue according to the old state. However, the reason for people resisting a change might, according to Ford and Ford (2010) very well also be because they consider the new tool or way of working to be inferior compared to the current one. Due to this possibility, it is therefore important to listen to the individuals who are going to use the tool and to remember that they are often the ones with the most knowledge about the process at hand.

This phenomenon was also identified during the study of the implementation of digital visual planning in project A. In this project, the software was not used as intended and not to the extent that it was aimed for. Thus, the barrier of *communication tools not used* was prominent. There seem to be several reasons why the software was not used, first, the software became an addition to prior existing systems for communication. Due to this, the usage of the software led to more time needed for administration which implied a threshold for the project members. In addition, the researchers concluded that the project itself was not entirely suitable for digital visual planning. The project was a low-intensity project spanning a long period of time, thus, the scale of the benefits of using digital visual planning compared to the effort needed was not considered enough by the members of the project.

In addition, large parts of project A involved the aim of establishing new and innovative solutions. Consequently, the project was quite open-ended, unstructured, and with few planned activities. Therefore, the planning was not so detailed, and the full potential of the software could not be utilized. Among the interviewees, there were different opinions regarding whether the lack of a plan in project A was deliberate or not. Interviewee A1 held the opinion that the lack of a plan was unintended and that it imposed a challenge since it was unclear what needed to be done. Interviewees C1 and C2, who have used Yolean for several years, stated that they consider that the software would work well together with the agile methodology. Despite this, the findings from this study indicate that digital visual planning is more suitable for structured projects run similarly to the Stage-gate methodology. Digital visual planning builds on principles of lean product development and during the literature review, lean product development was considered more similar to Stage-gate than to the agile methodology. A prominent difficulty that was discovered during observation A3 was to know where the activities should be placed on the planning board. Many of the activities in project A had no clearly determined deadline, and as described earlier, a visual planning board is built on two dimensions, rows for responsibilities, and columns for deadlines. Thus, several project members from project A requested a column with the functionality corresponding to a backlog, where activities without a deadline could be placed. However, this is not in line with the visual

planning philosophy, and therefore, the functionality is not included in the software. The usage of backlogs is more coherent with the agile methodology, and as described by Stenholm et al. (2016), for agile projects which are not so well defined, a Kanban board is probably more suitable than a visual planning board. The reason is that a Kanban board does not have a dimension with deadline dates, instead, it is defined by sprints or phases and often has a column for a backlog.

5.5 Limitations

The empirical data in this study has been collected from literature reviews, interviews, observations, and demonstrations at three different projects. One of the projects, project C, has used the software Yolean for several years and could thus be used as a reference when analyzing the other projects. Since data has been collected from these multiple sources, triangulation has been achieved. However, the study is imposed by some limitations as well. Due to the short timeframe of 20 weeks in combination with a long time horizon of the projects, especially for project A, time was limited for making a formal and structured assessment of the impact of implementing digital visual planning with the software. Due to this, no project performance metrics were measured, hence, no objective conclusions could be made regarding the impact of the digital visual planning software on the project communication and project performance.

Instead, the researchers did a current state analysis of the project communication and studied the implementation and early usage of the software in projects A and B. In addition, the current state of the project communication in project C was studied and used as a reference for comparing with the current state of projects A and B. Furthermore, project C was used to learn more about the benefits and drawbacks of the software. Regarding the generalizability of the findings of this study, there are some limitations. Three case projects have been studied and several companies have been included in the study. However, all companies and projects included in this study originate from manufacturing companies, hence, this is important to have in mind when generalizing the findings to other contexts. In addition, it is a qualitative study that is considered to have less ability to generalize compared to for example quantitative research (Bell et al., 2019). Furthermore, using the Activity theory to structure the results of the study was in retrospect considered to not be the most suitable choice. Some of the categories of this framework were not entirely relevant and this affected the structure of the empirical data negatively.

6. Conclusions and Recommendations

In this chapter, the conclusions of the study are summarized and presented. To fulfill the aim of the study, two research questions were formulated and these were used as a guide when conducting the study. The structure of this chapter thus revolves around the answering of these two research questions:

RQ1: Which are the barriers to efficient project communication in engineering development projects?

RQ2: How can digital visual planning software address the barriers to efficient project communication in engineering development projects?

Furthermore, recommendations for the case projects established by the researchers are presented. These recommendations are based on the combination of empirical findings and knowledge gathered from reviewing the scientific literature.

6.1 Answering RQ1

The first research question, "*which are the barriers to efficient project communication in engineering development projects?*" was investigated through literature studies and by studying project A, B and C with observations, workshops, and qualitative interviews. As a result of this, 27 barriers have been identified as possible hinders to efficient project communication. In Table 8, these barriers are listed and sorted based on the corresponding category that they belong to and which source they originate from. Of the 27 barriers identified, 16 were found in both literature and from the thematic analysis of the empirical data. Hence, the literature in which these barriers were identified, can be strengthened by the empirical data of this study.

Table 8. Barriers identified through literature review and empirical findings.

Barrier	**Source**
Attitude	
Egocentrism	Lohikoski et al (2015), empirical data
Lack of trust	Lohikoski et al (2015), empirical data
Unwillingness to share information	empirical data
Ambiguity	
Unclear actions needed due to use of mass email	Lohikoski et al (2015)
Communication content ambiguity	Lohikoski et al (2015), empirical data
Power asymmetry	Lohikoski et al (2015), empirical data
Unclear responsibilities	empirical data
Lack of transparency in communication	empirical data
Long and unstructured meetings	Lohikoski et al (2015)
Social	
Social aspects	empirical data
Cultural differences	Lohikoski et al (2015), empirical data
Insufficient language knowledge	Lohikoski et al (2015), empirical data
Unresolved conflicts	Lohikoski et al (2015)
Lack of team building	Lohikoski et al (2015)
Technical	
Insufficient technical knowledge	Lohikoski et al (2015), empirical data
Technical problems	Lohikoski et al (2015), empirical data

Document access difficulties	Lohikoski et al (2015), empirical data
Subjectivity	
Lack of customized communication	Galli (2020), empirical data
Lack of shared goals	Lohikoski et al (2015), empirical data
Differences in preferred communication frequency	Galli (2020), empirical data
Insufficiency in peoples' availability	empirical data
Differences in preferred communication channels	Galli (2020), empirical data
Time zone differences	Lohikoski et al (2015)
Tools	
Communication tools not used	Lohikoski et al (2015), empirical data
Excessive use of email	Lohikoski et al (2015), empirical data
Security	
Cyber security	empirical data
Data confidentiality	empirical data

6.2 Answering RQ2

The second research question was "*how can digital visual planning software address the barriers to efficient project communication in engineering development projects*?". To answer this research question and contribute to a research topic with few previous studies, digital visual planning was tested by the researchers through the implementation of a software. It could be concluded that in total, eight barriers to efficient project communication could be addressed. These barriers are summarized together with a description of how they are addressed by digital visual planning in Table 9. The fact that eight barriers could be addressed implies that digital visual planning can bring benefits to project communication in a development project. Therefore, this study can confirm the statement by Lindlöf (2014) that visual planning strengthens and makes communication in a development project more efficient.

Table 9. Project communication barriers addressable by digital visual planning software.

Barrier	**How digital visual planning addresses**
Ambiguity	
Communication content ambiguity	Colors, symbols, and other visual representations in Yolean ease the understanding of information.
Unclear responsibilities	Every project member or function can be given their own row on the Yolean board.
Lack of transparency in communication	Communicated information is accessible for all project members on the Yolean board.
Long and unstructured meetings	The Yolean board is used as a structure for discussion during meetings. The automated meeting minutes reduces the administrative work needed.
Technical	
Insufficient technical knowledge	Easy to learn lowers the threshold for learning and starting to use Yolean.
Technical problems	From observations, Yolean is seldom down for maintenance, which implies a high dependability.
Document access difficulties	Yolean is not connected to a specific company intranet, the only thing needed to get access is an email address.
Tools	
Excessive use of email	The questions function and visualization of progress and what to do decreases need of status update emails.

However, challenges could be identified as well and, thus, the balance between the benefits and the challenges which come with this methodology should be assessed in relation to the specific project before implementation. The empirical data could also confirm the theory by Lindlöf and Söderberg (2011) that digital solutions for visual planning increase the distance between people and risk leading to less communication. The fact that no tool will solve all problems in all types of projects was apparent during the study. Differences in organizations, products, and compositions of project teams were concluded to affect how well certain methods and tools suit specific projects. In the case of realizing digital visual planning through the software, it was concluded that it is more suitable for well-defined and structured projects, like Stage-gate projects rather than flexible projects run according to the agile philosophy. For agile projects that require more flexibility, the visual tool Kanban board with a backlog functionality is probably more suitable. Another important challenge that was identified during the study was to integrate the software in the project and ensure that it is properly used. When implementing digital visual planning, it is important that it replaces previous tools and methods and not become an addition to the current ones. If not succeeding with this, the software will only lead to an increased need for administration and very few benefits. An additional drawback of the software is that the emphasis on transparency can lead to issues connected to confidentiality when collaborating with external actors. All information is visible to all members and there is no functionality for hiding confidential information from certain members.

In this study, no quantitative assessment of the project performance indicators was conducted. However, during the interviews, indications of how the performance indicators of health, lead time, and quality were affected by digital visual planning could be identified, see Figure 18. Health was seen to benefit because of less stress for project members and leaders as a result of fewer emails, less uncertainty, and easier understanding of information. In addition, it was shown that when using Yolean for planning all aspects of a project, project members were relieved from the stress of needing to keep activities in their minds. The quality of project output is increased since the risk of activities being forgotten is decreased when visually presented and responsibility is assigned to specific individuals. Since visual planning emphasizes simple and intuitive communication, the software is built so that there is never a need to scroll to find all information. Instead, all necessary information is displayed immediately on the board, and therefore, the risk of missing information is decreased. An improved lead time can potentially be achieved since less time is needed to search for information, interpret information and less time is needed for administration.

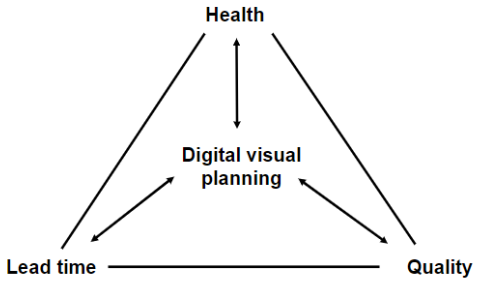

Figure 18. Identified areas where digital visual planning software can provide benefits in project performance.

6.3 Recommendations

As was learned during this study, to ensure efficient project communication, it is important to implement digital visual planning software at the start of a project, not when the project is already up and running. This would minimize the perceived amplitude of the change for the project members, and consequently, reduce the risk of the software and methodology not being used to the extent that was intended. Furthermore, when implementing digital visual planning, it is recommended to make adaptations to the software so that it visually looks like the previous software being used in the project. This way, the perceived amplitude of the change will be reduced further. This can help avoid the change to be seen as a hindrance, and instead a possibility to conduct the same work more efficiently. This together with the strategy of implementing it at the start of the project thus decreases the risk of resistance to change. Since the only way to unlock the benefits of digital visual planning is if the software is used to its full extent and that the meetings are structured with the visual planning board, it is crucial to take these change management aspects into account.

As was touched upon previously, to increase the structure and thereby the efficiency of project meetings, the planning board in the software can be used as a basis for discussion during meetings. When the notes and activities on the planning board are used as an agenda for meetings, it leads to a clear structure of the project meetings. This is emphasized in the concept of visual planning, it is therefore recommended to use the board both for general project planning, and to show and discuss it during the meetings.

However, there is also a trade-off that becomes apparent when using digital visual planning. The software which was studied helps to ensure high transparency in the information that is distributed, but at the same time lacks the attribute of personalization of information. Hence, it is a necessity to always choose the right tool with regard to the aim of the usage.

6.4 Future research

For future research, it is recommended to recreate the study to confirm the newly discovered barriers from the empirical data that was not found in previous research. This is recommended to ensure that the barriers are correct, but also relevant. Furthermore, it is suggested to include more participants in the projects of study. Even though this study unveiled many interesting findings, more participants could result in new perspectives not considered in this study. If doing so, it would be of interest to also discover new contexts, e.g., including different countries and cultures, and even different industries. Thereby, it could be assessed whether the barriers to efficient project communication are specific to similar contexts as this study, or if the findings can be generalized for even wider circumstances.

Since this study builds upon and is limited to qualitative research, the findings could be strengthened by including some elements of quantitative research as well. By using quantitative research, the impact of using digital visual planning could be more objectively investigated. It is difficult to measure the performance of project communication, but as was found out during the literature review, project communication has a direct impact on project performance. Hence, by quantitatively measuring and studying project performance metrics, the impact of using digital visual planning software can be assessed.

Finally, it would be suggested to not only study three different projects that are in different phases of the implementation of digital visual planning. Instead, it is advocated to follow one or several projects throughout the whole implementation, from the initial phase, through the development phase, and into the post phase. This would, however, require a significantly longer timeframe for the study, but would imply a more accurate evaluation of an organization's journey of digital transformation when implementing digital visual planning software.

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