

The impact of the COVID-19 pandemic on Agile Software Development Teams

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Abstract

Background: Teamwork is crucial in agile software development. Agile software development teams (ASDTs) were forced to work from home due to the COVID-19 pandemic. A lack of physical colocation and face-to-face interactions presented teamwork challenges for ASDTs and a necessity for changes in technology and practices.

Aim: The thesis aims to investigate how the COVID-19 pandemic impacted agile software development teams. This is examined by researching how teamwork effectiveness, agile practices, and productivity were impacted by the pandemic. The study aims to complement the research field by exploring how ASDTs performed during the COVID-pandemic.

Method: A qualitative study was conducted. The qualitative data consisted of 16 semi-structured interviews. The interview data was analyzed with the agile teamwork effectiveness model (ATEM).

Results: The results showed that teamwork effectiveness in ASDTs was negatively impacted by the COVID-19 pandemic. Agile practices adapted and translated well with digital tools. Productivity in ASDTs did not change significantly.

Conclusion: Using the ATEM-model for this thesis proved very useful for identifying team factors in ASDTs that were impacted by the COVID-19 pandemic. The most negatively impacted team factors were ‘communication’ and ‘mutual trust’. The other team factors have a heavier focus on agile practices and showed little impact because of the pandemic. The perceived productivity remained high and stable during the COVID-19 pandemic. However, well-being and work motivation were noticeably reduced during the pandemic.

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1 Introduction

The COVID-19 pandemic marked a sudden change for the world. On March 11, 2020, the World Health Organization (WHO) declared the novel coronavirus (COVID-19) outbreak a global pandemic (Cucinotta & Vanelli, 2020). The world faced a global threat and unprecedented challenges for public health, economies, and more. The coronavirus named ‘SARS-CoV-2’ was discovered in December 2019 in Wuhan, China (CDC, 2021). Since the beginning of the outbreak, the virus quickly spread throughout the world. Consequently, leading to lockdowns and preventive social measures on a global basis. Employees were encouraged to work remotely from home while simultaneously avoid the spread of the coronavirus disease.

Working from home quickly became the new normal. Although working remotely and working in a distributed manner is a trending practice within the software development industry, it was still not the common practice. Common inherent challenges in distributed and remote software development are communication and coordination (Shrivastava & Date, 2010). On a global basis, the pandemic forced everyone to work from home. The sudden necessity to work from home meant digital collaboration and communication tools had to evolve rapidly to ensure work from home was possible.

The COVID-19 pandemic introduced new challenges for co-located agile software development teams (ASDTs). Social distancing and social isolation were unknown challenges in many ASDTs. Despite social distancing, given the inherent digital nature of software development, social and professional communication exchanges often relied on digital communication before the pandemic. Thus, one can assume software development is less impacted than other type of professions. In some respects, software development is already distributed to a degree with collaboration tools such as version control with Git and examples of developing software as seen with open-source software. The key differences between distributed development and work from home during the COVID-19 pandemic is the additional challenges of involuntary work from home and the lack of colocation.

1.1 Motivation

In the past two years 2022 to 2020, the research on the impact of the COVID-19 pandemic on agile software development have given different findings. The research conducted on this topic

seems to lack a general consensus so far. There has not been a crisis of such magnitude in recent times. The lack of physical colocation in ASDTs presents challenges to communication and collaboration. The importance of social aspects such as face-to-face communication and collaboration are heavily emphasized by the Agile Manifesto (Fowler & Highsmith, 2001). Communication and collaboration are also known to be common challenges in distributed agile software development teams (Shrivastava & Date, 2010).

The thesis studies the impact of the COVID-19 pandemic on ASDTs working in Oslo, Norway. The findings in this master thesis aims to reflect the context of agile software development in Norway. Thus, the thesis also aims to complement existing research on agile software development and provide insight to potential success factors for ASDTs under crisis circumstances where colocation is limited.

1.2 Research Questions

This thesis aims to investigate how the COVID-19 pandemic affected teamwork effectiveness, agile practices, and productivity in ASDTs. The purpose of this thesis is to provide insight into how ASDTs adapted to working under the pandemic and how it affected the teamwork. Research in this thesis is based upon an assumption that the use of agile practices could have been affected by the COVID-19 pandemic due to involuntary work from home and lack of colocation. The thesis aims to answer the following research questions:

- **RQ1:** *How does agile software development from home during the COVID-19 pandemic affected teamwork effectiveness in Agile Software Development Teams?*
The first research question aims to address how ASDTs from home during the COVID-19-pandemic has affected teamwork effectiveness in the team.
- **RQ2:** *How has agile software development teams adapted agile practices in response to the COVID-19 pandemic?*
The second research question aims to research how ASDTs adapted agile practices to work from home because of the COVID-19 pandemic.
- **RQ3:** *How has productivity in agile software development teams changed because of the COVID-19 pandemic?*
Third research question aims to investigate if productivity changed during the pandemic. The research question addresses how performance in ASDTs and factors

such as well-being, work motivation, and work environment were impacted by the COVID-19 pandemic. The assumption is that these factors are closely related to productivity.

1.3 Thesis structure

The rest of the thesis is structured as follows:

Section 2: Background briefly presents the background of the COVID-19 pandemic and presents relevant theoretical background for this thesis.

Section 3: Related Work presents related relevant research and findings on the topic of the COVID-19 pandemic, agile software development, and software developers.

Section 4: Research Method describes the interview study. The section goes into detail on the chosen structure for the interview, the design of the interview guide, interview subjects, interview groups, interview process, research context, and analysis of the data.

Section 5: Results presents findings from the interview data in relation to the research questions.

Section 6: Discussion discusses the results and previous findings in relation to the research questions.

Section 7: Conclusion concludes the thesis and presents suggestions for future work.

2 Background

This section provides an overview on the background of the COVID-19 pandemic and the transition to remote work. Furthermore, an overview of agile development, the philosophy behind it and popular agile practices. Finally, an overview of some of the findings from studies related to the impact of the COVID-19 pandemic on agile software development teams.

2.1 COVID-19

The widespread novel and global disease virus COVID-19 named SARS-CoV-2 was discovered in December 2019 in Wuhan, China. It was recognized as a global pandemic on March 11th, 2020, by the WHO (World Health Organization) (Cucinotta & Vanelli, 2020). Countries worldwide had to enforce state of emergency and introduce policies such as lockdowns and social restrictions mandated by law to prevent the further outbreak of COVID-19. On March 12th, the national government in Norway launched multiple strategies to contain the virus. (Ursin, Skjesol, & & Tritter, 2020). The strategies enforced closing national borders, prohibiting cultural and sports events, and establishing national quarantine regulations (Ursin, Skjesol, & & Tritter, 2020). At the peak of COVID-19 pandemic's outbreak in year 2020, the whole world experienced a global lockdown with home quarantine and isolation.

The sudden shift to remote work led to a rising need for digital collaboration communication tools to set up the digital workspace from home. Before the pandemic occurred, home office was an inadequate workplace for many. ASDTs often worked in co-located open office spaces. The purpose with co-located open office landscapes is to inspire more open and informal communication between employees. However, the transition to remote work from home meant ASDTs had to facilitate social events and face-to-face communication in other ways with the help of digital tools.

2.2 Agile Software Development

The concept of agile is described by Atlassian as an iterative approach to project management and software development (Atlassian, u.d.). There are many different popular agile frameworks in ASDTs today. Agile methodology is widely adopted and can be generalized as the common

standard in the software development industry. The 15th annual state of Agile Report (2021) from digital.ai stated over half of respondents from their survey said either a majority or all their company's teams have adopted agile (Digital.ai, 2021). The most common methodology adopted at team level is Scrum at 66 percent. Only 3 percent said none of the company's teams have adopted agile practices. In comparison to the traditional "waterfall" model, which has a linear sequential lifecycle, agile is defined by a series of tight feedback cycles and continuous improvement (Atlassian, u.d.). The word 'agile' is defined by Oxford Learner's dictionary as being "able to move quickly and easily" (Oxford University Press, u.d.). The ability for software development teams to be agile is a response to the historical "waterfall" model's inability to adapt to changes. Furthermore, the increasing popularity and adoption of agile is shown in Digital.ai's annual report with their study indicating a significant growth in agile adoption within software development teams. The study showed an increase from 37 percent in 2020 and up to 86 percent in 2021. Hence, organizations and software development teams were incentivized to adopt agile in order to be able to swiftly adapt to uncertainty and changes during the COVID-19 pandemic (Digital.ai, 2021).

2.2.1 The Agile Manifesto

The basis for values and principles in agile methodologies are derived from the Agile Manifesto which was introduced in 2001. Its purpose was "*uncovering better ways of developing software*" (Fowler & Highsmith, 2001). The Agile Manifesto was assembled by software professionals with the intention of introducing values and principles that could guide the software development industry. It was made in response to frustrations with the inefficiency of traditional software development. Traditionally, software development relied on heavy documentation and linear sequential development lifecycle. Common pitfalls in this strategy, also known as 'the waterfall model', which consists of a linear sequential development flow, was the inability to adapt to changing requirements, reacting to updates, and a higher complexity the bigger the project evolved. There was an emergent need for change in the way software was developed. Most specifically, the software development lifecycle. The Agile Manifesto kicked off a revolution in software development practices.

The manifesto consists of four core values and twelve principles (see Appendix B). The Agile Manifesto is over 20 years old, was made under different premises, and was made in response to needs in a different time. For example, one of the twelve principles 'The most

efficient and effective method of conveying information to and within a development team is face-to-face conversation' is difficult to achieve when the development team is distributed. It has become more possible for agile teams to work distributed with modern technologies that can facilitate adequate communication and collaboration across different time zones and borders.

2.2.2 Scrum

Scrum is a simple lightweight framework that uses an iterative approach with time-boxed intervals that splits the project into fixed time periods called sprints (Schwaber & Sutherland, 2020). There are several ceremonies and practices in Scrum that agile teams can use. Scrum includes ceremonies or practices such as the sprint, Sprint Planning, Daily Scrum (daily-standup), Sprint Review, and Sprint Retrospective. Sprint planning initiates the sprint by laying out the work to be done for the sprint. The team in the sprint planning chooses items (tasks) based on priority. The chosen items create a sprint backlog. Sprints are usually fixed length events of less than a month (Schwaber & Sutherland, 2020). There are three immutable roles: Product Owner, Scrum Master, and the Team. The Product Owner represents the customer orders work into the product backlog. The Scrum Master is typically responsible for fostering the environment, and ensuring the Scrum ceremonies and rituals are followed, e.g., facilitating the daily stand-up meetings (Schwaber & Sutherland, 2020). While the 'Team', also referred to as the 'development team' consists of team members tasked with primarily focusing on development of the software (Atlassian, u.d.).

2.2.3 Kanban

Kanban is a method that allows for teams to visualize their work visually to exchange information and collaborate more effectively (Schwaber & Sutherland, 2020). Typically, this is done with a Kanban board. A Kanban board is a board that 'is divided into columns which represent different stages of the workflow' (Schwaber & Sutherland, 2020). The board organizes work items by placing into different columns to represent different stages of workflow. This method makes real-time communication, transparency, and collaboration more effective by visualizing and to promote a better overview of the whole work process.

2.3 Distributed Agile Software Development

Distributed agile software development (DASD) is agile software development applied on a global distributed setting (Shrivastava & Date, 2010). Over the last decade, many organizations have experimented with distributed software development and agile methods to potentially gain a competitive advantage (Shrivastava & Date, 2010). The principal difference between distributed and collocated agile software development is that DASD attempts to overcome the challenges associated with being geographically distributed. Advantages with being distributed includes the software development becoming multi-site, more multicultural, having larger pools of available talent to develop software at a reduced cost, and distribution reduces risk of natural catastrophes (Shrivastava & Date, 2010). Moreover, being distributed means ASDTs must inherently be highly coordinated in software development, communication, and collaboration to be successful in deliver working software. To achieve adequate communication, collaboration, and coordination, ASDTs must heavily rely on digital tools that enable the aforementioned factors.

DASD comes with clear disadvantages. Common disadvantages met in DASD are communication and collaboration. The agile principles in the Agile Manifesto (Fowler & Highsmith, 2001) includes core values and principles that puts a high emphasis on communication and collaboration. Working in a distributed setting excludes the principle of face-to-face interactions (see appendix B, table 2, principle 6) and core values on collaboration (see appendix B, table 1, core values 1 and 3). Challenges faced in distributed ASDTs in relation to communication and collaboration are strategic issues, cultural issues, inadequate communication, knowledge management, project and process management issues, technical issues, and risk management (Shrivastava & Date, 2010).

The adoption of agile in distributed software development teams presents challenges. Challenges faced by distributed agile teams are documentation, pair programming, different work hours, training on Agile practices and distribution of work (Shrivastava & Date, 2010). In distributed environments, remote teams may miss out on details in communication that would otherwise be common in co-located teams. The lack of rich conversations may lead to overall less details and a need to supplement it with more documentation. In global distributed software development, a major challenge is teams that span over different time zones (Shrivastava & Date, 2010). Coordination of team members must be facilitated to align the

working hours, meetings, and general availability for contacting other team members. Another challenge is that the impact of communication can be felt more for new remote team members (Shrivastava & Date, 2010). Further, a challenge met by distributed teams is to avoid overspecializing competence and architecture based on geographical locations. Distributed teams in different geographical locations may be more susceptible to overspecializing in their own particular component and hinder the ability to be cross-functional.

DASD shares several similarities with work from home under the COVID-19 pandemic. The COVID-19 pandemic forced software development teams on a global basis to work from home. Both share inherent characteristics of being mostly remote software development teams with digital communication and collaboration. While working from home during the pandemic also shares these characteristics, other additional challenges such as social isolation, lockdown, and a lack of physical collocation were present.

2.4 Teamwork Effectiveness Models

This section looks at teamwork effectiveness models. First, a brief overview of models used to assess the teamwork effectiveness in studies of software engineering teams are presented. Secondly, a teamwork effectiveness model for agile teams (ATEM) is presented.

2.4.1 The Big Five

The ‘Big Five’ model describes five components that gives rise to effectiveness in teams (Salas et al., 2005). The components are: team leadership, mutual performance monitoring, backup behaviour, adaptability, and team orientation. Furthermore, these five core components are facilitated by supporting coordinating mechanisms: shared mental models, closed-loop communication, and mutual trust.

2.4.1 Input-Process-Output (IPO)

The Input-Process-Output (IPO) model is a framework for studying team effectiveness proposed by McGrath in 1964. The IPO model consists of three antecedent factors: Inputs, Processes, and Outcomes (McGrath 1964; Mathieu et al., 2008). Inputs are factors that directly impact the interaction between team members (Mathieu et al., 2008). Inputs can include individual team members’ characteristics (e.g., personalities), team-level factors such as task

structure and external leader influences, and organizational and contextual factors such as organizational design features and environmental complexity. Processes describe how inputs transform into outputs. Processes can include transition phases such as monitoring progress and interpersonal progresses (e.g., conflict management, motivation) (Mathieu et al., 2008; Dingsøy, Strode & Lindsjørn, 2022). Outputs can be described as the outcomes or results of team activity. This can include results from both on a team-level and on an individual level. The outcomes on a team-level mainly reflect team performance while outcomes on an individual level can reflect team members' affective reactions such as satisfaction and viability (Mathieu et al., 2008).

2.4.2 Teamwork Quality

The TWQ (Teamwork Quality) construct was conceptualized by Hoegl and Gemuenden (2001) to measure collaboration in teams. Six facets are specified to capture both task-related interaction and social interaction within the team (Hoegl & Gemuenden, 2001). These six facets are: communication, coordination, balance of member contribution, mutual support, effort, and cohesion. This section describes the six facets.

Communication

Communication is the most elementary component of TWQ (Teamwork Quality) within a team (Hoegl & Gemuenden, 2001). 'Communication provides a means for the exchange of information among team members' (Hoegl & Gemuenden, 2001).

Coordination

Coordination is described by Malone and Crowston (1994) as 'managing dependencies between activities'. Agile teams coordinate by delegating tasks when planning new iterations. The prioritized "user stories" (requirements) in the product backlog are estimated and tasks are assigned to each team member.

Balance of Member Contributions

The balance of member contributions refers to the ability to employ the team members' expertise to its full potential (Lindsjørn et al., 2016). Agile teams support this with daily stand-

up meetings (Stray et al., 2016). and cross-functional teams where all team members are expected to contribute.

Mutual Support

Mutual support is an essential component of TWQ (Hoegl & Gemuenden, 2001). The degree of mutual support depends on the team members' support for other team members' ideas and contributions in order to achieve a common goal, rather than in the interest of competition and outdoing other team members (Hoegl & Gemuenden, 2001).

Effort

To achieve higher teamwork quality, it is expected by team members to support and have an overall understanding of the expected shared commitment towards the team's task and goals (Hoegl & Gemuenden, 2001; Lindsjörn, Sjøberg, Dingsøy, Bergersen, & Dybå, 2016).

Cohesion

Cartwright (1968) defines *team cohesion* as the degree to which team members desire to remain on the team. According to Mullen and Copper (1994) there are three distinguishable aspects of team cohesion: 'interpersonal attraction of team members', 'commitment to the team task', and 'group pride-team spirit'.

2.4.3 Comparison of models measuring teamwork effectiveness

Model	Description	Source
Salas Big Five model	The 'Big Five' model is composed of five components that promotes team effectiveness. The components are: team leadership, mutual performance monitoring, backup behavior, adaptability, and team orientation. Furthermore, these five core components require supporting coordinating mechanisms: shared mental models, closed-loop communication, and mutual trust.	(Salas et al., 2005)

Input-Processes- Output (IPO)	The IPO model consists of three antecedent factors: inputs, processes, and outputs. Inputs are factors that directly impact the interaction between team members. Processes describe the transition phases of inputs into outputs. Outputs are outcomes and by-products of team-activity	(Mathieu et al., 2008; McGrath 1964)
Teamwork Quality (TWQ)	The TWQ model measures collaboration in teams. The model has six sub-constructs: communication, coordination, the balance of member contributions, mutual support, effort, and cohesion.	(Hoegl & Gemuenden 2001)

Table 1: Comparison of teamwork models is based on (Strode, Dingsøy, & Lindsjørn, 2022).

2.4.4 ATEM – Agile Teamwork Effectiveness Model

The Agile Teamwork Effectiveness Model (ATEM) is built on the ‘Big Five’ model (Salas et al., 2005; Lindsjørn, Dingsøy, & Strode, 2022). In contrast to other models for measuring teamwork effectiveness or teamwork quality, the ATEM-model is specifically designed with agile teams in mind. ATEM-model consists of three coordinating mechanisms and supports five teamwork components that are critical for team effectiveness. The three coordinating mechanisms ‘shared mental models’, ‘mutual trust’, and ‘communication’ that facilitates, support each other, and support the five teamwork components. The five components for effective teamwork are: ‘shared leadership’, ‘peer feedback’, ‘redundancy’, ‘adaptability’, and ‘team orientation’. Each component and coordinating mechanism have an associated set of behavioral markers (Strode, Dingsøy, & Lindsjørn, 2022). Behavioral markers are described as specific, observable behavior that is not an attitude or personality trait (Klumpfer, Flin, Hausler, Sexton, & Fletcher, 2001). Behavioral markers are used in the Big Five model and ATEM-model to indicate the observable behaviors associated with a coordination mechanism or component, which gives immediate value for practitioners to evaluate teamwork effectiveness (Strode, Dingsøy, & Lindsjørn, 2022). Each factor in the model can consist of

sub-components that can consist of items. This section will describe the eight interacting factors that constitute teamwork effectiveness.

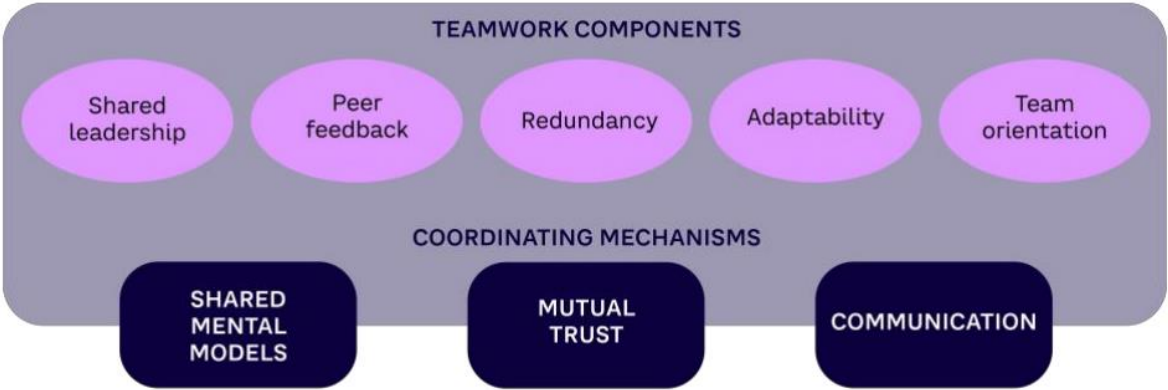


Figure 1: The Agile Teamwork Effectiveness Model (ATEM). Figure from (Dingsøy, Strode, & Lindsjörn, 2022)

TEAMWORK COORDINATING MECHANISM	TEAM BEHAVIORAL MARKERS
<p>Shared mental models “An organizing knowledge structure of the relationships among the task the team is engaged in and how the team members will interact.”</p>	<ul style="list-style-type: none"> • Anticipates and predicts each other’s needs • Shares common understanding of: goals, tasks, work process, product, individual skills, and expertise
<p>Mutual trust “Shared belief that team members will perform their roles and protect the interests of their teammates.”</p>	<ul style="list-style-type: none"> • Adheres to information sharing • Is willing to admit mistakes and accept feedback • Supports team social climate
<p>Communication “The exchange of information between a sender and a receiver irrespective of the medium.”</p>	<ul style="list-style-type: none"> • Follows up on progress of tasks • Visualizes project information • Facilitates informal communication

Table 2: Coordinating mechanisms with behavioral markers in the ATEM. The table from (Dingsøy, Strode, & Lindsjörn, 2022)

TEAMWORK COMPONENT	TEAM BEHAVIORAL MARKERS
<p>Shared leadership</p> <p>“The ability of the team to direct and coordinate their activities, assess team performance, assign tasks, develop team knowledge, skills, and abilities, motivate one another, plan and organize, and establish a positive atmosphere.”</p>	<ul style="list-style-type: none"> • Facilitates team problem-solving • Determines performance expectations and acceptable interaction patterns • Synchronizes and combines individual team member contributions using Agile practices combined with automated tools • Seeks and evaluates information that affects team functioning • Uses Agile values and methodologies to determine team member roles • Uses Agile values and methodologies to determine frequency and type of preparatory meetings and feedback sessions • Servant leader facilitates boundary-spanning function • Agile team practices provide planning function
<p>Peer feedback</p> <p>“The ability to develop common understandings of the team environment and based on those understandings to give accurate peer feedback to team members.”</p>	<ul style="list-style-type: none"> • Identifies mistakes and lapses in other team members’ actions • Contributes regular feedback regarding team members’ actions to facilitate self-correction
<p>Redundancy</p> <p>“The ability to anticipate other team members’ needs through accurate knowledge about their responsibilities. This includes the ability to shift workload among members to achieve balance during high periods of workload or pressure.”</p>	<ul style="list-style-type: none"> • Recognizes workload distribution problem in team • Shifts work responsibilities to underutilized team members • Supports completion of whole task (or parts of tasks) by other team members
<p>Adaptability</p> <p>“The ability to adjust strategies based on information gathered from the environment through the use of backup behavior and reallocation of intra-team resources. Altering a course of action or team repertoire in response to changing conditions (internal or external).”</p>	<ul style="list-style-type: none"> • Identifies cues that a change has occurred, assigns meaning to that change, and develops new plan to deal with the change • Identifies opportunities for improvement and innovation for habitual or routine practices • Remains vigilant to changes in the internal and external environment of the team
<p>Team orientation</p> <p>“The propensity to take others’ behavior into account during group interaction and the belief in the importance of team’s goals over individual members’ goals.”</p>	<ul style="list-style-type: none"> • Considers alternative solutions provided by teammates and appraises that input to determine what is most correct • Performs increased task involvement, information sharing, strategizing, and participatory goal setting • Sticks together and remains united

Table 3: Teamwork components with behavioral markers in the ATEM-model. The table is from (Dingsøy, Strode, & Lindsjørn, 2022)

Shared Mental Models

Shared mental models are defined as ‘An organizing knowledge structure of the relationships among the tasks the team is engaged in and how the team members will interact’ (Salas et al.,

2005). Shared mental models refers to the common understanding developed among team members over the time as they become familiar with each other and the situation (Dingsøyr, Strode, & Lindsjørn, 2022). An effective shared mental model will help a team with coordination, a smoother working environment, and fewer interruptions because team members can focus more on work tasks than spending time on learning and observing other team members. The main sub-component was ‘common understanding of goals’ (Strode, Dingsøyr, & Lindsjørn, 2022). Case studies showed that certain agile development practices such as specification meetings, planning meetings, and stand-up meetings supported shared mental models.

Mutual Trust

Mutual trust is defined as the ‘shared belief that team members will perform their roles and protect the interests of their teammates’ (Salas et al., 2005). The concept of mutual trust relates more to the empowerment of the team. Mutual trust supports the agile principle that states ‘Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done’ (Fowler & Highsmith, 2001). A lack of mutual trust can prompt more formal information sharing within the team, greater individual orientation, and an increased hierarchical project structure (Dingsøyr, Strode, & Lindsjørn, 2022). The sub-components for mutual trust are ‘respect’, ‘social climate’, ‘conflict’, ‘openness’, and ‘other’. The sub-component ‘other’ included ‘safety’, ‘engagement’, ‘belonging’, ‘stress’, ‘balance in team’, and ‘collaboration’.

Communication

Closed-loop communication, revised as ‘communication’ in ATEM, was defined as ‘the exchange of information between a sender and a receiver irrespective of the medium’ (Salas et al., 2005). The noted sub-components are ‘colocation’, ‘openness’, ‘communication infrastructure’, ‘visualizing status and progress’, and a ‘friendly atmosphere’. The empirical findings from the case studies suggested multiple findings from the focus groups. Firstly, that communication in an agile team setting is oriented toward the whole team. Secondly, the findings suggest that there was a perceived importance of colocation for achieving close-loop communication (Strode, Dingsøyr, & Lindsjørn, 2022).

Shared Leadership

Team leadership, revised as ‘shared leadership’ in the ATEM model, is defined as the ‘Ability to direct and coordinate the activities of other team members, assess team effectiveness, assign tasks, develop team knowledge, skills, and abilities, motivate team members, plan and organize, and establish a positive atmosphere (Salas et al., 2005). The top five sub-components are: ‘planning’, ‘shielding from interruptions’, ‘work process’, ‘adequate resources’, and ‘infrastructure’ (Strode, Dingsøy, & Lindsjörn, 2022).

Peer Feedback

Mutual performance monitoring, revised as ‘peer feedback’ in ATEM, is defined as ‘the ability to developed common understandings of the team environment and apply appropriate task strategies to accurately monitor teammate performance (Salas et al., 2005). Empirical research from Salas’ Big Five model finds that mutual performance monitoring is important in stressful situations where team members are more likely to make errors. This can be remedied with feedback. Noted sub-components are ‘reflect on practice’, ‘joint responsibility of result’, ‘feedback’, ‘measuring effectiveness’, and ‘other’. The sub-component ‘other’ includes: ‘status’, ‘clear expectations’, ‘turnover’, ‘openness’, ‘recognition’, ‘demonstration’, and ‘joint review’ (Strode, Dingsøy, & Lindsjörn, 2022).

Redundancy

Backup behavior was revised as ‘redundancy’ in the ATEM model. Backup behavior is defined as the ‘ability to anticipate other team members’ needs through accurate knowledge about their responsibilities. This includes the ability to shift workload among members to achieve balance during high periods of workload or pressure’ (Salas et al., 2005). Main sub-components of backup behavior are: ‘the right competence’, ‘distribution of tasks’, ‘time to work together’, ‘specialization’, ‘joint commitment to tasks’, and ‘experience sharing’. Backup behavior was renamed as ‘redundancy’ because the redundancy of skill sets in agile software development is necessary to enable backup behavior (Strode, Dingsøy, & Lindsjörn, 2022). Agile teams aim to be cross-functional, thus the team should contain suitable skills and aim to be generalizing specialists to assist team members when tasks and workload needs to be distributed (Strode, Dingsøy, & Lindsjörn, 2022).

Adaptability

Adaptability is defined as ‘the ability to adjust strategies based on information gathered from the environment through the use of backup behavior and reallocation of intra-team resources. Altering a course of action or team repertoire in response to changing conditions (internal or external)’ (Salas et al., 2005). Main sub-components are ‘organizational constraints’, ‘team environment’, ‘collaboration culture’, ‘team focus’, ‘right competence’, ‘conflict’, ‘other’. The ‘other sub-component includes: ‘joy of work’, ‘engaged team members’, ‘little priority to team tasks’, ‘team composition’, and ‘openness’ (Strode, Dingsøy, & Lindsjørn, 2022).

Team Orientation

Team orientation is defined as the ‘Propensity to take other’s behavior into account during group interaction and the belief in the importance of team goal’s over individual member’s goals (Salas et al., 2005). Main sub-components are ‘team cohesion’, ‘team environment’, ‘prioritization of team tasks’, ‘team member respect’, ‘responsibility’ and ‘conflict’. Team orientation was described by the Salas Big Five model as an attitudinal dimension, unlike other dimensions which is described as behavioral (Strode, Dingsøy, & Lindsjørn, 2022). Agile practices involving frequent meetings such as daily stand-ups, joint planning, demonstration, retrospective meetings, and practices such as pair programming and shared code ownership are likely to make the team members more ‘united’ and cohesive (Strode, Dingsøy, & Lindsjørn, 2022).

3 Related work

Since the start of the COVID-19 pandemic in 2020, multiple studies have researched the impact of COVID-19 on ASDTs and factors such as communication and productivity. The different findings from the studies suggests a lack of consensus within the scientific research community on whether productivity in ASDTs was significantly affected. Some studies focused merely on measuring productivity by the throughput of code, while other studies took into consideration aspects such as well-being of the developers. Additionally, it is not clear if many of the studies have considered new phenomena from the pandemic such as social isolation over prolonged periods on the productivity and well-being in the agile team. Thus, this thesis aims to cover some of the related studies to provide a broader perspective on how communication, agile practices, and productivity in ASDTs have been affected.

3.1 Studies from LASD on impact of COVID-19 on ASDTs

The international conference on Lean and Agile Software Development (LASD) discusses each year recent research findings and presents the top-rated accepted research papers. Three papers from LASD studies the impact of the COVID-19 pandemic on productivity and performance among Agile software developers. All studies' findings are based on data collected in 2020 and presents conclusions with different outcomes.

3.1.1 Study on the state of Agile Software Development during the COVID-19 pandemic

The first mentioned study on the state of Agile Software Development Teams during the COVID-19 pandemic concluded that the transition to remote work did not disrupt ASDTs' communication, but rather reduced the number of unnecessary meetings, which was a factor in reducing their productivity (Marek, Wińska, & D'abrowski, 2021). Furthermore, the paper argues that fully remote work improved communication in teams that were distributed and non-remote before the pandemic by moving all communication to online tools. Consequently, prevented the exclusion of remote or distributed team members from on-site, in-person discussions and meetings (Marek, Wińska, & D'abrowski, 2021). Therefore, it is argued that moving the entirety of communication to online tools improved communication in agile teams.

3.1.2 Study on Agile Project Development issues during the COVID-19 pandemic

Second study focused on Agile project development issues during the COVID-19 pandemic and stated the agile methodology faced so many issues that it impacted the software development negatively. The issues mentioned because of the pandemic situation and work from home were less satisfaction of work, fewer meetings with the client, health stress, less work pressure, and an increase in cost and time. It is stated in the paper: *'agile does not work effectively during the COVID-19 pandemic... There is a massive downfall in software productivity compared to normal'* (Butt, Misra, & Anjum, 2021). Causes for less productivity is explained as an increase in cost and time, less coordination among the team and developers, less satisfied with input on any user story, no official work environment due to spending more time with family, stress related to the COVID-19 pandemic, and less social interactions.

3.1.3 Study on Sars-Cov-2 Pandemic and Agile Methodologies in Software Development

The last paper studied the effect of the COVID-19 pandemic and agile methodologies in software development. The paper consisted of a multiple case study with three cases. Results showed that most of the teams did not experience any loss in performance (Neumann M. , Bogdanov, Lier, & Baumann, 2021). In this case, the results from their study claimed that since March 2020, the performance remained the same or even improved. The results are justified with observations of qualitatively more efficient working hours, increased transparency in the agile approach, and more involvement of the Product Owner (Neumann M. , Bogdanov, Lier, & Baumann, 2021). Additionally, the paper examined the impact of the pandemic on communication. Their findings claimed communication became more objective and efficient because of less misunderstandings with virtual communication.

3.2 Related studies on COVID-19's impact on productivity among developers

Several of the scientific research papers conducted during the COVID-19 pandemic focused on how productivity among software professionals was impacted. This subsection describes main findings from some of the studies.

3.2.1 Changes in perceived productivity of software engineers during COVID-19

A study on 'Changes in perceived productivity of software engineers during COVID-19 pandemic' conducted an analysis which reported that software intensive companies have generally transitioned smoothly into the Work-From-Home mode during the COVID-19 pandemic, and organizational productivity on average has not significantly changed (Smite, et al., 2021). The analysis was based on a study of thirteen surveys and aggregated a total of 7686 data points. Their study on individual productivity evidenced large groups of developers reporting being more productive. While a group of developers also reported being less productive in a commit-based survey (Smite, et al., 2021).

3.2.2 Longitudinal study on developers' well-being and productivity

Russo et al. conducted a four-wave longitudinal study over 14 months from the start of COVID-19 pandemic in April to July 2021, involving 192 software developers (Russo, Hanel, & Berke, 2021). The study aimed to investigate the impact COVID-19 on the developers' well-being and productivity. Findings from the study revealed that productivity remained constant during the pandemic. The productivity level of software professionals did not change during lockdown and compared with the pre-pandemic time (Russo, Hanel, & Berke, 2021). Well-being increased in all four time points. The study also revealed that the developers reported being less lonely and improving social contacts. In sum, the longitudinal study well-being and productivity were not affected by the pandemic.

3.2.3 Pandemic programming

A study researching how COVID-19 affects software developers was conducted during the height of the pandemic (Ralph, et al., 2020). The paper reports it as the first large-scale study to research the problem of how the pandemic affects software developers. The study was a questionnaire that included an especially large sample size of 2225 responses. The main findings from the study were: evidence of productivity and well-being have declined, productivity and well-being being is closely related, indication that different people need different kind of support from their organization, and indication that the pandemic may disproportionately affect women, parents, and people with disabilities.

3.2.4 Questionnaire study on Agile working during COVID-19 pandemic

C. Doering, M. Schmidtner, J. Maerz, V. Mueller, H. Timinger conducted a questionnaire with the target groups being managers and project management experts in Germany (Doering, Schmidtner, J. Maerz, & Timinger, 2021). The study investigated agile working during the COVID-19 pandemic and involved more than 170 participants. Main findings of the study were summarized as follows: companies adapted quickly and kept up with agile working and productivity. The study reported only a small loss in productivity. The main conclusion from the study was ‘The sudden release of strong measures, also known as “lockdown”, had significant impact on the way of agile working’ (Doering, Schmidtner, J. Maerz, & Timinger, 2021). Home office was stated as expected to become part of the future work environment (Smite, et al., 2021).

3.3 Conference Paper on the impact of COVID-19

A conference paper based on an XP 2020 panel organized by Steven Fraser and featuring Aino Corry, Steve McConnell, and Rachel Reinitz discussed the impact of COVID-19 on knowledge workers, the acceleration of digital workplace transformation, and long-term effects from the pandemic in the context of agile practices (Mancl & Fraser, 2020). There were four key observations from the panel discussion. The first observation was that virtual collaboration is enabled through the various use of communication tools that act as a substitute for face-to-face interactions. Second, agile work practices are more difficult to perform given the virtual nature of meetings and interactions. Third, ‘communications tools are not always satisfactory adequate for high-bandwidth interactions or informal interactions. Examples of high-bandwidth- or informal interactions are brainstorming, side-discussions, or hallway conversations. Lastly, the onboarding and forming of new team members and staff is challenging in a virtual work environment (Mancl & Fraser, 2020).

4 Research Method

This chapter describes the research methods applied in this thesis. The research is comprised of interviews and a literature review. Further, a description on how the data was gathered and analyzed is presented.

4.1 Research Design

Assessing the impact of the COVID-19 impact on ASDTs can be difficult to measure. Specifically, measuring and assessing productivity and communication with quantitative metrics would likely only give an understanding of the throughput of code in ASDTs and not necessarily a broader picture on how the COVID-19 pandemic impacted social phenomena in ASDTs. By contrast, qualitative research could provide a deeper understanding of the COVID-19 pandemic as a social phenomenon. ‘Qualitative research aims address questions that are more concerned with developing an understanding of the meaning and experience of humans’ lives and social worlds’ (Fossey, Harvey, McDermott, & Davidson, 2002). In Fossey, Harvey, McDermott & Davidson’s scientific article on ‘Understanding and Evaluating Qualitative Research’, qualitative research is explained as more appropriate for investigating health problems, understanding individuals’ and groups’ subjective experiences of health and disease; social, cultural, and political factors in health and disease; and interactions among participants and health care settings (Fossey, Harvey, McDermott, & Davidson, 2002). Further, investigating these problems may be difficult with using quantitative approaches. Thus, the research questions for this thesis were formulated in a qualitative nature by being more open-ended.

4.1.1 Semi-structured Interview

The chosen method of qualitative research for data collection was semi-structured interviews. The purpose with research interviews is to ‘explore the views, experiences, beliefs and/or motivations of individuals on specific matters (Gill, Stewart, Treasure, & Chadwick, 2008). Furthermore, because research interviews are believed to provide a “deeper” understanding of social phenomena than from quantitative research, it is believed interviews are more appropriate for where little is already known about the study phenomenon or when detailed insights from individuals are required (Gill, Stewart, Treasure, & Chadwick, 2008). Semi-structured

interview is a popular data collection method that is more versatile and flexible than typical structured interviews (Kallio, Pietilä, Johnson, & Docent, 2016). The approach to data collection and the interviews were of a more exploratory nature. The goal of the research was to research patterns, similarities, or reveal potential directions from the data. Semi-structured interviews contain a list of predefined questions, but the interviewer is allowed to be flexible with changing the order of questions, asking follow-up questions, and sometimes deviate away from the original question. Therefore, the nature of semi-structured interviews is more informal. Additionally, if some questions were to be regarded as unimportant during the interview process, they could be discarded or ignored.

4.1.2 Interview Design

Several of the questions were constructed and inspired from questionnaires and questions from ‘future work’ sections. Importantly, the questions were constructed to be more open-ended and avoid questions that were seeking clarification. For example, “How badly did the COVID-19 pandemic affect your work?” compared to “How did you experience working under the COVID-19 pandemic?”. The interview guide (see Appendix A) was created for this thesis with the intention of lasting 30 to 45 minutes. Most of the interviews finished at around 30 minutes. The objective was to target the three different specific topics: agile practices, communication, and productivity.

The interview process was carried out in the early parts of 2022. The interview subjects consisted of software developers from two different companies. This section will roughly describe the backgrounds of 16 interview subjects and shortly describe the two different companies. The companies will be referred to as company A and company B.

4.1.3 Company A

The first company is a consulting company with focus on business and IT. The company has multiple offices in Europe and has a portfolio of over 6000 employees in over 15 countries. Eleven of the interview subjects worked in this company. Several of the interview subjects work together in teams with colleagues in both Poland and Denmark. The group of interview subjects consists of IT consultants and will be referred to as group Alpha.

Interview subjects with less than a year of experience were all newly graduated students in 2021 and started working for Company A in autumn 2021. Because of rapidly growing infection rates of COVID-19, Company A encouraged workers to work from home to prevent further spread. Rest of the interview subjects had all been working within the company and worked during the entire pandemic.

ID	Role	Age	Gender	Experience
S1	Software Developer	26	Male	2 and ½ years
S2	Software Developer	24	Male	Over ½ year
S3	Software Developer	23	Male	Over ½ year
S4	Software Developer	24	Male	Over ½ year
S5	Software Developer	25	Female	Over ½ year
S6	Software Developer	24	Female	Over ½ year
S7	Software Developer	31	Male	5 and ½ years
S8	Software Developer	26	Male	Over 2 and ½ years
S9	Software Developer	25	Male	Over 2 and ½ years
S10	Software Developer / Team Lead	28	Male	Over 3 and ½ years
S11	Software Developer	26	Male	Over 2 and ½ years

Table 4: Interview subjects in group Alpha

4.1.4 Company B

The second company is a large Norwegian bank with a heavy focus on delivering bank services with modern technology. The five interview subjects from this company will be referred to as Group Beta. Some of the interview subjects worked within the same team and worked together

with an offshore team in India. All the interview subjects worked in-house and focused on developing working code for the company.

ID	Role	Age	Gender	Experience
S12	Lead Architect	41	Male	14-15 years
S13	Tech Lead / DevOps-Engineer	31	Male	7 years
S14	Senior Software Engineer	62	Male	30-40 years
S15	Senior Data Engineer	46	Male	23 years
S16	Tech Lead / Software Developer	44	Male	Over 20 years

Table 5: Interview subjects in group Beta

4.1.5 Interview Process

Interview subjects in Company A were interviewed in the earlier months of 2022, January, and February. While subjects in Company B were interviewed in March 2022. I came in contact with the interview subjects in group Alpha through the HR department, which was in turn contacted by them. While for group Beta, I came in contact with them through personal contacts. I first contacted an individual with a leading role in Company B’s software development department. The person of contact provided me with seven potential interview subjects, five of them replied and accepted the invitation to be interviewed for the thesis research.

The interviews were held both online and in-person. If online, then the interview meetings were held on Google Meet or Microsoft Teams. Most of the interviews were held in Norwegian, except for one that was conducted in English. The interviews were transcribed with notetaking on a laptop. Fortunately, transcribing without audio worked sufficiently. All participants were patient with letting me write down all their words and viewpoints. During the process of interviews, some of the questions in the interview guide were discarded or changed along the

way. Some of the questions were regarded as irrelevant or did not provide a deeper understanding of the study phenomenon or value to the research questions. While other questions may have been altered with follow-up questions to be more specific, or to further explore in detail any potential patterns. The altering of questions could introduce reliability issues for the analysis of the data if the questions are formulated differently. Furthermore, there were also ethical considerations for how the data gathering was going to be processed. The interviews were transcribed but not recorded by audio. Participants of the study were informed of the study details, the purpose of the research, and their ability to withdraw their response at any time. Transcribed words do not provide the same details as audio would. Transcribed notes from the subjects did not include any personal identifying information. The drawback with this approach is potential reliability and consistency issues when revising the interview data. The process of conducting interviews was time-consuming. A minimum of 30 minutes per interview subject meant the interviews in total was over eight hours. Besides that, other activities such as reaching out to respondents, planning, scheduling, and analyzing the interview data took a substantial amount of time.

4.1.1 Research Context

When the interviews took place in the first months of 2022, the Norwegian society was in a state of gradual reopening. Comprehensive measures to prevent the spread of COVID-19 in Norway was introduced 12th March 2020 (Regjeringen, u.d.). Multiple vaccine dosages have been offered to the population and helped reduce the severe outbreaks of COVID-19. After almost two years of mandating measures, the Norwegian government reopened in 2022 by gradually repealing the social measures. Finally, on Saturday 12th February, the infection control measures against COVID-19 were lifted. These measures included requirements for face masks, one-meter distance, and the obligation to social isolation in the event of illness (Regjeringen, u.d.). Since the measures were lifted, daily life has mostly returned back to normal for most people. The semi-structured interviews of group Alpha and group Beta took place from the end of January and the whole of February. People in Norway were getting less sick, and the vaccine offered good protection against the disease (Regjeringen, u.d.). Consequently, this allowed for several of the interview meetings to take place in physical meeting rooms.

4.1.2 Interview Data Analysis

The interview guide was divided into three distinct sections that reflected the research questions. A drawback to choosing interviews as the qualitative study for this thesis is that it is more difficult to generalize findings due to smaller sample size. There is also a potential cultural bias in the data because all the participants were working in a Scandinavian country. Thus, a potential threat to the validity of the qualitative study is the reliance on the researcher's understanding of the topic. Another potential threat is that the interview subjects in group Alpha were contacted through an invitation by one of the employees working in the HR department and respondents in group Beta were invited to this study through a leading figure in their organization. Hence, these respondents may reflect people that have more expressive opinions on working during the COVID-19 pandemic than the average software developer. Lastly, because nearly all of the interview data was transcribed in Norwegian, translating directly to English may introduce consistency issues.

5 Results

This section provides the findings from the analyzed data. The findings from the data will be presented in relation to the eight interacting factors in the ATEM model to measure teamwork effectiveness.

5.1 Demographics of the Interview Subjects

All interview respondents were software professionals that worked in Norway during the pandemic and experience with Agile Software Development. Most of the informants were male, and only two of the informants were female in group Alpha. The most noticeable difference between the informants in group Alpha and group Beta is the age. The youngest informant in group Alpha was 23 years old and the oldest was 31 years old. While the youngest in group Beta was 31 years and the oldest was 62 years old. Furthermore, the informants in group Beta had significantly much more experience with software development compared to group Alpha.

5.2 Teamwork Effectiveness

This subsection presents the findings on teamwork effectiveness. The findings were identified using the behavioral markers for the eight interacting factors in the ATEM model.

5.2.1 Shared Mental Models

Behavioral markers for shared mental models are:

- The anticipation and prediction of other team members' needs
- Common understanding of goals
- Common understanding of tasks
- Common understanding of work processes
- Common understanding of the project
- Common understanding of individual skills and expertise

The interview respondents' teams in group Alpha had their own unique ways of developing shared mental models. Company A had developed their own agile project framework that many of their teams use in their projects. Interview respondents in group Alpha described it as a hybrid model combined of the waterfall model and an agile methodology such as Scrum or Kanban. Fundamentally, it is an agile project framework but with heavier documentation to supplement the work processes. Most of the documentation is stored on a platform they call 'Toolkit'. The Toolkit platform stores most of the information related to team projects, including estimated work hours on user stories, task boards, current progress on work tasks, progress on testing of user stories and so on. The information in the project is also shared with the customer to provide a better overview and current status. Thus, analyzing Toolkit in relation to the behavioral markers, software development teams in Group A with Toolkit can anticipate and predict others, while achieving common understanding with respect to goals, tasks, work processes, and understanding of the product. However, Toolkit does not take into consideration an understanding of the individuals' skills and expertise. But, because many of the teams in group Alpha exercise agile practices such as sprints, backlog, daily stand-up meetings, and sprint retrospective meetings, the team members can easily get a sense of other team members' skills and expertise.

Interview respondents in group Beta achieved shared mental models under the COVID-19 pandemic by relying more on agile practices, and digital communication platforms to document the work processes and communication. Most of the interview respondents' teams in group Beta used Scrum or Kanban. The most commonly mentioned agile practices were sprints, daily stand-up meetings, sprint retrospective meetings. Interview respondent S12 said:

S12: Most written communication is on Slack, and Teams. Typically, we use Bitbucket, Jira, Confluence, and Atlassian Stack, with respect to code, tasks, and documentation. Additionally, we use some email.

Slack was reported as the main communication platform in Company B. Each team had their own 'digital space' with own channels for the products separately. Respondent S13 said Slack was used as a replacement for open office landscape. Thus, software development teams in group Beta relied on the use of agile practices in conjunction with the use of digital communication platforms to gain a common understanding of the mentioned behavioral markers.

5.2.2 Mutual Trust

The behavioral markers for mutual trust are:

- Information sharing
- Willingness to admit mistakes and accept feedback
- Supportive team social climate

The concept of ‘trust’ was not heavily researched during the process of the interviews. Social aspects that were not taken into consideration were: respect, conflict, and openness. However, related social aspects such as social climate and cultural differences were researched.

Social Climate

The behavioral marker of a ‘supportive team social climate’ was found to have been impacted predominantly negatively in both group Alpha and group Beta. With lockdowns, social restrictions, and lack of physical social interactions during the COVID-19 pandemic, communication had to be carried out using digital communication platforms. Videoconferencing became a replacement for face-to-face interactions during the pandemic. Company A regularly encouraged and hosted social teambuilding events. Several of the interview respondents in both groups expressed that their teams made an effort to improve team spirit with social digital teambuilding activities. Some of the social activities tried to emulate the office feeling. Interview respondent S1 said the team tried to emulate the office with activities such as digital lunches and digital coffee breaks.

Other social digital teambuilding activities included games and quizzes. S1 brought up examples of quizzes with Kahoot and online games such as Scribble. Moreover, S1 said Company A arranged digital socializing events. S1 described one of those events as socializing through an online game called “Gather” or “Gather.Town”. The game was described by S1 as ‘an online virtual 8-bit game-work-world’ where people could interact similarly to the real world. Each person in the game could create their own personal avatar where they could socialize and interact with other through video-chat. The video-chat with other people was location and proximity-based. The purpose of proximity-based video-chat was to simulate the ability for side-discussions and hallway conversations just as in the physical world, which is typically difficult to accomplish in a video-conferencing tool.

Many of the interview subjects in group Alpha expressed they missed the physical social interactions. Interview respondents commented that digital social activities were not adequate substitutes for physical co-located social interactions. S4 said *‘No matter how social it is with beer on Teams, it is not the same as in real life. People do not sit until late at night on Teams’*.

S16 said the team attempted to create the social channels they used to have before naturally. He expressed the biggest problem was creating social arenas. Often social interactions consisted of calls and small talk to discuss problems. He further went on to say it was more difficult to get better known with each other digitally. Social interactions in the office were described as more natural. Whilst in a digital setting you had to create a space or room for having personal contact. S16 found it disappointing because he expressed there was no platform that served as a social meeting place for keeping in touch with each other.

The frequency of the social events was reported as significantly less than before the COVID-19 pandemic. Several of the interview respondents in group Alpha reported that there were many more social events after summer in 2021 when Oslo had lifted many of the social restrictions due to lower infection. They further commented that social events reduced drastically when the infection rates increased significantly, and people had to work from home again at the end of year 2021. S3 expressed that working from home again led to a lack of social contact, reduced motivation, social isolation, and a lack of inability to disconnect from work.

Interview respondents expressed that the threshold for contacting and sending messages were higher over digital mediums than in face-to-face interactions. Many reported it was easier to get in touch with team members and engage in informal conversations by the coffee machine at the office or simply tapping the shoulder on the next person’s shoulder. Furthermore, in an office setting, it was reported as easier to see if the person you wanted to come in contact with was available. While in a digital setting one would often anticipate waiting longer periods for an answer. The higher threshold for sending messages suggests team members were not open and confident enough to initiate contact. This may suggest reduced frequency in communication and a lack of openness.

Integrating Newcomers

Findings from the interviews indicated strongly that newer team members found it challenging to get integrated with the team and organization. Newer team members or newcomers are in the

context of this research individuals that started working with agile software development right before the pandemic occurred, or during the pandemic. To put in perspective, the individuals either started working after summer in 2019 before the pandemic occurred or started working in the midst of the pandemic in either 2020 or 2021. Among the interview respondents, six of them had newly graduated from universities and begun their career in software development at Company A in 2020 or 2021. All newly started developers found it difficult to connect with colleagues and with the team. Typically, newly graduated students coming from the school desk are more inclined to be active in developing a network, getting to know colleagues, participate in social events, and getting known with the company culture. In the summer of 2021, Norway was in a phase of reopening because of less infections of COVID-19. Unfortunately, infection rates increased rapidly in the last months November and December in 2021. Consequently, newcomers that started in 2021 only had a brief period to socially interact physically before they had to work from home again.

Several of the informants expressed experiencing challenges with communication, social contact, and motivation. S3 expressed dissatisfaction with having to work from home again.

S3: There were rarely social events after it closed down. A lot of social things happening at the reopening and when it closed down again work became more intensive under the project. There were isolation and a lack of contact. Digital social events are not the same thing. Many people like that it is quiet and not much going on. But I am new, and I need a network. Besides, there are mostly younger people that attend the social events.

Moreover, S4 expressed ‘a lack of team spirit’ as one of the biggest challenges during the pandemic. S6 stated she found it more difficult to connect with colleagues. She elaborated on it further with challenges such cultural differences, language differences, digital communication becoming more formal, working with someone you never met in real life, not reading the same communication signals through video, e.g., body language, and a higher threshold for asking questions.

Some of the interview respondents in Group B had observed that the COVID-19 pandemic had a greater impact on the newer team members.

S14: *'I think for some of the younger team members it became a little lonely. Me, I did not experience it that way. I did not hear so many complaints. Although, the younger ones were very eager when it opened up again'.*

S13 experienced that newer team members in the offshore team in India met more challenges.

S13: *It became quickly for the new employees, some coming from the school desk in India, that it was difficult to ask questions when needed immediately. Extra time was set aside at the end of each day for them to receive follow-up and question round-up, which would have otherwise been more possible if it was physically together.*

Likewise, S16 expressed that one of the most difficult aspects of the pandemic was onboarding of new team members. He explained *'Typically, it was easier to meet people at the office. It was easier to meet people for coffee talk and getting known with each other'.*

Cultural Differences

The challenge with cultural differences had been exacerbated during the COVID-19 pandemic. Some of the interview respondents in Group A expressed experiencing cultural differences. Company A shares offices in multiple countries and it was common for team members from different countries to work together on projects. Thus, most of the interview respondents were already familiar with communicating and working together digitally. S1 expressed that cultural differences had already been a minor challenge before the COVID-19 pandemic. However, before the pandemic occurred, teams would on several occasions arrange physical collocated social gatherings to get better known with each other in a more informal setting. The lack of nonverbal communication, i.e., facial expressions, gestures, body language, etc., in digital communication made it more difficult to interpret the other person's intentions and social cues.

Group B experienced cultural differences with the offshore team in India. Both groups worked distributed on projects with teams and team members in other countries than they worked in. Interview subjects S12, S13, and S14 worked jointly with the offshore team. S12 and S14 worked together within the same team during the time of the interview, while S13 had previously worked in the team. S12 said he experienced poor communication between the workplaces in Norway and the workplaces in India.

S12: I noticed a bit that when everyone was suddenly going to work from home that the work was not scaled for it in India. Communication between the home places in India and Norway had poor communication. Team members in India had to turn off the video camera because of family that could be in the background.

S14 said communication was of lesser quality during lockdown.

S14: Tech Lead and up were more or less required to have camera on during meetings. It became difficult when they had to move the workspace back home with their families in India and still require the camera to be on. It meant we lost body language and the natural flow in the communication.

The findings from the interviews suggest that cultural differences were exacerbated with the lack of nonverbal communication in digital communication tools.

5.2.3 Communication

The behavioral markers for communication are:

- The team follows up on the progress of tasks
- Visualize project information
- Facilitate informal communication

Communication was the most impacted factor in the ATEM model. During the interview process, questions were asked on whether the respondents experienced changes to communication. Specifically, if communication within the team and with the customer had changed during the pandemic, how it was before the pandemic, and how it was after the COVID-19 infection measures were lifted. The findings from the interviews revealed that the lack of co-located face-to-face interactions had negatively impacted communication significantly. The lack of colocation supports the statement and was reported by almost all interview respondents as a heavily impacted aspect during the COVID-19 pandemic. Furthermore, the lack of colocation and nonverbal communication resulted in more formal communication. This subsection will describe the interview respondents' communication infrastructure and go through the findings in relation to the mentioned behavioral markers.

Communication Infrastructure

Both interview groups had set up the infrastructure for digital communication and the ability for individuals to work fully remote from home. Digital communication presented both advantages and disadvantages. A disadvantage was the inability to recreate nonverbal communication with the digital tools. Thus, it was a challenge for teams to have rich conversations and informal communication. Another disadvantage with digital communication was slower communication.

S3 experienced slower communication when it was only digital:

S3: Along the way, it went a little slower due to communication being only digital. The customer was understaffed with regards to feedback. It is important that they can define requirements and needs. Now in retrospect, we are better prepared. It has been more difficult with home office and digitally. People now are more aware of it.

S4, S8 and S10 shared similar opinions. On the other hand, interview respondents said communication was similar to how it was before the pandemic. S11 expressed ‘*it was the same as before the pandemic. Went a lot in messages before. Exactly the same I would say*’. Other interview respondents expressed they started working more closely with the customer and arranging in-person meetings when society gradually reopened again.

Digital communication offered several benefits. First, communication was more documented. Company B’s primary communication tools were Slack and Microsoft Teams. Slack was used more as a hub of channels for written communication while Microsoft Teams were used more for video communication. It was commented from both interview groups that having documented conversations was useful as it gave people more flexibility and the ability to catch up on other people’s conversation. This allowed for other team members that did not participate in the conversation to catch up on information that might have been useful and relevant for them. This function could have reduced the need for team members to ask questions and rather spend more time on work tasks. Second, video-conference meetings are better at facilitating one-to-many meetings. S2 expressed that physical meetings could become crowded if the meeting room was small. S10 mentioned that for digital meetings, one-to-many type of meetings were more advantageous, and many-to-many digital meetings worked poorly. Third,

digital communication provides more accessibility for people with disabilities. Digital communication tools can provide specific tools that can individuals in getting more clear communication. S14 expressed that at he had a dedicated home office space which was well adapted with regards to ergonomics, eye vision, and hearing. He mentioned he lacked reading glasses which were adequate for the computer screens at work. Furthermore, he suffered from Tinnitus, an age-related hearing loss condition, and often experienced difficulties with hearing colleagues clearly when working in an office landscape. Thus, S14 had to sometimes ask colleagues to repeat themselves. He further pointed out that if his colleagues were difficult to hear, he could simply increase the volume on his computer in his dedicated home office to fix the hearing problem. Lastly, digital communication offered more flexibility with respect to collaboration with the customer. S6 explained that working completely digital lowered the threshold for customer meetings. Microsoft Teams made it easier to have a simple video call meeting rather than needing to have people traveling from different locations to meet up at one physical meeting space.

Home Office Space

Furthermore, facilitating suitable office spaces at home were challenging for some of the interview respondents. What constitutes a suitable home office space can depend on various factors. Interview respondents mentioned factors such as not having enough space and not having the right desk and chair. The lack of a suitable office space is most evident among the younger and less experienced software developers in group Alpha. In the transition from working at the office to working from home, Company A offered to provide with typical work desk equipment such as mouse, keyboard, computer screen, etc. Most of the interview subjects described the experience of transition to remote work as most challenging in the beginning. Notably, most of the interview subjects lacked prior experience with working remotely in longer time periods from home. The main challenge with working from home was firstly getting adapted to digital tools. While the initial months of the COVID-19 pandemic with preventive social measures were challenging, many of the interview subjects commented that communication and team productivity improved gradually and eventually normalized when they adapted to working from home.

Some adapted quickly to using digital tools from home, while others found it more challenging. Individuals that were not experienced with digital tools were consequently forced to learn how to use the tools. Digital communication platforms such as Slack or Microsoft Teams became

central social communication hubs within the company A and company B. S13 expressed the benefit of the transition to remote work with:

S13: It is easier to get in touch with people under COVID than before. Before, some people did not use Slack or Teams, only email or phone. Now I feel like you can reach just about everyone in the entire organization on either Teams or Slack.

On the other hand, interview respondent S15 said he lacked a proper work environment in the beginning of the pandemic.

S15: I did not have a proper desk and chair. I used my dining chair, and it annoyed my wife a lot. It stopped her from making any noise. Eventually I was able to source a desk and screen from the company.

Many interview respondents described their workspace as being inadequate. Although interview respondents in group Alpha and Beta expressed the ability to borrow equipment from the office to their home office, some interview respondents were limited to a small office space. S3 said that a lack of a dedicated home office space impacted his motivation.

S3: The biggest challenges were motivation, isolation, lack of social contact, and relaxation outside of work. Not having your own office at home. My home office was also the bedroom, I was within the same walls all the time.

Similarly, S8 said he was burnt out from sitting home alone. He found it difficult to separate between work and leisure because he was constantly sitting in the same room. He added that he found it more difficult to relax and to convince himself that he was not at work. Many other interview respondents emphasized that separating work and leisure was more apparent when working at the office.

When S15 was asked about disadvantages with working from home under the pandemic, he said he found it difficult to disconnect from work when working from home. He commented that he took less breaks and lunch was always at the table. Further, he said he experienced weekends where he never felt disconnected from work during the pandemic. S15 emphasized he would often feel the urge to reply then and there when getting notifications and emails in the

weekends or later in the evening. On the other hand, when S15 worked at the office he said the work laptop stayed closed until the next morning.

Commute

A significant number of the interview respondents mentioned commuting to and from the office as a considerable drawback. Some of the interview respondents said they normally had to commute for longer periods of time. For example, an individual could typically spend an hour to commute to the office and one hour travel time from the office. S7 commented on commuting with ‘*I work sometimes at home and sometimes at the office. When working at home I can relax a bit and avoid a lot of rush and commute*’. S12 complimented the benefits of the hybrid approach with describing how he uses the office as a social arena while the home office is used more as a productive workspace.

S12: The good thing about hybrid is that when I travel to the office, typically there are not too many meetings, and I am available to meet and discuss or it is days where I have physical meetings or workshops. I use my time efficiently when I am physically at the office. Whereas at home I can focus on the work. When it comes to commute, I can save on travel expenses and such. I save one hour each way, two hours every day.

Interview respondents mentioned other benefits with the lack of commute such as being able to replace that time with focusing on the work, sleep longer, less stress during the mornings, and more time at the end of the day. S2 commented that a member of his team only worked remote. The reason for this was because the team member lived far away from the office and usually spent three hours commuting. S2 further commented that three hours of commute could be a huge obstacle for some.

The team follows up on the progress of tasks

The findings from the interviews indicated that this behavioral marker was not impacted substantially. Normally, follow-up on team members’ tasks is facilitated by teams with the use of agile practices such as daily standup meetings and sprint retrospective meetings to coordinate the team members on each other’s work tasks. Typically, in an office setting colleagues and team members could coordinate with each other by engaging in informal conversations, side

discussions and hallway conversations that update each other on their current progress on the tasks.

S1 expressed that following up on team members and the customer was more challenging when the communication was digital.

S1: It was worse communication when it happened digitally. The customer was not good at following up. Face-to-face communication potentially provided better answers. It also seemed like it took longer time for an answer. May depend on the person. It took longer time for clarifications. There was a lot of assumptions. Which is a mistake we got burnt on.

Under periods of lockdown during the COVID-19 pandemic, some of the interview respondents expressed that their teams tried to do more check-in meetings throughout the day to better follow-up on the status on work tasks of other team members. S5, S8 and S10 expressed they began practicing double daily stand-ups, with one in the morning and one in the afternoon. The second daily stand-up meeting in the afternoon was described by S10 as being much more social and informal. S8 described the second ‘check-in’ meeting as aimed more towards the well-being within the team.

S8: The meeting was especially geared more towards the well-being part. We had check-in at around 14:00. We talked together, different subjects, work, personal stuff, and nonsense. It was a way of keeping in touch and for getting the feeling of being a part of something.

Other interview respondents also mentioned that their team introduced additional “check-in” type of meetings similar to daily-standup meetings. S16 said they set aside time at the end of the day for social talk and updating each other. Respondent S11 expressed they began practicing more of ‘release planning’ meetings. S11 described it as a ‘Retrospect-ish’ type of meeting which has similar features to a sprint retrospective and sprint planning. On the other hand, interview respondent S7 expressed they had stopped practicing sprint retrospectives during the pandemic. Instead, S7 said they focused more on documenting work processes within the team. He emphasized that this became possible because all the tools had become digital and allowed for better documentation. Teams in group Alpha stopped performing ‘check-in’ meetings after the COVID-19 measures were lifted and working at the office became normalized again.

Visualize project information

All the interview respondents' teams had a way to visualize project information. Interview respondents in group Alpha visualized all the needed information on the project through their documentation platform 'Toolkit'. Interview respondents in group Beta relied more on a combination of digital communication platforms such as Slack and Teams, and software development tools developed by Atlassian such as Jira, Bitbucket and Confluence. Atlassian is a software company that develops and provides tools for agile teams (Atlassian, u.d.) Jira is a tool for project and issue tracking, Bitbucket is for version control of software with Git code management, and Confluence is a tool made for document collaboration. Moreover, many of the teams used Kanban boards to visualize work tasks. Both interview groups had facilitated robust tools for visualizing project information.

Digital communication tools offered functionality and flexibility with work from home. Several of the interview subjects mentioned screen sharing and remote access as highly beneficial supporting tools for communication and software development. In particular, pair programming was reported by several interview respondents to work well with the digital communication tools. Interview subject S3 viewed positively on the addition of digital tools:

S3: I am very fond of the physical, connecting to an external monitor, a physical whiteboard, and so on. But digital meetings with screen sharing and being able to give away control of the screen is works very well. Digitalization has pushed development further. It has given better working conditions and better facilities for working efficiently because of new functionality. Better solutions on how to collaborate digitally. The IT industry is already digital, so there are not too many challenges.

Digital whiteboard tools were mentioned by some interview respondents as still inadequate compared to physical whiteboards.

S13: I prefer to work at home, but I see the benefit from being in the office at least one day a week. There are some things that you can't do as well at home. For example, developing ideas together, the experience of being in the same room and drawing on the same whiteboard, and so on. It is not easy to recreate it in the digital collaboration tools. We have a whiteboard app but it is not the

same. Also, it is easier to opt out of the discussion when you are not engaging enough.

The findings from the interviews suggest that informal and high bandwidth communication is difficult to recreate with digital tools. Some tools are not yet adequate replacements for in-person communication and collaboration activities.

Facilitate informal communication

The frequency of informal communication was reported as significantly less by the interview respondents when their teams worked from home during the COVID-19 pandemic. Formalization is referred to as the degree of spontaneity in the communication (Lindsjørn, Sjøberg, Dingsøyr, Bergersen, & Dybå, 2016). Communication that is not inherently spontaneous is classified as formal communication in this study.

Interview respondent S11 reported that communication was less frequent, and productivity had decreased as a result.

S11: When the pandemic started, the communication was bad. People stopped asking questions. The threshold for calling and sending messages was higher. It took a long time before people started normally asking questions again.

S11 further added that this was an issue he had observed from everyone. Not only for newer team members, but for older team members as well. Additionally, S11 commented that people eventually managed to adapt to using digital communication.

Several of the interview subjects expressed a higher threshold for asking questions. S2 stated *'The digital tools are not adapted properly and does not offer the same benefits as in the real world'*. S2 also stated that when there was a digital meeting between two people, it was more difficult and unnatural to draw in other people. Being in a collocated setting such as the office were expressed by many of the interview respondents as an easier way to see if people were available.

Informal interactions were expressed as a better way to see if people were available compared to digital tools. Company A primarily used Microsoft Teams for digital communication. The communication platform offered the ability to display the status of the person's availability, e.g., with markers such as 'busy', 'gone', etc. Although the platform offered this function, the

person on the other end could still be unavailable. For example, the person was away from the keyboard or was unable to get notified. Digital communication tools still lack the ability to clearly see if a person is available. S4: said *‘Talking around the coffee machine can be easier for arranging meetings. While if you want to have a meeting with someone, you need to call them through Teams’*.

Furthermore, several of the teams attempted to facilitate informal communication with more social activities. As mentioned in the section ‘Social Climate’, informal conversations were facilitated with the help of social activities such as digital coffee breaks, digital lunches, and informal check-in meetings where people could discuss both work and interests outside of work.

Digital communication encouraged more formal communication. Written communication with emails and instant messaging typically requires more planning and is inherently less spontaneous than face-to-face communication. Thus, digital communication is considered more formal. This is supported by some of the interview respondents’ experiences with the lack of informal conversations.

5.2.4 Shared Leadership

The behavioral markers for shared leadership are:

- The agile team facilitates team problem-solving
- The agile team determines performance expectations and acceptable interaction patterns
- The agile team synchronizes and combines individual team member contributions using agile practices combined with automated tools
- The agile team seeks and evaluates information that affects team functioning
- Agile values and methodologies determine team member roles
- Agile values and methodologies determine the frequency and type of preparatory meetings and feedback sessions
- A servant leader facilitates a boundary-spanning function

- Agile team practices provide a planning function

This component was not heavily researched during the interviews. The observations from the interviews with respect to the behavioral markers did not indicate anything that would suggest the COVID-19 pandemic had an impact on shared leadership. However, it can be relevant to take into consideration how the teams were set up with respect to agile practices to further understand potential success factors and how the teams managed to stay synchronized.

Agile Teams in Group Alpha

The teams of the interview respondents in group Alpha were autonomous and used agile practices. Some of the interview subjects in group Alpha utilized Scrum as their agile project framework. However, many of the interview subjects' teams in group Alpha used a project framework developed by the company. The interview respondents that worked with this framework described it as 'Scrum-ish' or a hybrid between the waterfall approach and Scrum. Fundamentally the framework implements some Scrum ceremonies and combines it with heavier documentation.

Agile Teams in Group Beta

All the interview respondents utilized at least one or more Scrum ceremonies in their projects. The structure of the teams in Company B shared similar practices and structure. Interview respondents' teams in Group Beta were autonomous agile teams. The teams in Company B were organized under "Tech Families". There was a role with the title 'Head of the Family', which was the individual or group with the responsibility for developing and maintaining the service, which consists of a group of software components. Within a 'Tech Family', there could be multiple autonomous agile teams. The interview respondents in Group Beta said they worked 'Scrum-ish' or 'Scrumban'.

Agile Practices during the Pandemic

Agile practices were insignificantly impacted by the COVID-19 pandemic. The interview respondents were asked if they had experienced changes to agile practices during the COVID-19 pandemic. Responses from the interviews made it clear that most of the agile practices hardly changed and translated well with the digital communication tools during the COVID-19 pandemic. The minor differences noted by interview respondents were that daily stand-ups

became sitting meetings instead. Although, existing agile practices hardly changed, as mentioned in section ‘Communication’, in subsection ‘Facilitate informal communication’ several teams introduced additional daily standup meetings or “check-in” meetings during the COVID-19 pandemic.

The interview respondents were asked about what agile practice they found most useful during the pandemic. The daily standup meeting was by far the most mentioned agile practice. The daily standup meeting was used in all teams. Interview respondents reported daily stand-up as the most useful agile practice during the COVID-19 pandemic. Interview respondent S14 described daily stand-ups as ‘very valuable for getting up to date and getting synchronized with each other’. Other mentioned agile practices were Kanban board, sprint retrospective, sprint planning, sprint demo, and backlog grooming. Some of the other interview respondents found sprint retrospective to be the most useful agile practice. S5 described sprint retrospective as an agile way of learning. She further said it was good for learning what to do better or different. Additionally, S5 described the sprint retrospective as a meeting where they could discuss both work and social matters such as suggesting doing more social events together.

5.2.5 Peer Feedback

Behavioral markers for peer feedback are:

- Identifying mistakes and lapses in other team members’ actions
- Regular feedback regarding team member actions to facilitate self-correction

Identifying mistakes and lapses in other team members’ actions

The interview respondents reported using different tools and practices that fostered joint work and feedback. The interviews did not focus on the aspect of feedback itself, but rather on the set of agile practices, development tools, or other tools that assisted development in their teams. Practices and tools mentioned by interview respondents were pair programming, sprint demo, sprint retrospectives, daily standup meetings, and continuous build and test-driven development. The mentioned practices and tools include functionality that gives the participants opportunities to give others feedback. Pair programming was a highly common practice among all of the interview respondents. Digital communication tools today offer high bandwidth communication with video-chat, together with functionalities such as screen sharing and remote

desktop access that makes pair programming highly accessible. Sprint demo and sprint retrospective were mentioned by several of the interview respondents. While all interview respondents reported their team using daily standup meetings. It could be argued that daily standup meetings (Stray et al., 2016) function as a mechanism for providing feedback to others. Daily standup meetings were reported by most of the interview respondents as being the most useful agile practice during the COVID-19 pandemic. Sprint retrospective was also mentioned by several of the respondents. Lastly, continuous build and test-driven development could also be argued as a practice that leads to feedback and awareness of errors and was integrated in all the interview respondents' teams in group Beta.

Regular feedback regarding team member actions to facilitate self-correction

Regular feedback regarding team members were facilitated with agile practices. While daily standup meetings offered a more general way of synchronization of the team members, sprint retrospectives were expressed by several respondents as a useful practice for getting feedback. Respondent S5 said 'Retrospective makes it a bit agile by learning what to do better and different. For example, that we should be more social, make it easier to get in touch'.

5.2.6 Redundancy

Behavioral markers for redundancy are:

- Recognition by potential backup providers that there is a workload distribution problem in their team
- Shifting of work responsibilities to underutilized team members
- Completion of the whole task or parts of tasks by other team members

The findings from the interviews did not clearly suggest if redundancy was impacted significantly by the pandemic. Neither did the findings indicate workload distribution problems among any of the interview respondents. Rather, the findings indicated conflicts of work responsibilities and coordinating issues. Interview respondents in group Beta that worked together with the Indian offshore team expressed challenges with the Indian team members adapting to work from home. The offshore Indian team experienced challenges with security restrictions working from home. Limited resources among the team members in India, such as

inadequate work environment, tools, and internet connection at the home offices made it difficult to get security access for development. S13 detailed further on the situation during the period of lockdowns.

S13: There were some lockdowns that were the problem. Especially for the team in India. Internet was a problem. The main problem was allowing access to internal problems at their main office space. While at home it was not allowed. In practice, it was reduced down to only two persons who had access. Overnight very few who could contribute. The focus shifted towards competence development because they were simply not allowed to use the systems. We had to send down equipment and computers that were approved for use, which took half a year.

Consequently, S13 expressed that because the underutilized team members were limited, there was little focus on development, and many of the Indian team members were instead delegated work tasks related to operation and maintenance.

Coordination

The behavioral markers of ‘shifting work responsibilities’ and ‘completion of tasks by other team members’ will be grouped under ‘Coordination’. Coordination refers to the ability for different parts to work smoothly and efficiently together. Thus, this section will describe how team members coordinated during the COVID-19 pandemic.

A problem mentioned by several of the interview subjects was the fragmented communication and coordination caused by the hybrid work solution. The unanimous consensus among the interview subjects was that when the team was split between team members working from home, and team members working at the office, there was lost communication. Additionally, coordinating when team members planned to meet up at the office together became a tedious and a more complicated task for some of the interview subjects. S12 claimed coordinating the team and getting an overview of when team members meet at the office became more difficult and complex.

S12: Let's say on Wednesday I plan on going to the office. But, getting an overview of your own department and when they can meet you physically is

challenging. It becomes clumsy to say every week when they want to meet up physically. Nobody wants to be locked in on fixed days.

S10 stated that a problem with hybrid solution is that a significant amount of communication between individuals at the office was lost. He further said it was unfortunate for the people working from home. S10 pointed out that when the team was split between some of the members working from home and some of the members working at the office, meetings would always become digital to include everyone.

Another similar coordination issue mentioned by S12 was setting up workshops. He added that occasionally some of the participants or hosts of the workshops were suddenly unable to attend. The workshops would consequently turn into a hybrid workshop with someone attending physically and others digitally. S12 emphasized that hybrid workshops worked poorly and stated that workshops should be either completely physical or digital.

5.2.7 Adaptability

Behavioral markers for adaptability are:

- Identify cues that a change has occurred, assign meaning to that change, and develop a new plan to deal with the changes
- Identify opportunities for improvement and innovation for habitual or routine practices
- Remain vigilant to changes in the internal and external environment of the team

Challenges with adapting to Work from Home

All the interview respondents described their team as adapting quickly to working from home during lockdown in the COVID-19 pandemic. The interview respondents were asked whether any new agile practices had been implemented or changed because of the COVID-19 pandemic. None of the interview respondents expressed significant changes to agile practices. Interview respondents in group Alpha expressed mostly challenges related to communication and workplace at home. In particular, the interview respondents that experienced these problems the most were younger and began working during or right before the pandemic started. The findings from the interview respondents in group Alpha indicate that the teams recognized the lack of informal communication. Despite having informal social activities such as digital

lunches, digital coffee breaks, and digital beers, several respondents expressed that the digital communication tools did not facilitate satisfactory social activities and events. Thus, the ability to fully adapt to working under the COVID-19 pandemic was limited by what the digital tools could offer.

5.2.8 Team Orientation

Behavioral markers for team orientation are:

- Taking into account alternative solutions provided by teammates and appraising that input to determine what is most correct
- Increased task involvement, information sharing, strategizing, and participatory goal setting
- The team sticks together and remains united

The main sub-components of team orientation were ‘team cohesion’, ‘prioritization of tasks’, and ‘team member respect’. One of the mentioned items ‘high motivation level’ foster ‘prioritization of tasks’. The interview questions did not consider prioritization of tasks and team member respect. Team cohesion is defined as ‘a general preference to work in team settings (Salas, Sims, & Burke, 2005). Also, job satisfaction amongst individuals in the team is often grouped together with team members’ motivation to work together under the broad definition of team effectiveness (Strode, Dingsøy, & Lindsjörn, 2022). Job satisfaction includes factors such as communication, team spirit, and identity (Strode, Dingsøy, & Lindsjörn, 2022). However, for this analysis, job satisfaction is used synonymously with well-being to better fit with the interview data. Thus, for this section ‘team cohesion’ is discussed with respect to related aspects motivation and well-being.

Motivation

The impact on motivation level among the interview respondents varied. Many reported that the level of work motivation stayed high during the pandemic. It was pointed out by many of the interview respondents that work motivation is likely related to individual personality types. Several interview respondents said they experienced lower work motivation and team morale

when the team had to work from home under lockdown. S1 said he had observed higher staff turnover than usual during the lockdown period.

S1: The motivation varied. It was low when it was lockdown. Many people quit. They did not get a sense of belonging in the company. I saw higher staff turnover in consultant companies. Many switched jobs and only worked from home.

Interview subject S8 described his personal productivity as very high and was pleased with working from home in the beginning of the pandemic. However, as several months passed, S8 said his intrinsic work motivation fell.

S8: Everything turned upside down. I had the opportunity to meet people before the pandemic. I was very pleased with home office in the start. It was very flexible. No time for commute and suddenly saving two extra hours per day. After some time, some things felt off. In particular, it was communication on development. I also worked with management which went well. There I worked with bugs and configuration which did not require much communication. I think after around six months in the home office the communication part was noticeably negatively affected. I eventually felt that the intrinsic motivation became worse. Sitting alone at home, no longer feeling togetherness, and being stuck in your work area. It was difficult to see the whole entirety and celebrate small victories. Teamwork things fell away even though we worked well and were aware of these things.

On a general basis, the response from the interview respondents indicated that productivity had not been impacted heavily during the COVID-19 pandemic. One interview respondent reported less productivity during the pandemic and another interview respondent reported more productivity. The overall general response was that general productivity and code throughput had not changed significantly, except for at the start of the pandemic. The interview respondents that reported less productivity blamed it on various factors such as communication and motivation. S1 and S3 reported slower communication with the customer as the attributing factor. S1 said 'It was poorer communication when it was digital. The customer was not good at following up. It took longer time for an answer'. S3 said 'communication was slower when

it was digital. It could have taken longer time. The customer was understaffed with respect to feedback. It is important that they can define requirements and needs'. Interview respondent S15 reported that productivity was even better during and after the pandemic. S15 argued that the pandemic had given people the ability to dedicate more time to working.

S15: Before the pandemic everyone was motivated. After the pandemic I have seen people dedicating more time. The pandemic has given people the ability to work longer with less breaks. Productivity went up. Productivity in the office was low. Probably because when at the office you are busy with meetings. Nonetheless, it is more productivity than before the pandemic. Productivity during the pandemic also went up.

Furthermore, interview respondents highlighted that their productivity differed when working from home or at the office. Several of the interview respondents experienced being more productive working home, while other interview respondents were more productive at the office. Although some of the interview respondents reported less or more productivity, most of the answers from the interview respondent said productivity stayed roughly the same.

Well-being

Well-being is commonly thought to affect the productivity of developers (Ralph, et al., 2020). Last question of the interview was how their well-being was now compared to before and during the COVID-19 pandemic. All of the interview respondents except for the last respondent S16 reported better well-being now than before and during the pandemic. Many of the respondents emphasized the importance and need for occasional social gatherings and meetups with colleagues at the office. Even the only respondent S15 that reported greater productivity during and before the pandemic expressed that his well-being significantly worsened during the pandemic. S15 commented that working hybrid now made him appreciate social events more than before.

Team Cohesion

As mentioned in the subsection 'cohesion' under subsection 2.4.2 'Teamwork Quality', there are three distinguishable aspects of team cohesion: 'interpersonal attraction of team members', 'commitment to the team task', and 'group pride-team spirit' according to Mullen and Copper (1994). 'A good and healthy culture', and 'understanding of the importance of all team

members' are items of the main sub-components in team orientation that fall under the coordinating mechanisms 'mutual trust' and 'shared mental models'. Analyzing the results in relation to team cohesion is arguably already presented with the earlier mentioned results of 'social climate', and the results on the behavioral markers on common understanding of goals for 'shared mental models'. Lastly, the aspect of 'group pride-team spirit' is already presented with findings on 'team spirit' under social climate as well under the team factor 'mutual trust'. Hence the three distinguishable aspects of team cohesion are impacted negatively. Thus, in relation to the aspects 'motivation' and 'well-being' which are mostly reported as negatively impacted by the interview respondents, the team factor 'team orientation' was negatively impacted by the COVID-19 pandemic.

6 Discussion

This section discusses the findings from section 5 ‘Results’ and previous findings on this research topic in relation to the research questions.

6.1 Teamwork

RQ1: *How does agile software development from home during the COVID-19 pandemic affected teamwork effectiveness in Agile Software Development Teams?*

Findings from the interviews showed that agile software development from home during the COVID-19 pandemic had a considerable negative impact on teamwork effectiveness. The findings were presented and analyzed in relation to the eight interacting factors in the ATEM model (see subsection 2.4.3). In particular, the most negatively affected factors were the coordinating mechanisms ‘communication’ and ‘mutual trust’. All the eight factors in the ATEM-model interact and affect each other. Therefore, the negative impact on communication and mutual trust had an impact on all the other factors.

6.1.1 Communication

The main findings from analyzing behavioral markers on communication from the interview data revealed that the COVID-19 pandemic had a negative impact on a multitude of different items of sub-components of communication.

Negatively impacted items of sub-components in communication:

- Bad office facilities at home
- Lack of colocation
- Less frequent social activities
- Inadequate digital whiteboard solution
- Less frequent informal communication

The negatively impacted items will be grouped into two different groups ‘communication infrastructure’ and ‘informal communication’.

Communication Infrastructure

Communication infrastructure is highly dependent on the individual’s available space at home. An own dedicated office space at home is difficult to facilitate as some of the interview respondents were restricted to limited space in their homes. Examples of limited workspaces from interview respondents were working at the dinner table and working next to their bed. Having limited workspace was mostly expressed by the younger software developers. The lack of clear physical boundaries between work and personal life made it difficult for the interview respondents to separate work and leisure. On the other hand, those with a good home office space typically expressed experiencing more productivity at home than in the office. A dedicated home office space could remove distractions, interruptions, and noise that may occur in typical office spaces. Additionally, having enough space to dedicate a room for a home office workplace makes the physical boundaries of work even clearer.

Digital Communication and Collaboration

Communication and collaboration translated mostly well with digital tools. The biggest disadvantages with digital communication and collaboration tools are that they still lack the ability to recreate nonverbal communication and informal communication which is normally facilitated with colocation. Communication challenges met by agile teams working remotely from home during the COVID-19 pandemic are well-known challenges in distributed software development. Some challenges met in distributed software development are the lack of rich conversations, less frequent communication, cultural differences, time zone differences, and a lack of group awareness (Shrivastava & Date, 2010). Another potential drawback in digital communication tools is that slower communication or response times is expected. Longer periods without answer could suggest team members working on assumptions, as described by interview respondent S1. Additionally, waiting longer periods of time for quick questions or clarifications could suggest a considerable amount of time is wasted. Thus, for inexperienced newcomers that are often reliant on frequent clarifications, minor questions, and rapid feedback could encounter this problem far more often.

Visualizing status and progress are often associated with collaboration tools and whiteboards. However, digital whiteboard tools were described as inadequate and unable to provide the same positive type of collaboration as in a collocated setting.

Communication improved in some areas because of the COVID-19 pandemic. The pandemic accelerated the use of digital communication, and in turn digital tools improved significantly. Digital communication provides more flexibility than face-to-face communication and functionality that includes more documentation of communication, efficient pair programming, and easier to other team members and people within the organization. The success of working from home is largely due to fully distributed teams being created out of necessity (Nolan., et al., 2021). Having partially distributed teams could negate benefits of work from home in terms of communication, personal recognition, and reconciliation (Smite, Moe, Klotins, & Gonzalez-Huerta, 2021; Nolan et al., 2021). Overall, communication and collaboration improved in some areas, while other areas worsened.

Informal Communication

Informal communication was significantly less frequent in ASDTs during the COVID-19 pandemic. A lack of communication in teams can be identified by checking whether a team has open and informal communication (Dingsøy, Strode, & Lindsjörn, 2022). Unfortunately, open communication was not asked about directly in the interviews. However, several of the interview respondents in group Alpha expressed a higher threshold for initiating conversations and sending messages. The higher threshold for contacting other team members may suggest a lack of openness. Issues that occurred because of lack of openness were duplication of work and less knowledge sharing. Thus, time was wasted on unnecessary work that otherwise would be quickly clarified with asking questions. The lack of spontaneity in the communication suggests more planning and effort were required to contact team members.

The lack of collocation was the most observable factor for why there was less frequent informal communication. Furthermore, facilitating informal communication with digital tools and video chat is still challenging today. Informal communication was reported by respondents as better than formal communication at encouraging ideas and contributions that are usually shared, discussed, and evaluated among team members. This is supported by interview respondents expressing the lack of discussions and lack of developing ideas together among team members during the pandemic. Further, instant messaging with digital chat functions does not offer the

same spontaneity in the communication as casual chatter with e.g., hallway conversations. Hence, to increase the degree of spontaneity in the communication, team members would need to rely more on digital video calls. However, video calls were described as unpractical if the aim of the conversation was only to clear up minor clarifications or questions. The findings from the thesis indicate that digital communication tools are still unable to facilitate informal communication and nonverbal communication to a level that is typically experienced in co-located settings.

6.1.2 Mutual Trust

Mutual trust was considerably impacted negatively. Communication and mutual trust were the most observed negatively impacted factors from the interviews. Mutual trust is reliant on communication and collaboration, which are the most significant challenges met in distributed software development. The most impacted items in mutual trust were ‘social climate’, ‘integrating newcomers’, and ‘cultural differences’.

ASDTs are dependent on mutual trust within their teams to promote teamwork effectiveness. Trust is emphasized in the agile manifesto with the agile principle ‘Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done’ (Fowler & Highsmith, 2001). Further, trust and respect are organizational conditions needed for psychological safety in a team (Edmondson, Kramer, & K.S., 2004). ‘Team psychological safety’ is described by behavioral scientist Edmondson as people’s perceptions of the consequences of taking interpersonal risks in a particular context such as workplace (Edmondson & Lei, 2014). In addition, psychological safety is described as one of the key factors for successful teams (Dingsøy, Strode, & Lindsjørn, 2022). Less frequent communication might suggest that psychological safety was not strong enough for some team members. A negative impact of the COVID-19 pandemic could have been some individuals becoming ‘loners’ or ‘lone wolves’ due to social isolation and less frequent communication during the pandemic. Less frequent communication was identified as a problem and relates to both peer feedback and redundancy. The higher threshold for initiating communication was evident for some of the interview respondents. As reported by some of the respondents, higher threshold for communication prompted issues related to duplication of work and time wasted on unnecessary work. To further clarify, respondent S11 said some team members received

little help in the start and had spent extra time on work tasks and problems, up to a whole day which could have been quickly clarified if they asked.

Furthermore, findings from the interviews indicated that a lack of colocation and informal communication greatly impacted the social climate in teams. Lack of trust and a social climate prompt for more formal communication and a lack of information sharing (Dingsøy, Strode, & Lindsjørn, 2022). The lack of social climate and trust makes integrating newcomers more challenging for teams. One of the interview respondents reported that working during the COVID-19 pandemic worked well the first six months. But after working six months, the respondent experienced communication being noticeably negatively affected and worsened intrinsic motivation. Studies on developer productivity and motivation in the first year of the COVID-19 pandemic have not taken into consideration the potential long-term effect of working isolated from home. Especially, for younger individuals working isolated from home. Newcomers are often more dependent on communication with quicker clarifications and getting familiarized with the culture within the team and organization. In summary, the COVID-19 pandemic had a negative impact on mutual trust in ASDTs.

6.1.3 Other Team Factors

The other team factors in the ATEM-model are more dependent on the set of agile practices the teams utilize.

Shared mental models relied heavily on how well coordinated the team was. Shared mental models were prominently facilitated by the set of agile practices used in the teams. Behavioral markers for shared mental models such as anticipating team members and common understanding project information was facilitated with agile practices such as daily standup meetings, Kanban board, sprint retrospective meetings, or other activities such as pair programming. Additionally, documentation as observed in group Alpha can support with achieving better common understanding of the project, or shared mental models.

Other team factors such as ‘shared leadership’, ‘peer feedback’, and ‘redundancy’ also relied on agile practices in the team. The data from the interviews analyzed in relation to these team factors indicated that the team had a strong foundation of agile practices that translated well to working under the COVID-19 pandemic. The interviews indicated that the shared leadership was evident in the ASDTs. The combination of being autonomous with agile practices

automated tools such as continuous build and deployment enabled for efficient self-organized teams. Peer feedback was also evident with feedback mechanisms from agile practices such as sprint retrospectives or pair programming and testing or continuous build and deployment tools. Redundancy in ASDTs was slightly impacted by the COVID-19 pandemic. However, redundancy is closely related to shared mental models, which is supported strongly by the foundation of agile practices in ASDTs.

ASDTs showed in most parts a strong ability to adapt to working under the COVID-19 pandemic. This is demonstrated with how well agile practices translated with working from home, and how well agile software developers adapted to working fully remote with digital tools. Although, some teams were met with certain challenges due to limitations of technology. For example, a challenge with adaptability was the Indian offshore team being limited because of security related issues and having to be delegated to other work tasks such as maintenance. Lastly, teams attempted to facilitate informal communication and social activities. It was identified by many of the teams that there was less frequent communication, and the social aspect of the team had worsened. The teams' attempt to deal with these problems was shown with more social activities such as extra "check-in" meetings, digital lunches, digital coffee breaks, and digital beers. However, adapting social activities and creating a supportive social team climate showed to be difficult with digital tools.

The team factor 'team orientation' was negatively impacted. Team orientation is dependent on sub-components such as 'team cohesion', 'prioritization of team tasks', 'team member respect', and items such as 'high motivation level', and 'a good and healthy culture'. As team orientation is closely related to the other factors of 'shared mental models' and 'mutual trust', team orientation was negatively impacted.

6.2 Agile Practices

RQ2: *How has agile software development teams adapted agile practices in response to the COVID-19 pandemic?*

The findings from the interviews and studies suggests that agile practices adapted well in response to the COVID-19 pandemic. In particular, the findings on the factors 'shared leadership', 'peer feedback', 'redundancy', and 'adaptability' from the ATEM-model showed

that agile practices were robust and arguably did not change because of the pandemic. This subsection discusses the second research question of the thesis.

6.2.1 Digital tools

The turbulent transition to remote work during the COVID-19 pandemic encouraged a higher dependency on digital tools in ASDTs. Agile practices and methods focus on communication and collaboration, which is emphasized by the core values and principles of the agile manifesto. Prior to the COVID-19 pandemic, teams of the interview respondents had already experience with performing agile practices through digital communication and collaboration tools. Thus, teams in both interview groups had experience with virtual communication and collaboration. Interview respondents were already familiar with digital communication platforms such as Slack, and Microsoft Teams, and agile tools developed by Atlassian that facilitate collaboration such as Jira, Confluence, Bitbucket, and Trello. ASDTs in company A consisted of team members from different countries and cultures. While most of the interview respondents from group Beta had experience collaborating with an outsourced team working in India. Hence, the teams of the interview respondents had digital infrastructures that were suitably prepared for a crisis such as the COVID-19 pandemic where a lack of colocation became the prominent challenge. Agile practices are dependent on the set of digital collaboration and communication tools used by the ASDT. The teamwork effectiveness in the team is therefore contingent on how well the team has adapted to using digital tools, and how well the digital tools can recreate or improve upon previous communication and collaboration. As shown in the interviews, digital tools are still unable to recreate informal communication.

6.2.2 Changes to Agile Practices

Agile practices went through a digital transformation with digital communication and collaboration tools during the COVID-19 pandemic. Any dependency on physical artefacts or physical colocation in the agile practices were promptly virtualized because of the pandemic. Whiteboards became digital, daily standup meetings became sitting meetings, and sprint retrospective meetings replaced Post-it notes with digital notes. Some of the teams from the interview data started doing extra meetings in the afternoon or at the end of the day. These meetings efficiently served as a type of ‘check-in’ meeting or described by some respondents as an additional daily standup meeting that was more social and relaxed.

The findings from the interviews reflect previous findings in this research topic on the impact of COVID-19 on ASDTs. A literature review on the impact of COVID-19 on agile software development showed that ASDTs rapidly adopted their approach to working during COVID-19 pandemic (Neumann & Bogdanov, 2022). Another literature review investigating software engineers during the COVID-19 pandemic found that research on this topic claims that agile development teams adapted well to the COVID-19 context because of practices that were already in place (Nolan., et al., 2021).

6.3 Productivity

RQ3: *How has productivity in agile software development teams changed because of the COVID-19 pandemic?*

Productivity in agile software development did not change significantly. The overall response by the interview respondents was that productivity or performance in their teams had not noticeably changed. However, several research studies on the impact of COVID-19 on developers and ASDTs discuss aspects such as well-being in their findings on productivity. A systematic review of empirical studies of agile software development by Dybå & Dingsøyr (2008) suggested that job satisfaction played an important role in effectiveness of the software development process. Some studies also suggests that productivity and well-being is closely related. A study on social debt found that the decisions concerning the community of developers influences well-being (Tamburri, Kruchten, Lago, & Vliet, 2013). Further, the article stated that the success of software engineering is increasingly dependent on the well-being of developers' communities (Tamburri, Kruchten, Lago, & Vliet, 2013; Keyes, 2011). The study 'pandemic programming' (see subsection 3.2.3) suggested productivity and well-being were closely related. Lastly, findings from the interviews suggested that job satisfaction was highly related to aspects such as social environment, workplace, and motivation. This section will discuss the third research question with how productivity was affected in relation to the three different mentioned aspects 'social environment', 'workplace', and 'job satisfaction'. Job satisfaction is discussed with respect to motivation and well-being, as they are suggested to be closely related.

6.3.1 Social Environment

The social environment around the work was clearly negatively impacted by the COVID-19 pandemic. Less frequent number of social events and activities, less frequent informal communication, lack of colocation, and a lack of trust among team members support the statement. Further, the social environment was a vital aspect to well-being and motivation among the interview respondents that were newcomers. Many of the interview respondents reported the social environment as one of the biggest challenges during the COVID-19 pandemic. Some of the respondents emphasized the consequences of a lack of social environment with having observed higher turnover than usual.

6.3.2 Workplace

The workplace had a profound impact on the well-being of the interview respondents. It was clear from the interviews that the interview respondents in group Alpha had an overall more negative view on working from home, while interview respondents in group Beta had a highly positive view on work from home. There are several evident factors mentioned by the respondents that makes it clear why the interview groups had opposing views on remote work.

The age difference was the most evident distinction. Most of the interview respondents in group Alpha were younger and under the age of 30. As described by the respondents, younger and less experienced people are more inclined to be social and grow their work-related social network. Further, they have less space at home and worse facilities for a dedicated home office. Generally, office spaces offer more space, reliable work space with necessary equipment, and more face-to-face interactions. Newcomers are also more reliant on quick clarifications and questions from their peers. It is important for newcomers to be integrated into the team, the culture in the organization, and getting overall familiar with the structure. In organizations such as consultant companies where individuals might switch teams and projects on a more regular basis, it becomes more important to make sure newcomers are integrated. Thus, it is likely more beneficial for newcomers to work at the office. It is also beneficial for teams to make sure newcomers are integrated quickly to increase the team's shared mental model.

Key findings from a study on developer productivity, work cadence, and collaboration in the early days of COVID-19 conducted by the GitHub Data Science Team found that patterns of

developer activity may have implications for burnout (Forsgren, 2020). The analysis suggested that developers continue to do sustained and increased amounts of development. However, combined with their findings on work cadence which suggested developers' work days have gotten longer, it is suggested that developers and team leaders take proactive steps to prevent burnout (Forsgren, 2020).

On the other hand, interview respondents in group Beta were older, had leading roles in their teams such as 'Tech Lead' and 'Tech Architect', and most had families. Several of the interview respondents favored working from home because of less distractions. As noted by one of the respondents, he could turn off notifications and focus on working. The respondents in group Beta expressed they were often interrupted and distracted at the office, while at home they could focus on their work. Working from home can save time on commute. As mentioned by interview respondents, typical time spent on commute could rather be spent on other matters such as making it easier to pick up kids from school, and house chores such as walking the dog or doing the laundry. It could be argued that more experienced software developers have less need for socializing at work because they have already familiarized themselves with the team and the organization. The findings from the interviews suggest that those with more experience leader roles found it more difficult to concentrate and be productive with work at the office. Findings from the interviews also showed that many of the respondents experienced a deeper concentration on work at home.

6.3.3 Job satisfaction

Job satisfaction was dependent on motivation and the well-being of the developers. Interview respondents reported higher well-being and work motivation after the restrictions and measures from the COVID-19 pandemic were lifted. The interviews found that well-being was negatively impacted during the pandemic. The interviews showed clearly that respondents were highly satisfied with working hybrid. Respondents found it beneficial to have the flexibility of working both from home and at the office. The flexibility of hybrid makes it easier for individuals to work in their preferred work environment and have the possibility to dedicate time to other activities and personal matters. Many of the interview respondents pointed out personality types as a significant factor in personal productivity for team members. For example, some of the respondents pointed out that teams should maximize the potential productivity and output of team members both on an individual level and on a team level. A suggestion was that the team

should let individuals work from home if they find it more productive, while having team policy occasional meetups at the office to ensure team spirit and prevent isolated team members.

6.3.4 Comparison of Results on Productivity with Studies

The recent findings on developer's productivity does not share similar outcomes. The interviews found that productivity had not changed significantly. However, productivity was most likely perceived by the interview respondents as the throughput of code. When asked about work motivation and well-being, the interview respondents gave more opposing answers. The mentioned studies on productivity among developers in subsection 3.2 had different outcomes as well. Notably, the two studies mentioned in subsection 3.2.2 and 3.2.3 both considered well-being and productivity and reported different outcomes. Interestingly, the study in subsection 3.2.2 reported an increase in well-being and productivity (Russo, Hanel, & Berke, 2021) while the study in subsection 3.2.3 reported the opposite with a decrease in well-being and productivity (Ralph, et al., 2020). Thus, due to a disagreement of findings from previous recent studies, it is difficult to draw a conclusion on whether productivity was impacted significantly by the COVID-19 pandemic. However, findings from the interviews suggest that productivity in terms of delivering working software did not decline significantly, but suggested related factors motivation, and well-being were negatively impacted by the pandemic.

6.4 Implications for Theory

The main theoretical framework applied in this thesis is the ATEM-model for measuring teamwork effectiveness in Agile Teams.

6.4.1 ATEM-model

The theoretical implication of studying agile teams with the ATEM-model is that teams aiming to incorporate distributed development into the development process must especially acknowledge the challenges related to communication and mutual trust. The ATEM-model was efficient at identifying strengths and weaknesses in agile teams of the interview respondents. The context for the interview data is agile teams working distributed during the COVID-19 pandemic. Coordinating mechanisms 'shared mental models', 'mutual trust', and 'communication' clearly suffered because of the pandemic. Agile teams effectively transformed

into virtual agile teams working in a distributed manner, but with the additional challenges of involuntarily working from home and social isolation. The interview questions were not constructed with the ATEM-model in mind, thus better constructed questions may have provided clearer answers in relation to behavioral markers in the ATEM-model.

Furthermore, the interview respondents were in ASDTs with a strong foundation of agile practices. Thus, applying the model on ASDTs with a weaker agile foundation will give different findings. However, applying the model on agile teams working in a distributed manner will yield similar findings.

The ATEM-model was suitable for explaining and better understanding the phenomenon of agile teams working virtually during the COVID-19 pandemic. Although the most negatively impacted team factors ‘Communication’ and ‘Mutual Trust’ were revealed by the findings from the interviews, it can be difficult to facilitate items such as informal communication and a better social climate when the team is working distributed. Therefore, certain team factors in agile teams may be limited due to additional challenges to teamwork effectiveness which is commonly seen in distributed development such as temporal, geographic, and sociocultural distance (Ågerfalk & Fitzgerald, 2006).

6.5 Implications for Practice

ASDTs should integrate and support agile practices with digital agile tools. ASDTs are trending towards working hybrid. Many agile teams nowadays are partially distributed by consisting of team members working only at home, only at the office, or both. Work from home has become more acceptable because of the COVID-19 pandemic and because digital tools are able to support fully remote work. Findings from the interviews analyzed with the ATEM-model indicate that ASDTs incorporating digital tools to support communication and agile practices made the teams more robust and able to maintain productivity in terms of delivering software.

Agile teams need to facilitate better informal communication. This is integral for agile teams to promote more trust within team members. Promoting better trust is fundamental for a team’s psychological safety, which refers to a climate where people are comfortable with expressing themselves (Edmondson, Kramer, & K.S., 2004). Teams suffering from a lack of trust due to a lack of informal communication and colocation may suffer from less work satisfaction, less motivation, less rich conversations that encourages ideas and discussions, and team cohesion.

Newcomers must be integrated into the team and organization more effectively. It is vital for the team and the organization to ensure newcomers rapidly assimilate. The team and the organization must provide a supporting healthy social environment and encourage better trust among newcomers and established team members. Integrating newcomers rapidly is important to prevent high turnovers in organizations, to make sure newcomers gain better confidence, and for team members to gain better trust in other team members.

Agile teams should acknowledge team members' preference to work at home. A suggestion is for the team to consider how the team can be most productive on an individual level and on a team level. Teams should recognize that people work differently in different work environments. Organizations should provide individuals with the necessary equipment to make work from home possible. However, agile teams want to avoid isolated team members. To avoid this problem teams can implement team policies and regular informal social events that can facilitate better trust and more frequent informal communication. The aim of this is to optimize both individual- and team performance.

6.6 Limitations

This subsection presents limitations in the thesis.

6.6.1 Interview Data

The qualitative data in this thesis is gathered from a total of 16 interview respondents. Interview data was gathered from February 2022 to March 2022. The COVID-19 pandemic in Norway almost lasted two years with the initial outbreak and related enacted national measures starting in March 2020 and lasting until the measures were lifted nationwide in February 2022. Thus, the findings and the interview data are based on subjective post COVID-19 pandemic opinions and reflections on the last two years. The personal experiences and opinions of the interview respondents would have likely been different if the study was conducted at a different time during the pandemic, For example at the start or in the middle of the pandemic. The advantage with interviewing at the end of the pandemic was getting an overall perspective of the whole pandemic and interview respondents' experience with working hybrid. Therefore, a case study that studied a few agile teams over the course of the pandemic would have likely given more beneficial data. But due to the unpredictability of the pandemic, time constraints, and the limited

scope of this thesis, a case study was too difficult to perform for this thesis. Lastly, the thesis could also have benefitted from conducting a mixed-methods study. The interview data is of qualitative nature. Conducting a quantitative research study with e.g., a survey would give better indication and support for the findings from the interviews.

6.6.2 Study Sample

The sample size of the thesis is small. Number of participants for the interviews was not small. The study sample represents software developers in ASDTs in Oslo, Norway. Therefore, the thesis represents best ASDTs working in Norway and can be limited to a Scandinavian context. Furthermore, if a qualitative research study was conducted then a bigger sample size could better support findings from the interviews and better represent general opinion among software developers in ASDTs.

6.6.3 Research Studies

Research studies used to support the findings from the interviews are mostly newer and recent studies conducted during the COVID-19 pandemic. Thus, most or if not all of the studies were not peer reviewed. The research studies with respect to software developers and the COVID-19 pandemic must be looked upon through a more critical view. The advantage with the research studies is that most of them were based on quantitative research. The lack of quantitative research studies for this thesis can therefore instead be supported by the findings from similar studies conducting quantitative studies on the impact of COVID-19 on agile practices and developer productivity.

6.7 Validity and Reliability

This subsection reflects upon the aspects of validity and reliability to denote the trustworthiness of the results for this thesis.

6.7.1 Construct Validity

The aspect of construct validity refers to what extent the studied measures represent what the researcher has in mind (Runeson & Höst, 2009). The interview guide and interview questions do not directly reflect the ATEM-model and the behavioral markers that were used to measure

teamwork effectiveness for the first research question. Construct validity for the second and third research question is addressed with using multiple data sources which were the interview data and findings from multiple similar research studies addressing similar research questions.

6.7.2 Internal Validity

Internal validity refers to whether the researched causal relationship is not influenced by other hidden factors or variables (Runeson & Höst, 2009). To combat this the predictions for the thesis and questions for the interview guide were constructed based on previous findings in the research topic.

6.7.3 External Validity

This aspect of validity refers to what extent the findings are generalizable and how relevant the findings are to other research contexts. The theoretical model applied in this thesis is the ATEM-model by Strode, Dingsøy, and Lindsjørn (2022) for measuring teamwork effectiveness in agile teams. The ATEM-model is built on the teamwork effectiveness model ‘The Big Five’ by Salas, Sims, and Burke (2005) which is a model with a solid basis in literature and practical applicability (Strode, Dingsøy, & Lindsjørn, 2022). This thesis could be more generalizable if the selection of participants for the interviews were outside the context of Norway. However, for this thesis the aim was to isolate the interview participants and research in the context of Norway to avoid hidden external factors and strengthen the internal validity.

6.7.4 Reliability

The aspect of reliability is concerned with to what extent the data and analysis are dependent on specific researchers (Runeson & Höst, 2009). In other words, reliability is concerned with if this study can be repeated under the same conditions. The methodological approach to collecting data for this thesis should be clear-cut and straight forward. However, the threat to reliability comes from recreating the same conditions. The COVID-19 pandemic was a special research phenomenon that had a global impact. In contrast to distributed development, the COVID-19 pandemic involved additional challenges such as social isolation and involuntary work from home. Thus, reproducing the results are therefore mostly dependent on applying the research when there are similar external circumstances.

7 Conclusion

This thesis has conducted and presented findings of a qualitative study with semi-structured interviews as the chosen method for researching the impact of the COVID-19 pandemic on agile software development teams.

The first research question is aimed at understanding how agile software development from home during the COVID-19 pandemic affected teamwork effectiveness in agile software development teams. This research question was researched with an analysis of the interview data with the ATEM-model by Strode, Dingsøy, and Lindsjörn (2022). Based on the interview data, results showed that teamwork effectiveness in the interview respondents' teams had been negatively impacted. In particular, the most negatively impacted factors 'communication' and 'mutual trust'. The findings showed that informal communication and the social climate suffered the most during the COVID-19 pandemic.

Second research question addressed how agile software development teams adapted agile practices in response to the COVID-19 pandemic. Findings from the interviews indicated little change to agile practices in ASDTs. Agile practices adapted well in response to the COVID-19 pandemic and integrated well with digital collaboration and communication tools. However, the lack of informal progress reports that is traditionally presented in informal social interactions such as hallway conversations, side-discussions, lunch, etc., were facilitated with new practices such as a second informal daily standup meeting in the afternoon, digital lunches, and digital coffee breaks.

The last research question was aimed at researching how productivity in agile software development teams changed because of the COVID-19 pandemic. The overall response on productivity was that it had changed insignificantly. Productivity is typically perceived in software engineering as the output of or changes in code. However, findings from the interviews indicated that aspects related to productivity such as well-being, motivation, and team cohesion were negatively impacted. Several cases of low motivation, well-being and poor work environments at home reported by interview respondents suggested some experienced burnout. Comparing the findings on productivity from the interviews with findings from recent studies is challenging due to conflicting research findings on the topic of developers' productivity. Thus, for the scope of this thesis, only the findings from the interviews in this thesis are

considered. Although, it is important to mention the findings on well-being, motivation, and team cohesion from the interviews to give a better holistic perspective on the impact of COVID-19 on ASDTs.

7.1 Future work

There are several suggestions on topics that could be interesting to research further. It could be interesting to study how the most negatively affected factors in this thesis ‘communication’ and ‘mutual trust’ could be facilitated or improved with digital tools. These are common challenges seen in distributed development, but it is increasingly becoming more common for agile teams to be partially distributed. According to the 15th annual State of Agile report by digital.ai, only three percent reported they would be back in the office fulltime, 25 percent reported they went remote during COVID-19 and expected to remain remote, while 52 percent reported they would we back in the office on a regular basis but not full time. The report suggests remote, or hybrid work is not a temporary trend, but rather the direction that the software development industry is heading towards (Digital.ai, 2021). Therefore, moving onwards it could be interesting to research how to improve ‘communication’, ‘mutual trust’ or other negatively impacted factors with the ATEM-model on partially distributed ASDTs. Further, analyzing partially distributed ASDTs could suggest new agile frameworks or models that is more suited for agile teams that wishes to be partially distributed.

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A Interview Guide

Introduction before interview

- Thank the participant for taking time for the interview
- Present myself with name, study background, and purpose of the interview
- Inform the interview informant about anonymity

Estimated time for the interview: 30-45 minutes

General introduction

1. Which gender do you identify the most with?
2. How old are you?
3. What is / how would you describe your profession?
4. How long have you worked within this profession?

Remote Software Development

1. What is your view on remote/distributed software development?
2. Do you prefer working from home, at the office, or both?
3. How do you work now?
4. What are good things about your current work situation?
5. What disadvantages do you have with your current work situation?

Agile Practices

1. Which role do you have in your team?
2. How many is on your team?
3. Does your team work in Sprints? If not, describe your agile framework or your process of delivering software?
4. What agile practices do you have?
5. Were there any new practices that were implemented as a result of the COVID-19 pandemic?
6. Were there any practices that was changed due to the pandemic?
7. Were there any challenges for the team because of the pandemic? If so, what were the biggest challenges?

Communication

1. How do you communicate and coordinate within or across team?
2. Has there been any challenges with communication under the pandemic or under lockdown and social restrictions?
3. How is the communication in your team now compared to under the pandemic?
4. Has working from another place than the office affected you or your work routines?
 - a. What changed most about your work environment?
5. Which way do you find is the most effective way of communicating within your team?
 1. Face-to-face conversation
 2. Videoconferences, e.g., Microsoft Teams
 3. Chat or email

4. Other?

Productivity

1. How was the work motivation in your team under the pandemic?
2. How is the motivation in the team now?
3. Has communication with the customer changed for the better or worse under the pandemic?
4. Has your team been able to deliver the same quality and results under the COVID-19 pandemic?
5. Lastly, how is your personal well-being in your job now compared to under the pandemic, and before the pandemic?

Closing

- Is there anything you would like to add with regards to you, or your team and the COVID-19 pandemic?

B Agile Manifesto – Values and Principles

The four core values and twelve principles as stated by the Agile Manifesto (Fowler & Highsmith, 2001):

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

Table 1: Core values (Fowler & Highsmith, 2001)

The twelve principles

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.

7. Working software is the primary measure of progress
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity – the art of maximizing the amount of work not done – is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

Table 2: Principles (Fowler & Highsmith, 2001)