Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
Dept. of Industrial Economics and Technology Management

Marte Eirin Stenvaag
Henrik Sagosen Smeby

Structure-Culture Alignment for Effective Collaboration in Virtual Teams

A Comparative Case Study of two Multidisciplinary Team Collaborations During a Pandemic

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Supervisor: Nhien Nguyen
Co-supervisor: Alf Steinar Sætre
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NTNU
Norwegian University of Science and Technology

Abstract

Amid a pandemic, multidisciplinary teams have been forced to work digitally without knowing how this affects collaboration. Our study extends current knowledge by investigating two construction projects in a multiple case study with an in-depth analysis of interviews and observations. The findings indicate that a virtual environment brings several cultural changes, such as a lack of human relations and increased multitasking. As culture and structure are known as two cornerstones of effective collaboration, we emphasize the importance of aligning these dimensions to overcome challenges and exploit opportunities in digital collaboration. This thesis also contributes by giving practical guidance on how to influence the structure-culture fit. The study is conducted on two multidisciplinary teams in the construction industry. It lays out the groundwork for future research to further explore factors and generalize the findings in other teams and industries.

Sammendrag

En pågående pandemi har tvunget tverrfagelige team til å samarbeide digitalt, uten videre kunnskap om hvilke konsekvenser det kan ha for samarbeid. Studien utvider nåværende forskning ved å se på to byggeprosjekter i et multippel casestudie med grundig analyse av intervjuer og observasjoner. Funnene indikerer at et virtuelt miljø gir flere kulturelle endringer, i form av mangel på menneskelige relasjoner og økning i multitasking. Ettersom kultur og struktur er kjent som to pilarer i litteraturen om effektivt samarbeid, understreker vi viktigheten av å tilpasse de to dimensjonene for å overkomme utfordringer og utnytte mulighetene med digitalt samarbeid. Studien bidrar også med praktisk veiledning for hvordan man kan skape et balansert forhold mellom struktur og kultur. Analysen er basert på to tverrfaglige team i samme bransje og legger grunnlaget for fremtidig forskning for å undersøke andre faktorer og generalisere funnene for å gjelde i andre typer team og bransjer.

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1 Introduction

As organizations encounter increasingly more complexity, multidisciplinary teams have emerged as an attractive approach to solve ambiguous problems (Ratcheva, 2009; Chiocchio et al., 2011). The motivational premise is to assemble experts from relevant areas with diverse knowledge and experiences to obtain a broader range of perspectives (Milliken and Martins, 1996; Van der Vegt and Bunderson, 2005). Nevertheless, managers are increasingly challenged to balance the tradeoff between expert diversity (Van der Vegt and Bunderson, 2005) and mutual understanding (Cramton, 2001). The more diversity, the more will individuals' mental models disperse and create challenges for collaboration (Dougherty, 1992). In the literature, correct choice of communication media has been elaborated on as an enabler to establish common ground (Daft and Langel, 1986; Dennis et al., 2008). According to *media synchronicity theory* (MST) (Dennis et al., 2008), successful communication depends on the match between synchronicity needed in a given setting and the synchronicity of the communication media. A complex multidisciplinary project may require more face-to-face communication to foster effective collaboration, as opposed to intra firm coordination.

During the ongoing pandemic, multidisciplinary teams have been forced to alter their traditional working processes and leverage digital collaboration to continue business as usual. Previously physical industries have transitioned into virtual teams (Gibson and Gibbs, 2006; Bjørn and Ngwenyama, 2009), substituting face-to-face meetings with computer-mediated communication (Walther, 1992; DeLuca and Valacich, 2006). Through decades, the extant literature has conveyed vast benefits with digitalization. However, digital collaboration imposes novel challenges on team climate (Malhotra et al., 2001; DeLuca and Valacich, 2006; Walther, 1992). Due to lower synchronicity in digital communication, establishing shared understanding and team

cohesiveness may be more challenging in virtual teams with diverse backgrounds and lack of prior relationships (Dennis et al., 2008; Gibson and Gibbs, 2006). Aligning structures with the cultural aspects thus seems to be even more important for multidisciplinary teams to foster effective digital collaboration (Edmondson and Nembhard, 2009; Pirola-Merlo et al., 2002; Vlaar et al., 2006).

When examining the literature on virtuality in teams, there are several studies conducted on globally dispersed teams (Jarvenpaa and Leidner, 1999) and intra firm teams (Kirkman et al., 2002). However, there is only a small subset of studies concerning virtuality in multidisciplinary teams, in which face-to-face communication is restricted and limited prior relationships are established (Malhotra et al., 2001). The purpose of this thesis is therefore to build upon previous research and contribute with practical guidance on virtual collaboration in multidisciplinary teams. To investigate this manner we wanted to answer the following research question: *How does the adoption of virtual interaction affect collaboration in multidisciplinary teams?*

To investigate our research question, we will base our research on multidisciplinary teams in the construction industry. As the construction industry has become more complex and specialized over the years, the ambiguity in project delivery demands even more comprehensive collaboration structures (Kent and Becerik-Gerber, 2010). Although the digital transformation has been accelerated the past few years, the adoptions have mainly been concerned with 3D visualization software and workflow planning tools. Communication has up to this point been performed offline, especially with the rise of ICE-meetings (Kunz and Fischer, 2011) where everyone is gathered in the same room to create a shared culture and understanding of the project. Due to fragmented constellations (Hall et al., 2018), stakeholders also tend to lack experience in working together and these meetings are crucial to enable efficient collaboration (Kunz and Fischer, 2011). During the pandemic, the

construction industry has been through a significant transformation in regard to communication. Within a couple of weeks, everyone was forced online, and novel communication methods were deployed. In terms of digital collaboration in multidisciplinary teams, the current state of the construction industry therefore provides a highly relevant lens for our research question.

To close the gap we have conducted a comparative case analysis of two multidisciplinary teams, following the Gioia method (Gioia et al., 2013). Based on the proposed literature and results, we found that the culture in multidisciplinary teams will undergo several changes and challenges due to digital collaboration. Our thesis contributes to previous literature by giving an understanding of *how virtual interaction affects collaboration*. Moreover, how the interdependency between structural and cultural factors are affected by virtual collaboration in multidisciplinary teams. Based on these findings and previous literature, we will propose how structure and culture need to be aligned to overcome the cultural challenges and ensure the positive effects of digital collaboration.

2 Theoretical Background

2.1 Collaboration in Multidisciplinary Teams

Multidisciplinary teams have been described at length in the literature; however, the term is often confused with similar terms such as interdisciplinary teams (Edmonson, 2003) and cross-functional teams (Majchrzak et al., 2012). The common foundation of these concepts is to assemble individuals from several relevant areas in the same team and leverage a certain degree of expertise diversity (Van der Vegt and Bunderson, 2005) to solve problems collectively. Experts from various areas will possess unique knowledge, skills, and experiences to understand and solve problems differently (Dougherty, 1992). Thus, diverse teams will often provide a more nuanced interpretation of problems and create innovative solutions through the cross-fertilization of ideas (Milliken and Martins, 1996). In the context of this study, our understanding of multidisciplinary teams will differ from interdisciplinary teams regarding what degree of disciplinary boundaries crossing that is needed to solve the problem (Chiocchio et al., 2011). Interdisciplinary teams are often characterized by integrating knowledge and a high degree of disciplinary boundary-crossing to provide a coherent solution. In contrast, multidisciplinary teams leverage the diversity to share invaluable information and independently coordinate workflows towards a common goal. However, individuals will remain in their dedicated discipline and work in parallel.

In the extant literature, collaboration in diverse teams are often related to structural aspects (e.g., leadership style, project management, communication processes) and cultural aspects (e.g., social behavior, interpersonal relations, cohesiveness) (Cummings and Kiesler, 2005; Edmondson and Nembhard, 2009; Hoegl and Gemuenden, 2001; Nembhard and Edmondson, 2006; Pirola-Merlo et al., 2002; Ratcheva, 2009; Van Der Vegt and Bunderson, 2005; Vlaar et al., 2006). Hoegl and

Gemuenden (2001) argued that highly collaborative teams exhibit fundamental teamwork quality facets relating to social interaction and collaborative processes. Adding to this notion, Hoegl et al. (2004) further found a positive relationship between effective collaboration and team performance. Based on the literature mentioned above, teams need to consider both structural and cultural factors to enhance the quality of collaboration and, ultimately, team performance.

In multidisciplinary teams, each profession possesses localized knowledge and individual "language" that foster collaborative differences (Sole and Edmondson, 2002) and potentially create epistemological conflicts in how problem-solving is structured (Cummings and Kiesler, 2005). Both structural and cultural alignment is thus indispensable to foster effective collaboration. Without common ground in a team, challenges related to communication are more likely to emerge (Edmondson and Nembhard, 2009), and diversity will not be fully utilized (Dougherty, 1992). Ultimately, this leads to more division of labor (Haeussler and Sauermann, 2020) and less collaboration. Hence, the benefit of diversity becomes a challenge.

Furthermore, multidisciplinary teams are often challenged with the tradeoff between high diversity and lack of common understanding (Edmondson and Nembhard, 2009). Dougherty (1992) explained the concept of *thought worlds* and how members bring presumptions and biases into the team. If members' thought worlds diverge substantially, there is less foundation for mutual understanding, hence more challenging to facilitate effective collaboration. In the extension of that, Cramton (2001) presented the mutual knowledge problem - members of a team communicate problems and events according to their thought world and what they think other members know. The research conveys that mutual knowledge is established based on the following three knowledge-sharing mechanisms: direct knowledge, interactional dynamics, and category membership. Direct knowledge refers to how

mutual knowledge is obtained through firsthand experiences with other team members, while interaction dynamics are related to secondhand information sharing. Category membership is our presumption about individuals and their professional backgrounds. How knowledge is best integrated within the team depends on the given task and the team members' inherent processing capabilities (Majchrzak et al. 2012).

Xue et al. (2010) convey that a desirable team climate positively influences knowledge sharing behavior and attitude. For the purpose of this study, the term team climate or team culture is understood as the set of norms, behavior, and expectations that is encompassed and commonly understood in a team to perform a particular task (Pirola-Merlo et al., 2002; Xue et al., 2010). In multidisciplinary teams, various actors are brought together for a common objective. However, individual motivation may differ among them. Van der Vegt and Bunderson (2005) discovered that multidisciplinary teams that invested in facilitating emotional relationships with the team's overarching objective often performed better than their counterparts. Collective team identification was proven to enable commitment to the task and interaction among the members, which was crucial for successful collaboration. Furthermore, the degree to which members of a team are motivated to contribute to the team is strongly related to how they "value their membership [of the team] and strive to maintain positive relationships with other members" (Wendt et al., 2009, p. 2). Wendt et al. (2009) refer to this as team cohesiveness, which is strongly related to improved performance.

The development of team cohesiveness in multidisciplinary teams is a challenging but essential responsibility for team leaders (Druskat and Wheeler, 2003). The more diverse teams are, the more demanding it is for leaders to enable interpersonal relationships and build a collective culture. Leadership style is presented in the literature as an important factor influencing collaboration in teams (Martin et al., 2013). Wendt et al. (2009) argue that leadership style ranges between task-oriented style

and relationship-oriented style. Task-oriented style is characterized by dominating interactions, high task involvement, and target-focused behavior. Several studies find a negative relationship between team cohesion and task-oriented leadership style. However, less mature teams may benefit from a supervising management style (Wendt et al., 2009).

On the other hand, relationship-oriented leaders are more concerned about stimulating interactivity in decision-making (Nembhard and Edmondson, 2006) and facilitating positive interpersonal relations (Wendt et al., 2009). The term is closely related to empowering leadership (Martin et al., 2013), which often is described in conjunction with team climate (Pirola-Merlo et al. 2002). Although scholars agree that relationship-oriented behavior outcompetes task-oriented behavior, few have examined what style is most appropriate for virtual collaboration in multidisciplinary teams.

2.2 Team Virtuality

In recent years, the rise of digital tools has lowered the barriers to information sharing, enabling knowledge to be disseminated and stored within teams more easily (Wallin et al., 2017). The technology shift has allowed for *virtual teams*, in which collaboration is either wholly or partly supported by digital tools (Bjørn and Ngwenyama, 2009). Virtual teams are variously defined in the literature, but the recurring items are geographical dispersion and virtually dependency, meaning that physical meetings are rarely conducted (Gibson and Gibbs, 2006). The most common understanding is when team members are not co-located, face-to-face meetings are replaced by computer-mediated communication media, ranging from asynchronous media such as email to high-quality and synchronous video conferencing with the ability to visualize information (Zammuto et al., 2007). However, contrarian literature argues that co-located teams can also employ virtual interaction; hence,

dispersion is not a prerequisite for virtual teams (Kirman and Mathieu, 2005). Our understanding of *team virtuality* echoes Kirkman and Mathieu's (2005) definition: "(a) the extent to which team members use virtual tools to coordinate and execute team processes, (b) the amount of informational value provided by such tools, and (c) the synchronicity of team member virtual interaction" (p. 702).

In the extension of virtual teams, we define digital collaboration as the process of sharing and integrating knowledge from various team members through computer-mediated communication media (Walther, 1992; DeLuca and Valacich, 2006) and technology-enabled collaboration tools (Marion et al., 2012). Boland et al. (2007) argue that information technologies are more than the tool that is deployed - it is an innovative environment that includes support for social relations and architecture for project management. To provide a nuanced picture of how digital separates physical collaboration, we will look to the literature of communication for insights. MST (Dennis et al., 2008), in the extension of *media richness theory* (MRT) (Daft and Lengel, 1986), is widely applied to describe the affordance of virtual collaboration.

As the pandemic has forced multidisciplinary teams to collaborate and solve complex tasks online, change in communication paths has affected the capacity to carry rich information. To reduce information equivocality, it is essential to ensure communication channels that assist in processing rich information (Daft and Lengel, 1984; Lengel and Daft, 1984). Daft and Lengel (1986) defined information richness as:

> The ability of information to change understanding within a time interval. Communication transactions that can overcome different frames of reference or clarify ambiguous issues to change understanding in a timely manner are considered rich. Communication that requires a long time to enable understanding or that cannot

> overcome different perspectives are lower in richness. In a sense, richness pertains to the learning capacity of a communication (p.560)

To understand how to visualize the different communication channels and their capacity to comprehend information richness, Daft and Lengel (1986) designed the MRT. The theory has been further developed to fit the modern mediums, as shown in Figure 1.

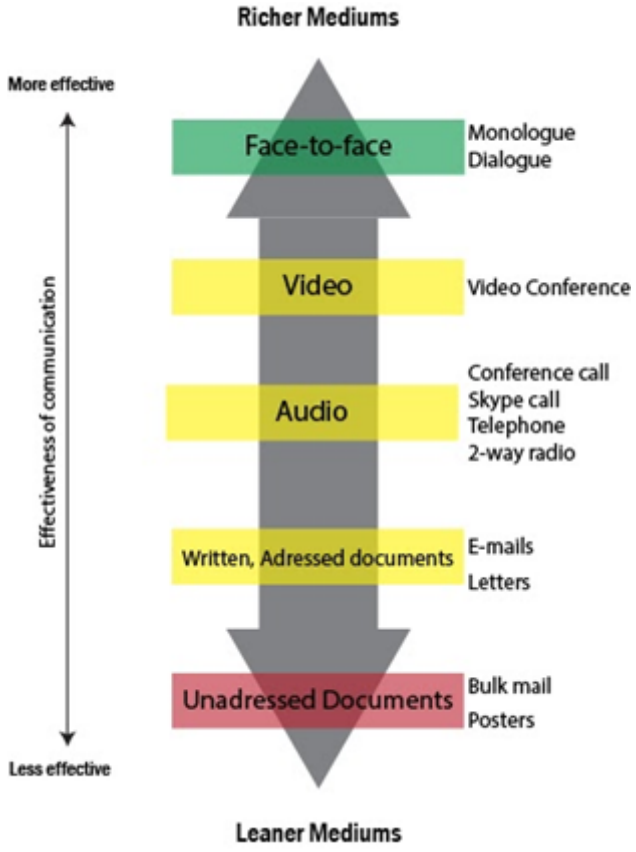

Figure 1: Media richness theory (self made but inspired from: Daft and Wiginton, 1979; Daft et al., 1987).

As Figure 1 demonstrates, face-to-face communication is the most effective medium. The rationale behind that claim is that it provides immediate feedback and verifies interpretation (Daft and Lengel, 1986). It also provides multiple cues like tone of voice and body language. On the other hand, leaner mediums process fewer cues and restrict feedback - and for this reason, they are less suitable for solving equivocal issues.

However, lean mediums are adequate to process standard data and well-understood messages.

Messages should be communicated in appropriate channels with sufficient media richness capacity. Messages made with "channels that are inappropriate to the equivocality of a situation and the richness of the information sought to be transmitted may be misinterpreted by recipients or may be otherwise ineffective concerning their intended purpose" (Carlson and Zmud, 1999, p. 155).

Furthermore, Dennis et al. (2008) argued that MRT was inadequate to describe communication media's social and interpersonal aspects. Thus, MST was proposed to provide a more nuanced picture of how the choice of media affects task performance. Dennis et al. (2008) put forward a three-dimensional model that explained problem-solving performance based on the intersection between media capabilities, communication process, and appropriation factors (see Figure 2).

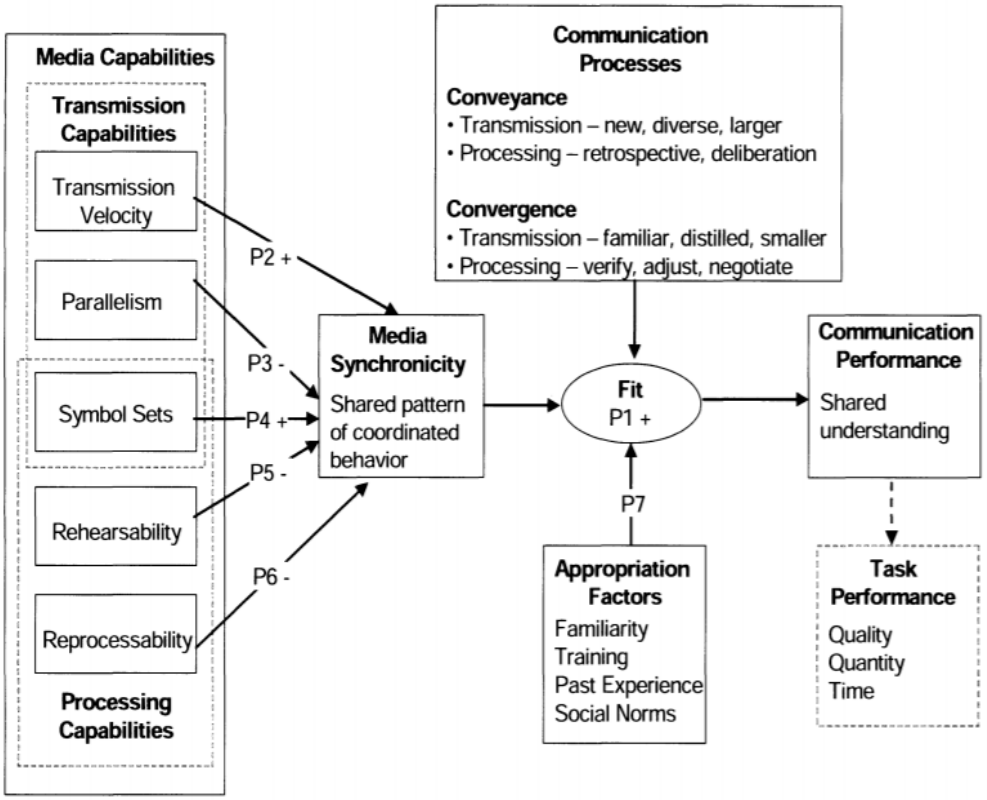

Figure 2: Media synchronicity theory (DeLuca and Valacich, 2006).

The core of the MST is based upon how teams should choose communication media to collaboratively perform micro-level communication processes and accomplish tasks in the best manner possible. Dennis et al. (2008) convey that communication is an exchange process, in which developing meaning requires a "dissemination of information and individual processing of that information" (p. 580). In collaboration, Dennis et al. (2008) identified two different communication processes: *conveyance* and *convergence*. Conveyance is the process of sharing novel and diverse information among team members to provide an adequate and common basis for mutual understanding. On the other hand, convergence processes discuss the meaning of preprocessed information and iteratively concur on a mutual understanding. Furthermore, Dennis et al. (2008) found that communication processes will change nature, based on how familiar individuals are with each other, the task, and the communication media. According to McGrath's (1991) time, interaction, and performance theory, in cases where team members are acquaintances, it is easier to develop shared meaning, and teams proceed more quickly from inception to execution mode. Hence, Dennis et al. (2008) argue that convergence processes are less time-consuming in such teams, given the shared mental models due to familiarity. On the other hand, if the communication context is novel, teams will spend more time establishing mutual understanding.

The fundamental part of MST is the concept of synchronicity. Synchronicity is achieved when team members "exhibit a shared pattern of coordinated synchronous behavior with a shared focus" (Dennis et al. 2008, p. 81). Dennis et al. (2008) argue that demand for synchronicity creates the basis for how effective a certain medium is in a given communication context, ie. convergence processes in temporary and novel teams demand higher synchronicity than convergence processes in familiar teams. In MST, five capabilities affecting synchronicity are

defined: the immediacy of feedback, symbols sets, parallelism, rehearsability and reprocessability (see Table 1).

Table 1: Media capabilities (Dennis et al., 2008)

Capability	**Description**
Transmission velocity	"The speed at which a medium can deliver a message to intended recipients" (p. 584)
Symbols sets	"The number of ways in which a medium allows information to be encoded for communication" (p. 585)
Parallelism	"The number of simultaneous transmissions that can effectively take place" (p. 585)
Rehearsability	"The extent to which the media enables the sender to rehearse or fine tune a message during encoding" (p. 857)
Reprocessesability	"The extent to which the media enables a message to be reexamined during decoding" (p. 857)

Inarguably, the change in communication affects how teams share information and integrate knowledge. As communication is viewed as the means for collaboration (Dennis et al. 2008), virtuality may impose several challenges to team performance. Kirkman et al. (2004) argued that the strength of relational ties and team empowerment is closely related to the number of face-to-face interactions in team collaboration. Hence, we hypothesize that the change in communication media may impact the team climate. To our knowledge, few studies have been conducted on the structure-culture interdependency in virtual teams and how structure and culture aspects need to be aligned to foster effective collaboration. Thus, we aim to investigate this notion further and see how virtuality aggravates and alleviates task-related processes and social interaction in multidisciplinary teams.

2.3 Why is the Construction Industry Interesting?

To answer our research question, we want to delve into the construction industry for insights. The industry has historically experienced a slow rate of productivity compared to other industries (Hall et al., 2018) and lags on digital adoption (Sheffer, 2020). Due to its massive importance in our society (Barbosa et al., 2017) and its highly complex social structure (Shibeika and Harty, 2015), the industry represents a relevant lens for investigating digital collaboration in multidisciplinary teams.

In the last decade, 3D visualization software such as computer-aided design (CAD) or building information models (BIM) have emerged as essential integrators, with strong influence on inter-organizational collaboration in the construction industry (Papadonikolaki and Wamelink, 2017). BIM, in particular, has gained traction as a digital innovation (Elmualim and Gilder, 2014) and played a crucial part in the ongoing digital transformation of the construction industry (Papadonikolaki, 2018). By and large, BIM is an interactive information aggregator built on structured and standardized knowledge from a vast history of operational experiences across construction projects (Laakso and Kiviniemi, 2012). Most importantly, key stakeholders can interact earlier in the design and planning phase, leading to more iterations and increased knowledge generation (Marion and Fixson, 2020). The ultimate goal is to generate and manage information quickly across projects and coordinate complex socio-technical processes (Sackey et al., 2015). Scholars have underscored increased interdisciplinary project collaboration as a critical effect of BIM's introduction (Papadonikolaki, 2018). Although the industry has not yet experienced the full-fledged impact of digital tools, BIM has put important collaboration issues on top of the agenda. Mistrust and individual perception are still the critical barriers to digital adoption across the construction industry (Lee et al., 2013; Son et al., 2015). Thus,

interdisciplinary synergies and a collective push are required for successful diffusion across project stakeholders (Sackey et al., 2015).

The construction industry is a project-based industry characterized by specialization and diverse actors, competencies, and goals (Dubois and Gadde, 2002). Each project comprises a complex structure of key participants, such as end clients, general contractors, specialized sub-contractors, material suppliers, and consultants. As the construction industry has become more complex and specialized over the years, the ambiguity in project delivery demands more collaborative project structures (Kent and Becerik-Gerber, 2010). Construction companies are increasingly embracing these mechanisms through integrated project delivery (IPD) models (Lahdenperä, 2012; Wamelink and Heintz, 2015; Hall et al., 2018). The end client provides a rough plan of the desired building, and the general contractor is responsible for design and production in collaboration with complementary sub-contractors. Thus, the question is not if organizations should collaborate but how they should collaborate (Poirier et al., 2016). Each project comprises intricate relationships, causing complex interdependencies between actors and tasks. The project structures are often characterized as distributed, heterogeneous and sociotechnical (Sackey et al., 2015), in which collaboration relies heavily on trust and human relations (Boland et al., 2007). Stakeholders also tend to be involved in various projects, with constant new timelines, new partners, and new objectives. Thus, their motivation is rarely exclusively related to one project, causing diverging motivation and vertical fragmentation (Fergusson, 1993).

Over the last few decades, the construction industry has slowly noticed their imperfections, which has spurred a shift from short-term wins to long-term thinking. Inspired by the increased deployment of lean methodology in adjacent engineering fields, the construction industry adopted its lean construction methodology, *virtual design and construction* (VDC) (Kunz and Fischer, 2011). The holistic VDC method

originated from Stanford University in 2001 to create a virtual framework to coordinate the entire project life cycle, from pre-planning to completion, to fulfill the customer's objective (Kunz and Fischer, 2011). To replace the manual linkage between multidisciplinary stakeholders and reduce transaction costs, redundancies, and decision latencies, the research group suggested a collaborative model where all information could be accessed in an integrated project database (Kunz and Fischer, 2011). The main objective of VDC methodology is to run a lean project in which resources are deployed efficiently and solely to deliver value to the customers. Due to its virtual and integrated nature, all stakeholders can closely monitor relevant metrics and quickly redirect if the progress slows. The very core of VDC is a three-folded process, including the 3D design and visualization tools, often BIM, a commonly understood workflow and resource planning system, and the interdisciplinary meeting structure *integrated concurrent engineering* (ICE). The objective of the meetings is to involve all relevant stakeholders to oversee the progress and ultimately reach decisions more efficiently based on common information from BIM and the workflow planning system. Consequently, workstreams could be executed both sequentially and in parallel with fewer latencies. However, none of this is possible without common ground and incentives to collaborate.

Amid a pandemic, teams have been forced to adjust their processes to accommodate non-physical collaboration. Considering the media synchronicity theory and the affordance of virtual media, we hypothesize that a transition to digital collaboration may provoke novel challenges regarding team cohesiveness, relational ties, and social behavior. In multidisciplinary teams, these cultural aspects are even more critical to establish mutual understanding successfully and to leverage the notion of expert diversity.

In the extant literature, digital collaboration is mainly observed through globally dispersed teams (Jarvenpaa and Leidner, 1999) and intra firm

teams (Kirkman et al., 2002). However, only a small subset of the literature focuses on virtuality in *multidisciplinary teams* and how virtual interactions aggravate and alleviate effective collaboration in diverse teams. Hence, we will look into *how the adoption of virtual interaction affects collaboration in multidisciplinary teams.* In light of two complex construction projects, we will investigate how structural and cultural aspects have been affected by a digital transition and see if we can extract learnings on aligning the structure-culture interdependency for effective collaboration. Due to the physical nature of the construction industry, the two projects serve as a highly relevant and timely lens for our research question.

3 Research Methodology

This thesis followed a qualitative method with an inductive research approach. The applied research design was a multiple-case study. In our method of data analysis, we took inspiration from the Gioia methodology to build a theory from our case study research (Gioia et al., 2013).

Two Norwegian construction projects that have experienced a forced transition to online collaboration projects were studied. Both cases were explored through a total of four meeting observations and semi-structured interviews with ten people.

To strengthen the validity of this thesis, we triangulated (Jick, 1979) the interview data by doing observations - in addition to gathering *secondary data* (e.g., websites, project documents, and reports) from each case (Yin, 2018). The cross-examination of different data sources ensured capturing several dimensions of the same phenomenon (Patton, 2002; Yin, 2018).

3.1 Research Method and Design

3.1.1 Why Inductive Qualitative Research Model

Before this thesis, we conducted a systematic literature review on collaboration in the construction industry and identified several research gaps. We found that there is a common understanding of the construction industry, and scholars agree upon the explicit challenges of fragmentation, competitive bidding, and complexity. With its complexity and the sudden digital transition, we wanted to investigate *how virtuality affects collaboration in multidisciplinary teams*. We had to grasp the opportunity to research the effects of the global pandemic, as it is a once-in-a-lifetime opportunity and has not been researched before.

From what we have investigated, no qualitative research is conducted on the effects of covid on collaboration in digital and complex teams. Consequently, it became clear that considerable knowledge remained to be explored in the realm of the forced digital transition in ambiguous teams.

The inductive approach is appropriate when little is known in the research field in question (Eisenhardt, 1989). Inductive and deductive research mirrors one another, where inductive theory is built on cases and produces new theory from data, and deductive theory is testing the data to test theory (Eisenhardt and Graebner, 2007). Thus, our thesis's inductive approach is suitable due to the lack of previous research in this particular field. However, it is essential to emphasize that even if the purpose of inductive research is to generate new theory, it does not impede researchers from using existing theory to formulate the research questions to be explored (Saunders et al., 2019).

3.1.2 Why Multiple-case Study Design

We selected a multiple-case study design because of our research question. In short, because it is a "how"-question and we believe an in-depth analysis will help us identify some answers. As Yin(2018) is one of the most cited research methodology authors within case study design, we found it natural to use his work as inspiration and guidance.

Yin (2018, p.15) defines case study as an empirical method that:

- *Investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when*
- *the boundaries between phenomenon and context may not be clearly evident*

Furthermore, a case study design is suitable when (1) the research question is formulated with "how" or "why", (2) the study focuses on current events, and (3) the investigated behaviors and events can not be intervened with (Yin, 2018).

Having regard to Yin's (2018) conditions, we considered a case study as a well-suited design because (1) our research question is how-oriented, (2) our interview objects reported events and behaviors from contemporary events, and (3) examined behaviors could not be manipulated, since there was no disclosure between the involved people.

By including another case in this study, we applied a multiple-case study design. In contrast to a single case study design, a multiple-case study enables comparisons to clarify whether a finding is peculiar or replicated in several cases (Eisenhardt, 1991).

This thesis aims to provide a general understanding of how the pandemic and forced digital environment have influenced collaboration and problem-solving in multidisciplinary teams. Therefore, while acknowledging that a sample size of two is still somewhat limited, we included multiple cases in the study.

3.1.3 Context of the Study

The study was conducted during the spring of 2021, with interviews and observations taking place in March-May, followed by a data analysis period from May-June. The time aspect is fascinating in this study, as it is approximately one year since the world got affected by the covid pandemic and was forced to conduct business in new ways. The pandemic gives this study a unique opportunity to understand the difference between multidisciplinary teams before the pandemic (when multidisciplinary teams can interact in several modes) and during the pandemic (when multidisciplinary teams must limit physical interaction

and transition to virtual interaction modes). The unique time period makes our research question both important and interesting.

As of January 2021, we had conducted a systematic literature review on collaboration strategies for innovation in the construction industry. Disregard this project thesis; we had close to no practical experience from the industry prior to this study. We hope that our lack of industry knowledge helped us investigate it with new eyes and possibly create a descriptive study for people outside the industry.

3.1.4 Selection of Cases

Due to a lack of network in the construction industry, we had to reach out to several companies to investigate if they had suitable projects for our research. After contacting a construction innovation cluster in Norway, we redirected to two similar projects that had solved the forced online transition differently. We found these cases quite interesting because they are very similar in structure, within the same company, and geographically close.

We had two selection criteria:

1. The collaborating team had to be a team that solves tasks that need multidisciplinary collaboration to find a solution.
2. The team members had to have gone through the forced transition from physical to online collaboration.

We chose to investigate the two cases since they both fulfilled our criteria. In addition, we got the opportunity to look at two separate cases with similar external environments, e.g., close in geographical location and same general contractor. It should also be mentioned that construction teams are separated into two disciplines, engineers and producers. In other words, the ones that are drawing and planning and the ones that

are constructing it on site. Before covid, they were all gathered physically on site to collaborate. They are now restricted to only have producers on site (and restrict physical contact between producing sub-contractors), forcing them to collaborate and coordinate digitally.

Furthermore, the cases have some differences in size, complexity and management that will be further elaborated in the case analysis in chapter 4.

3.2 Data Collection

3.2.1 Why Direct Observations

Observation as a method is helpful in many ways. It provides a way to investigate nonverbal expressions of feelings, determine who interacts with whom, understand how group members communicate with each other, and see how much time is spent on various activities (Schmuck, 1997).

Considering our research questions, a case observation is beneficial to explore how they work in the digital environment. The observations intended to add a new dimension for understanding how they collaborate in digital meetings with the new technology (or at least new to them) and what problems are being encountered. Schensul et al. (1999) stated that a reason for using observation in research is "to help the researcher get a feel for how things are organized and prioritized, how people interrelate, and what are the cultural parameters" (p.91) and "to provide the researcher with a source of questions to be addressed with participants" (p.91).

As we needed a better understanding of the industry, we found it relevant to have direct observations to get a holistic view of how they operate and collaborate behind the curtains. By doing observations before the

interviews, we prepared a more relevant interview guide, as we had more background knowledge of the interview objects and their new online day-to-day work routines.

3.2.2 Conducting Observations

Observations were conducted as silent participants to digital meetings where the group was aware of our observation activities. We were able to participate in four separate meetings for both of the cases. To get a comprehensive view of their day-to-day online work routines, we observed three different types of routine meetings, as shown in Table 2.

Table 2: Overview of observed meetings and their objective and participants

Observed in	**Type of meeting**	**Meeting objective**	**Participants**
Case A	ICE-meeting	Task management and clarification about dependencies in the design, followed by workshops to foster collaboration	All relevant actors in the current phase of the project, i.e. all engineers in the design phase
Case A	Special meeting	Solve dependencies among actors and emerging issues in the progress plan	Small group (3-6 people) of engineers and technical professionals
Case A and B	Progress meeting	Review of dependencies and progress plan	All responsible operational staff

For confidentiality reasons, we did not choose to record the meeting. In addition, it was not the technicalities that were being said in the meetings that were of our interest. We wanted to understand how they communicate with each other, how they solve problems, what digital tools they use, and how the media affects collaboration. Both of the researchers took notes from the meetings to get a more significant base of data. The observations were mainly used to get a transparent view of how they collaborate to develop a better interview guide and ask more relevant questions in the interviews. Furthermore, the observational data was used to exemplify and support the primary source of evidence, the interviews, which will be elaborated on in section 3.2.3 - 3.2.4.

3.2.3 Why Semi-structured Interviews

According to Yin (2018), the interview is one of the most important sources of case study evidence and is especially helpful to suggest explanations in "how" questions. Gioia et al. (2013) also mention that semi-structured interviews are important "*to obtain both retrospective and real-time accounts by those people experiencing the phenomenon of theoretical interest*" (p. 19).

For each of the two cases, we conducted five interviews. To ensure a broad range of views, we held interviews with various roles in each project. We wanted to interview general contractors and subcontractors as well as people working both within building engineering and production. We also wanted to interview two different projects because we were convinced it might result in a wider variety of observations and possibly several contradictory observations in the two cases.

3.2.4 Conducting Interviews

Due to the ongoing global pandemic and large geographical distances between the researchers and the interview objects, all the interviews were conducted as video meetings in Microsoft Teams.

The length of the interviews varied because of their semi-structured nature. Also, to respect the case's wishes, we invited the participants to a 45-minute long interview. Some participants had some extra time to share with us, while others only had 30 minutes. Table 3 shows the number of different interviews, dates, and duration. We chose to have the interviews in Norwegian, as it is the native language of the informants, and we believe in making it as simple as possible for the informants to share their thoughts and experiences.

Table 3: Overview of case interviews including role, date and duration.

Case	Informant	Date	Duration
Case A	A	22/03/2021	55 min
	B	23/03/2021	48 min
	C	20/03/2021	44 min
	D	3/04/2021	56 min
	E	27/04/2021	27 min
			3 hours and 50 minutes
Case B	A	4/04/2021	46 min
	B	10/04/2021	48 min
	C	10/04/2021	59 min
	D	7/04/2021	45 min
	E	4/04/2021	34 min
			3 hours and 51 minutes

After approval from all the interview objects, we took video recordings of the meetings that we later transcribed and transferred to qualitative research software, Nvivo. Each interview was conversational, where the informant was able to talk about their most essential views on collaboration and virtual interaction in their project. To stay on track, we had created an interview guide (see Appendix A), but we frequently asked follow-up questions to cultivate a deeper understanding. As explained in the theoretical background, we held prior knowledge that structure and

culture are known as cornerstones in collaborative teamwork. As Gioia et al. (2013) highlight the importance of not extensively theorizing beforehand, we constructed the interview guide with open questions about team communication, digital tools, and meetings to see how virtuality aggravates and alleviates collaboration (see interview guide in Appendix A).

3.2.5 Complementary Data

To establish construct validity and reliability of our evidence, we will use three different data sources, also called triangulation (Yin, 2018). We collected documents like meeting minutes, meeting agendas, and pages from the general contractor and subcontractor websites to supplement our interviews and observations about how they wish to operate with virtuality. We used the documents to support findings from the primary data analysis.

3.3 Structuring the Data

Since the Gioia methodology will be the backbone in our structuring and data analysis, we find it convenient to introduce the most important elements with this methodology before we display how we structured the data to analyze and find answers to our research question.

3.3.1 The Gioia Methodology Approach

The Gioia methodology is a highly cited and common approach for inductive qualitative research. When laying the groundwork according to the Gioia method (Gioia et al., 2013), the researchers should "get in there and get your hands dirty" (p.19) while consequently conserving the data

as close as possible to the informant's experience. Nevertheless, the risk of being too close to the informants' perspective can make the researchers lose "the higher-level perspective necessary for informed theorizing" (p.19). To reduce this risk, one of the researchers needs to take the role of devil's advocate and criticize interpretations that might look too good to be true.

Another vital element is the initial interview protocol with specific and non-leading questions. The protocol is to make sure that the interview is focused on the research question(s). As the research progresses, the interview protocol should be revisited due to the "twists, turns, and roller-coaster rides involved in discovering grounded theory" (p.19). The flexibility of interpretive research causes the researchers to follow the informant's lead when investigating the research question. To this point, the Gioia method is not particularly distinctive (Gioia et al., 2013). However, the element that enhances qualitative rigor with the Gioia method is its approach to analyses.

The initial part of the analysis is the 1st order analysis, "which tries to adhere faithfully to informant terms, we make little attempt to distill categories, so the number of categories tends to explode on the front end of a study" (Gioia et al., 2013, p.20). As the research advances, it is possible to see similarities and differences in the coding to reduce the categories to a manageable number.

After the 1st-order analysis is the 2nd-order analysis, the researchers ask "whether the emerging themes suggest concepts that might help us describe and explain the phenomena we are observing" (p.20). Furthermore, the researchers distill the emergent 2nd-order themes into 2nd-order aggregate dimensions.

The complete set of 1st- and 2nd-order analysis and aggregate dimensions is the basis for building the data structure, which is the "pivotal step" (p.20) in the Gioia method (Gioia et al., 2013).

3.3.2 Data Coding Process

To strengthen our research validity by having inter-coder reliability (Nili, Tate, and Barros, 2017), we commenced coding interview transcriptions individually and independently.

In the 1st order coding, we wanted to give a "voice to the informant" (Gioia et al., 2013, p. 17) and did not try to categorize or synthesize the data. Our 1st-order coding created two sets of 257 and 290 codes. We combined the sets and removed the duplicates, and ended up with a total of 429 codes.

In the 2nd-order analysis, we grouped the patterns in the data with relevant theories referenced in the literature. After having a workshop with our different suggestions of grouping the themes, we ended up with 23 different 1-st order *labels*. As our informants touched upon many different topics, we needed to move on to the analysis with the most common topics. While structuring the data, we iterated back and forth to our theoretical knowledge and synthesized it considering a theoretical framework. Our results amplify the importance of structure and culture as our informants mostly enlightened topics undergoing either the teams' culture or structure. Consequently, we moved on with four 2nd order codes falling under the team's structure and culture that the informants had elaborated thoroughly. After structuring codes regarding our structure and culture framework, we ended up with 278 1st order codes as the basis of our analysis.

Furthermore, the structure and culture were set as abbreviated dimensions as their thematic created a simple and more rigorous data structure with another layer of abstraction. A segment of the different steps of coding and data structure is visualized in Figure 3. The complete data structure can be viewed in Appendix B.

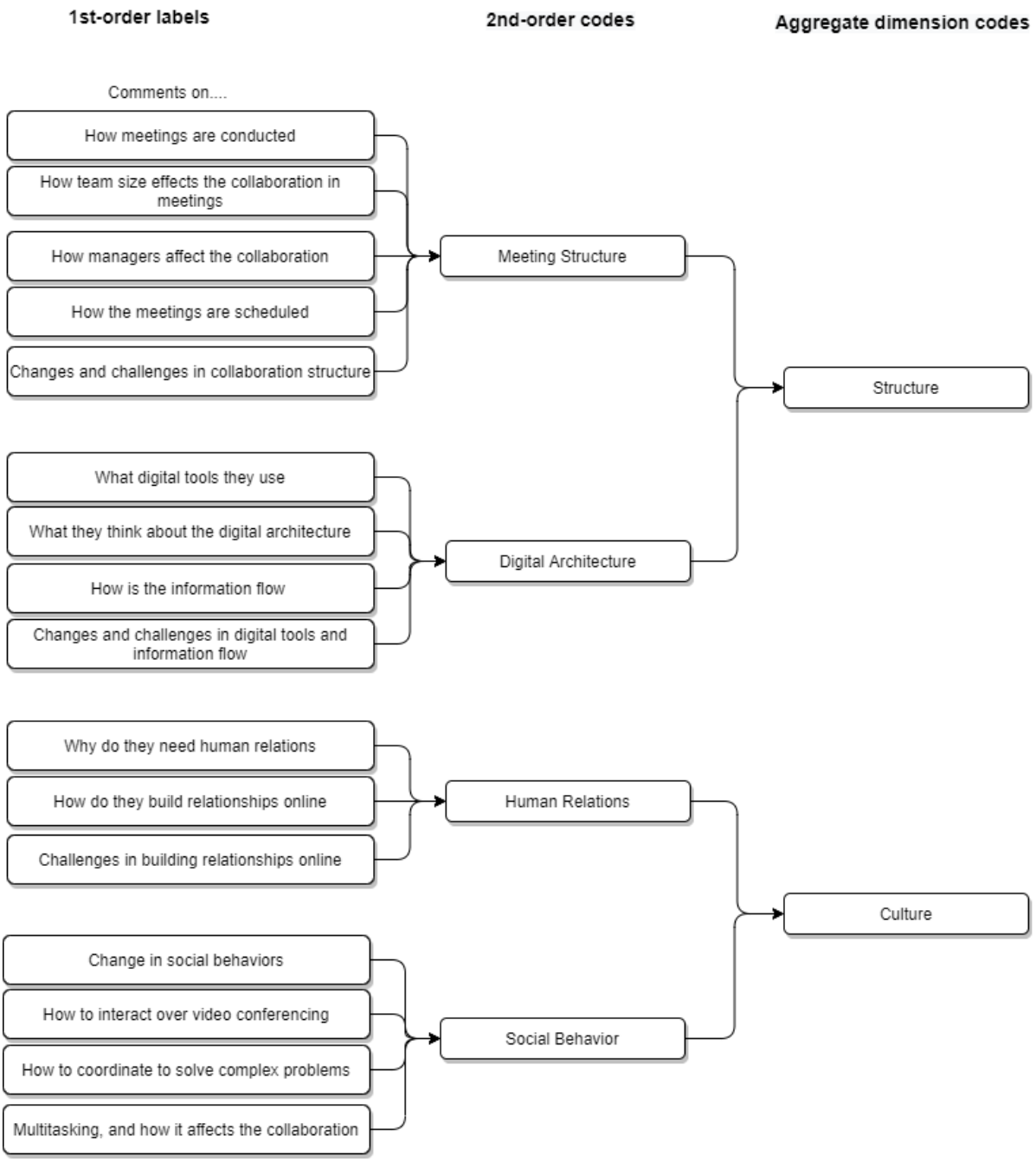

Figure 3: Segment of the data structure (self-made).

3.4 Analyzing the Data

3.4.1 Case Analysis

After setting the data structure, we commenced a within-case analysis, which in our study is a case description to understand the context of each case separately. We emphasized its most relevant happenings and structural elements for each case because it could be necessary to understand any differences and similarities in the cross-case analysis.

3.4.2 Cross-case Analysis

As mentioned, our primary emphasis will be on the cross-case analysis, where we will investigate each theme from the cases' perspectives. From this, we can try to develop patterns across cases within each abbreviated dimension, visualized as vertical boxes in Figure 4.

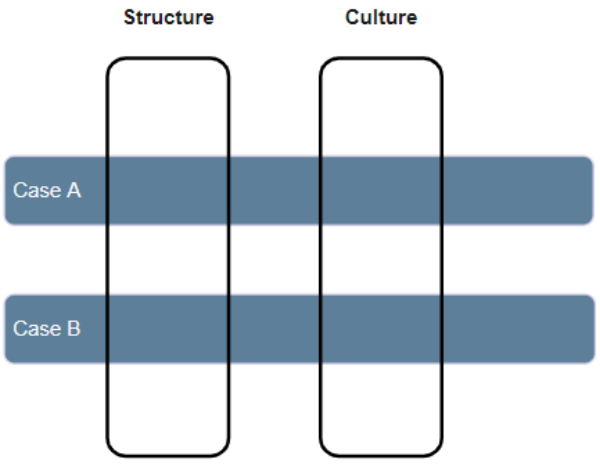

Figure 4: Cross-case analysis (vertical white boxes) compared to case analysis (horizontal blue boxes) (self-made).

To answer our research question on *how the adoption of virtual interaction affects collaboration in multidisciplinary teams*, we looked for answers across the structural and cultural aspects in the teams. Furthermore, we elaborated on the most common 2nd-order codes to get an in-depth analysis within each aggregated dimension.

3.5 Strengths and Weaknesses in the Method

3.5.1 Triangulation, Confirmation Bias, and Interview Protocol

To increase this study's credibility and validity, we chose to use three different sources of data to ensure triangulation. The primary source of evidence was the semi-structured interviews, and the secondary sources were the observations and complementary documents. The secondary data was used to either exemplify or support findings from the primary data.

Another strength of this study is our lack of pre-understanding of research in the construction industry, as a solid theoretical insight could cause a confirmation bias in our study. We also emphasized the importance of collecting the data before investigating the theory, as Gioia et al. (2013) highlighted to prevent manipulation of data. In this way, we will prevent the falsification of the data from fitting into a predetermined theoretical framework.

Our method also underlines a suitable interview protocol to assure confirmability. We created the interview guide to provide consistency in the questions asked that made the comparability between the cases more manageable. Moreover, since the primary source of evidence is the interview data, we were careful not to ask leading questions. A supervisor also reviewed the interview guide to reduce the risk of bias.

3.5.2 Generalization, Reflexivity and Selection of Informants

It is also important to be aware of the weaknesses and limitations of this thesis. First, this research does not include enough cases to state conclusions or fully generalize the findings confidently. As this research spans from January-June 2021, it has limited the number of cases and prolonged engagement.

Second, having interviews can cause several weaknesses. Yin (2018) sheds light on "*reflexivity - interviewee says what interviewer wants to hear*" (p.114). Considering our informants are in a work situation, there is possibly a higher chance of reflexivity since they can tell us what we think we want to hear to put themselves in a good light.

At last, we want to question our research reliability considering the selection of interview objects. Our data collection was initiated with direct observations of the team's digital meetings. After the meetings, we sent emails to people we would like to interview due to their role in the project or exciting things they had said in that particular meeting. In other words, we selected the interview objects to get several different views, but we can not certainly say that the informants reflect the team. Also, we think that possibly the most talkative and outgoing people are the ones that were interested in taking part in an interview in the first place, while more introverted people would instead pass.

4 Results and Analysis

4.1 Case Description

4.1.1 Case A

The project in case A is a turnkey project with a total cost of NOK 110 million. It is the largest project in our case study, involving 18-20 people alone in the design phase and more than 150 people in total. The project was preliminarily initiated right after the pandemic hit, and the initial plan is to conclude the project before the summer of 2022.

So far, the project has been executed mostly through digital communication. The pre-planning phase with contractual meetings and the first phase of coordination between detailed engineering and production have been conducted through video conferencing. Our informants conveyed that the timeline until operations commenced has been opportunistic, especially with digital collaboration in mind. "New working methodology in a digital environment has not been easy to implement. [...] Miscommunication has caused delays in the design phase", said one of our informants.

The project leaders in case A were also highly educated in the VDC methodology. Hence, they tried to replicate ICE meetings in a digital environment. Miro was then used for task management as a substitute for the physical whiteboard solution, and Microsoft Teams was deployed to gather everyone in "the same room". However, several of the actors were dissatisfied with the structure. "Digital collaboration goes against the core of VDC, in which we gather everyone in the same room and enable small discussions. [...] In virtual meetings with many people, it is difficult to involve everyone", said one informant. Consequently, case A decided to split the team into smaller groups after a couple of months.

The building in case A is a special kind of office building, which requires a technical room. The task was novel to most actors; however, they leveraged a vast diversity to solve the problem. In case A, aligning the drawings through a virtual interface was challenging, and misunderstandings emerged between engineers and operational staff. It was also demanding to assemble adequate information when actors were restricted from meeting at the site. Ultimately, decisions were often postponed. As of our interviews, the project in case A was delayed two weeks. Our informants explained that Miscommunication is the root of this delay; however, whether related to individual issues or digital collaboration is difficult to assess.

4.1.2 Case B

The project is a turnkey project where a general contractor has hired subcontractors to construct the building. In this case, the subcontractors are also responsible for their engineering. The subcontractors are often employed on several projects simultaneously and must manage their time to fulfill each contract.

The project was initiated at the beginning of 2020, and detailed engineering barely started when the pandemic caused a lockdown in Norway. They completed about 90% of each discipline's engineered 3D drawings at the end of May and finished them during June and July. The project was categorized as a more straightforward project because of its size and complexity. The project is worth around 65 million NOK, and it is estimated that about 100 people have been working on this project.

Since the project is to construct a rather ordinary building, they also use a more traditional management style, where the managers supervise and take part in most of the decisions.

The transition period from physical to digital communication "has been surprisingly good, and the biggest challenge was to learn everything about how to use the digital tools [..] as we only used paper documents [before covid]". Our informants conveyed that the older generation has struggled more with the transition compared to younger employees.

Besides getting used to having digital tools in their everyday work life, they encountered a more prominent and complex technical challenge - the building had been engineered too large and in the wrong position concerning their governmental approval. Luckily, the managers discovered the miscalculations before they started ground construction, "it would have been catastrophic if we had not caught it [..] it would have cost us millions". The incident triggered a pause in the project, and subcontractors had to redo the drawing according to governmental approval. Whether the project could avoid such interruption in a physical collaboration is difficult to answer.

4.1.3 Case Data Distribution

Both cases shared several different challenges and success stories that gave us an insight into how they collaborate through digital tools compared to previous physical work life. As mentioned, during coding, we separated it into the most prevalent four topics from our interviews. Both cases touched on all the topics (see figure 5).

	Case A	Case B	Sumations
Structure			**181**
Meeting Structure	66	44	110
Digital Architecture	39	32	71
Culture			**97**
Human Relations	23	10	33
Social Behaviour	34	30	64
	162	**116**	**278**

Figure 5: Distribution of data from each case (self-made).

4.2 Cross-case Analysis

4.2.1 Key Findings and Synthesis

To present our key findings, we need to revisit our research question: *How does the adoption of virtual interaction affect collaboration in multidisciplinary teams*? The RQ is broken down to looking specifically at structural and cultural factors in the virtual environment. Consequently, we can procure an insight into how *the adoption of virtual interaction* affects culture and structure as a foundation for effective collaboration in multidisciplinary teams. We must emphasize that there are additional factors to the ones we mention that impact the team's structure and

culture. However, this study will accentuate the main elements that are different compared to a physical team environment.

To synthesize our findings, we examined each aggregated dimension, structure and culture, and their relationship. Our key result is that a multidisciplinary team transitioning to a virtual team will undergo some cultural changes and challenges. Virtual teams tend to recreate their physical structure in a digital environment without minding the cultural challenges that may arise. Our analysis uncovered novel changes in human relations and social behavior that will affect collaboration in a virtual environment (see Figure 6). The structure is investigated by looking at the team's meeting structure and digital architecture that influence the virtual collaboration structure. It is not apparent that the physical structure-culture fit will be equal in a virtual environment. Hence, when transitioning to a virtual team, managers must be aware of the alignment between structural and cultural elements.

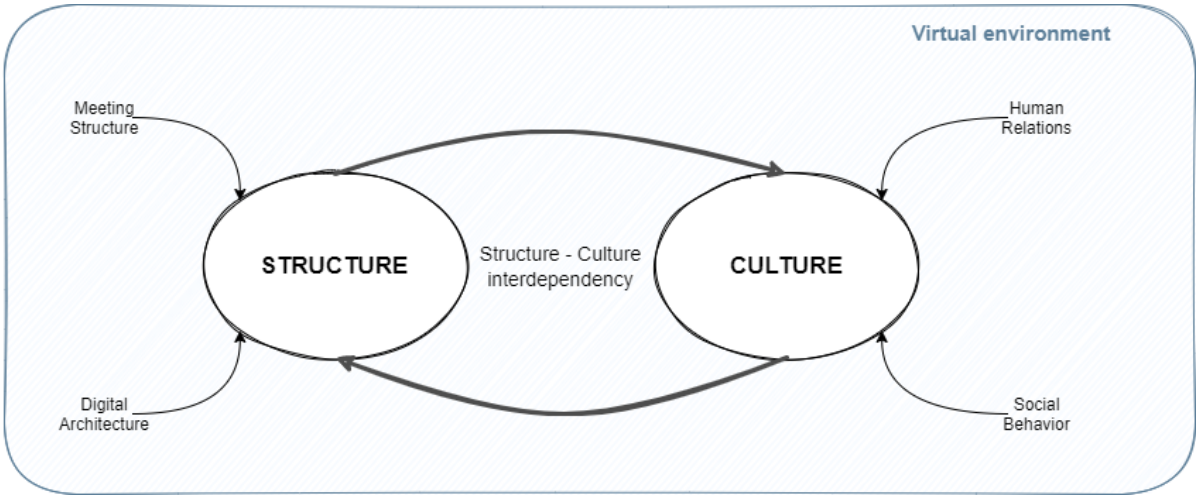

Figure 6: Structure-culture interdependency model (self-made).

In the next session, we will analyze the structural and cultural factors that affect multidisciplinary team collaboration when changing their interactions online during the pandemic.

4.2.2 Structural Factors Affecting Collaboration

Meeting Structure

Appropriate meeting structure is the cornerstone to facilitate communication and to perform efficient project management. Hence, it was one of the most prevalent aspects of our study. In this 2nd order code, we will particularly look into how meetings were structured to facilitate communication and coordination between actors. The analysis will draw on the size of the team, leadership, and meeting planning.

Both cases experienced an architectural change in meeting structure, however, in varying ways. Pre-Covid, almost all of the contractors were used to the VDC methodology in some way or another. ICE meetings were the preferred meeting structure, meaning everyone was gathered in a physical room to interact and collaborate on the project design. Often, there is an informal meet-up first, in which everyone contributes with status, current dependencies, and future progress. Afterward, people split up into groups and conduct smaller workshops separately. "In an ideal world, we would all sit in the same room and go through the issues face-to-face", said one VDC responsible for case A.

In the initial planning phase, both cases were supposed to use VDC for project management. However, when people were forced to work from home, the meeting structure had to be calibrated to function on a digital platform. In case A, they tried sticking to the original meeting structure: "First we have an all-hands meeting [digitally], and then splitting up in special meetings to focus on certain topics. […] The structure resembles a physical meeting, like in a big room*".* Although the structure is equal, some of the collaborative benefits of VDC were missing: "In a physical environment, we can assemble all the designers in one room, reconcile the plan and discuss challenges. […] Although we use the same structure for the digital meeting and the same requirements, the collaborative part

is missing". One of the informants in case B also stated a significant discrepancy of digital VDC meetings:

> The purpose of VDC is to have more clarity in other contractors' needs, what decisions are to be made by the general contractor, and how all this is dependent on my progress. […] It would have worked better if people were physically present and attended the workshop afterward. The workshop is not possible now.

Our study also exhibited a distinct difference between project management in the design phase and the production phase. Within both cases, the informants conveyed the importance of physical meetings in the production phase. Although digital meetings work well for clarification and decision-making in the design phase, both projects experienced a struggle to manage production through digital communication. "The small issues can actually be solved digitally, and I think we will continue with this structure. However, operations management will most likely revert to a physical environment", said one respondent from project A. Two other contractors in case A echoed that statement.

Without the ability to meet physically and with information transitioned online, *meeting management* seems to be even more vital for decision-making than before. One informant from case A conveyed the following challenge:

> In the design phase, a recurring structure is that we first have a special meeting with the relevant actors, which results in two possible solutions to the problem. Then we need to plan a new clarification meeting with other professions. Additionally, the buying client and its tenants have opinions about the next steps.

Consequently, meeting planning and information gathering have been even more important during the pandemic.

When silently observing the ICE meeting in case A, the progress planning seemed unstructured and chaotic. The general contractor decided to change tools in the middle of the project, which seemed to confuse the subcontractors. Our observations were confirmed in the interviews:

> They need to decide - they cannot have three different plans for the project. Moreover, simultaneously spending time on updating the plan in the meeting takes too much time. […] I think the cooperation would be better if the general contractor could let go and not try to micromanage.

In contrast to letting go of the VDC methodology as in case B, the project managers in case A overdid the progress planning and made the process excessively cumbersome. The observation indicates that subcontractors in case A took less responsibility for updating dependencies before the meeting and were thus forced to spend time on this in the meeting:

> Rather than creating a progress plan in the meeting, this should be decided beforehand in special meetings such that everyone is prepared for a status meeting. […] Then we can have a project review instead of taking the round in the meeting.

One of the pillars of ICE meetings is to be aware of and discuss each other's dependencies. However, in case A, these meetings were more important for the general contractor to overview the project rather than discussing dependencies and alternative solutions.

In case B, some of the informants experienced a tendency of micro-managing by the managers, however, with fewer digital tools. After the pandemic outbreak, they reverted quickly to a more traditional approach: "Due to the short time frame and high requirements on delivery, it was difficult to continue with a VDC planning in a digital environment". Meetings were conducted in a more top-down manner, in which sub-contractors were kept on a tight leash. Instead of collaborating

more independently, the general contractors managed the project more hands-on with strict deadlines.

Due to urgency and professionality, the collaboration worked well with strict management in case B: "There were low barriers to speak up and easy to solve problems in meetings. If technical issues were brought up that did not concern other parties, this was quickly moved to a special meeting". Another informant in case B conveyed:

> In VDC, we are used to managing more loosely, and actors are responsible for their work. […] The way we managed this project was more decisive. We often went through the model step-by-step, in which everyone could pitch in and make changes together. […] We were always pushing them.

The information was thus accurately shared, and the project did not need a detailed progress plan. "Everyone was professional and knew what they should do. […] Although it has been a rough plan along the way, most requests have been communicated via mail to meet the deadline", said one of the informants from case B.

Another interesting aspect regarding meeting management in the two cases was the difference in project managers' professional backgrounds. In case A, the project manager had vast experience with VDC, including a university degree. In contrast, the project managers in case B were originally construction managers responsible for the operational work. As former carpenters, they were used to traditional project management with a tight leash. The difference in the background may have affected how case B quickly transitioned to a traditional approach, while case B held on to the VDC method.

In addition to project meetings, our informants were also engaged in intra firm meetings, which were conveyed as more familiar. Several respondents conveyed that these meetings were more efficient and less

tedious due to a set agenda for each meeting. "It is often scheduled more time for open discussions and loose threads, as opposed to an ICE meeting with a tight agenda and less room for discussions", said one actor from project A. However, internal meetings are more often related to information sharing and not an arena for collaboration.

In the extension of meeting management, *the size of teams* has been conveyed as a major influencer on digital collaboration. During our meeting observations, we saw that the more people in a team, the more challenging it is to collaborate in a digital environment. The observations are both related to meeting efficiency and the complexity of project management. An informant from case B exemplified a typical right-sized meeting: "When a group of 4-5 people can discuss, clarify and plan undisturbed". The recurring message from both cases is that meetings in smaller teams resemble physical meetings better, leading to more productive discussions and easier decision-making.

Due to the challenge of large meetings, the project leader in case A decided to split the team into multiple groups to facilitate smaller meetings. Most of the subcontractors we interviewed in case A seemed pleased with this initiative: "The meetings are more effective [in smaller groups], meaning that the discussions are both more relevant for everyone and it takes a shorter time to reach a decision". The same observation with smaller teams was acknowledged in special meetings: "Special meetings work very well. Then you have the resources needed for the issue at hand. […] We use the allocated half an hour to go through the drawings and decide on the next steps". The statement was echoed in case B as well.

Most of our informants conveyed a critical limit of people to run an efficient meeting. When the number of participants exceeds ten people, the meetings are often longer with more complex agendas. However, how informants experienced these meetings varied. On the one hand, some

informants observed a more chaotic structure with large meetings. “With 12 or 15 people in the meeting, everyone wants to participate and talk simultaneously, and suddenly three hours have passed with no relevant information for your progress”, conveyed an informant in case A. On the contrary, another actor from the same project conveyed that some people tended to be more silent than usual in larger meetings. The statement was also echoed by an informant in case B where “Often it is more one-way communication in larger meetings”.

Pre-Covid, most of the contractors were used to casual conversations and honest discussions in large teams. However, actors recognized the need for a proper meeting design to fuel discussions in a digital room. The quality of meeting management thus becomes more visible in larger meetings when more people demand answers. “In large meetings, with many agenda points, it is difficult to manage efficiently and involve all actors in a good way”, conveyed an informant in case A. Large meetings that exceed a certain number of people are more demanding both for participants and project managers. The observations were recurring in our study and also echoed by people from case B.

In case B, inefficiencies were often related to irrelevant information sharing in large meetings: “In meetings when everyone attends, they are often less efficient concerning time management, mainly because more technical discussions are brought up”, conveys one of the informants. The statement is closely related to the observations from case A, where certain participants tended to diverge from the agenda and create lengthy discussion in a digital room: “Often, people raise issues that are less relevant for the rest of the group or persist discussions longer than necessary”. This notion was often more apparent in large meetings, causing delays for everyone.

Conversely, some of the informants from case B conveyed that they did not even notice the difference between large and small teams, nor

physical and digital meetings. As mentioned, this project is smaller in size, which was also acknowledged by one of the informants: "It is easier for a smaller project to manage through [Microsoft] Teams. […] In larger projects, more professions are involved, and collaboration could become chaotic. These projects may require professional VDC people to manage the project". The observation suggests that digital communication can be a good substitute for smaller projects.

How meetings were planned and scheduled emerged as a novel challenge for our informants. When people are forced to send online invitations instead of casually scheduling meetings on the construction site, time management becomes more prominent. "The number of meetings has changed drastically. My schedule is always full", conveys an informant from project A. One of the reasons for this change could be the low barrier to arrange digital meetings: "The flipside of digital meetings is that some people become inconsiderate and invite to meetings more often than necessary", said an informant from case B. Short internal meetings, in particular, have been easier to conduct when firms use computer-mediated communication platforms like Microsoft Teams: "Previously, some decisions were made in physical meetings and the rest via mail. Now, it is much easier to arrange a video meeting", said another actor from case B. Informants in both projects have experienced so-called *meeting marathons* or *meeting fatigue*, due to significantly more meetings than before. Although there is more communication among contractors, it may not increase collaboration and efficiency. Some informants even conveyed a lower quality of meetings because of more meetings.

Another aspect of digital meeting scheduling is the dichotomy of rigidity and flexibility. In case A, they experienced that digital meetings often become more rigid than physical meetings, mostly due to a tighter schedule among actors and more meetings in general. Some actors even

conveyed reluctance to speak up in tightly scheduled meetings, with the anxiety of diverging from the agenda and consuming too much time.

In some cases, rigid meetings led to a postponement of important discussions. “Sometimes we should have had half an hour extra. […] That extra time could have been important to clarify some agenda points that needed a discussion”, said one of the informants from case A, missing more flexibility in the allotted time, “it is often better to stop the meeting 30 minutes before time than postponing an important discussion”. When schedules are tight, a recurring issue among the respondents is that relevant actors often need to drop out due to other appointments. Then it is difficult to prolong the meeting if necessary. “Often you need a new special meeting to solve the problem; however, the first available slot is in a couple of days”, conveys an informant from case A.

However, there is always an efficiency tradeoff with too much allotted time. Some discussions are unnecessarily prolonged. An informant from case A conveyed that the meetings often were too long: “Some meetings tend to be tedious and poorly planned. In my opinion, these are one hour longer than needed”. Another informant from the same project suggested a time cap for meetings: “One should aim for a maximum length of two hours meeting, preferably one to one and a half hour, and also build in breaks for variation”.

Another recurring observation that was mentioned throughout our study was reduced travel time during the pandemic. In both cases, our informants emphasized the efficiency gains accompanied by digital meetings, when distributed teams can make small decisions online instead of driving to the construction site. Given that all information is online, the informants conveyed that online clarification meetings will be utilized more frequently. However, it will depend on the possibility of co-location and distribution of sub-contractors: “If any of the actors need

to travel or the teams are distributed, I reckon that meetings will be held online”.

On the contrary, travel time was often an unconscious break from meetings. Particularly in case A, with more meetings and tighter schedules, traveling to work could be a desired interruption in the day: “People tend not to take breaks when working from home. […] Driving to a meeting may force you to take five and clear your head”. Although digital meetings have some efficiency gains, several respondents acknowledge the absence of breaks and the need for change in a digital-centered workday.

The construction industry has always been conservative and slow, which is agreed upon among informants in both projects. The consensus is that digital collaboration structure will remain; however, to what extent is yet to be discovered.

Digital Architecture

In addition to meeting structure, we found support for *digital architecture* as an important factor in designing team collaboration. Moreover, we will look into how digital tools are used and convey their effect on team structure. Throughout the study, we observed the following tools that both cases used in collaboration; Microsoft Teams, Miro, Dalux (BIM tool), and Excel. Following their use of digital tools, we will investigate how the information flow is affected by the new digital architecture.

Several informants praise the easy use of Microsoft Teams. Several functionalities are being highlighted like "it works extremely well for sharing screens with documents so that everyone can join on the same screen", "you can easily just call someone on teams if you are wondering about something", and "use it as a database for documents, so that people can make and share documents in teams, and also work in the

same document". A manager in case B conveys that "we must keep using our digital tools and make them a part of our everyday work life, I think it may increase the effectiveness of the project". Conversely, an informant conveyed the use of digital tools as "not as effective, but it has clearly given a new dimension for the general contractors, as it is a lot easier for them" and later mentioned that "we work with many different general contractors and all have their systems, everyone has their way of doing it". Another informant echoes the lack of effectiveness in digital meetings but argues that "if you had been in a room you would have written ten post-it notes and *smack* done - compared to using half an hour to move and copy-paste [digitally]". Hence, the meetings were often spent on editing the project plan as opposed to discussing issues.

In both cases, the informants conveyed a change in how progress management is implemented due to digital tools. "The thinking around how we implement has been different [compared to in a physical environment], given that we use more digital tools for project management", conveyed one of the informants from case A. The observation was echoed in case B as well:

> A significant change in project planning before and after the pandemic is the use of virtual whiteboard solutions, in which you only need a web-access to plan and visualize the project, in comparison to a meeting where everyone conveys their status in the allotted time.

Although project B did not use advanced digital tools for planning, several informants argued that a better overview would benefit the project: "A full overview of the project, as opposed to sporadic mail correspondence requests and deadlines, would have been better".

Case A used Miro as a replacement for a physical whiteboard where they used post-it notes to grasp each sub-contractors tasks and dependencies. Even if Miro was an almost identical copy of the physical process, several

informants stated that it "did not work optimally" because "people do not go on the platform and use it in the meantime". For this reason, Case A chose to move on from Miro and attempt to get a better planning process in Excel.

Dalux is a common BIM tool that is used for digital drawings. This tool has been used before the pandemic hit, so its use is not particularly different from before. The main purpose of Dalux is to coordinate drawings among subcontractors to communicate how the building will look in different stages of the project.

Excel is also used for planning between the sub-contractors. As mentioned, Case A chose to discharge their Miro board and continue on Excel. In the meanwhile, Case B had used Excel all along. Excel is now used in both cases to "see tasks and their dependencies with other tasks".

Another key aspect of digital tools is that the users must set themselves up with appropriate hardware to take advantage of all the specs and functionalities. Both case A and case B conveyed issues in this manner. An informant from case A told us that "it is typically someone without a headset or camera. And where do you sit? It is typical that there is noise in the background and it is important to avoid such issues". He adds that it was a huge issue initially but that it has become a lot better over the past months. In case B, a sub-contractor thinks it is hard for the production group to use digital tools because "we are often on the construction site and do not have a computer available. Then you must use the phone on a wireless network - which is not always optimal. If you are sharing a document, it is not easy to see what is on there".

An extension of digital tools is how the increase in virtuality can affect the team's information flow, as it is an important element of collaboration. According to several informants, the most important information is sent over mail since "in our industry written [information] is key, and verbal decisions do not count". However, four different informants raise

challenges to mail communication. In case A, one informant brings up that "You must do both, you must take the phone call before you send the mail. If not, there can be misinterpretations". The same informant also highlighted that one must take discussions over mail or it will "bite you in the ass later down the road". On the contrary, another informant from case B thinks that "it is better to meet up instead of sending mail, especially if it is mail that's negative". Moreover, physical meetings are crucial for casual conversations since "the barrier to sending a mail for a stupid question may be a bit higher than sitting next to each other around the table".

Over the last year, the information flow has become increasingly complicated as the previously digital communication through the mail is now divided over several platforms. One of the sub-contractors in case B emphasizes that "instead of just looking through the mail inbox and looking for information that you got a week ago, you must do detective work in both the mail inbox, teams and SMS, to find the information you need". The informant also points out that:

> If you only work on one project, it probably works fine, but if you prioritize other projects, you will still receive information from this project [or any other project]. Then you must start doing detective work, as I have started calling it.

For another informant, the sub-contractors "are dependent on being out there and digging for information. The more information - the better". For this reason, several sub-contractors create their systems to keep track of the information. One informant from case A uses his calendar to be aware of events and information; another from case B has an excel spreadsheet for status, todos, and information.

Several informants conveyed that casual information is more difficult to capture in a digital environment, as stated by one informant from case B.

> The moment a meeting is finished, everyone hangs up. […] In a physical meeting, we can join each other on the way out. If you suddenly remember to bring something up that only concerns part of the team, you can do it more casually.

This casual information seems to be crucial to resolve misunderstandings and clarify more subtle issues. Also, the first-hand information you receive on the construction site is more difficult to seize when information is conveyed only verbally or through a 3D visualization. "You receive a complete picture of the project by being on the site and talking to the operational staff", conveyed one actor in case A.

4.2.3 Cultural Factors Affecting Collaboration

Human Relations

As mentioned in theory, building relational ties between team members will affect team culture and improve collaboration. To investigate this manner, this section will explain (1) how the informants value human relationships and (2) the challenges in building relations in a virtual environment.

The common ground seems to be a success factor for collaboration in the construction industry. An actor in project A conveys the urgency of productive relationships:

> Most of the actors in construction projects have not worked together before. […] You need to interact with people and get to know them pretty fast. In one and a half years, the project should be complete without errors and omissions.

With a short time frame and high complexity, a collectivist culture is what keeps the project together and spur collaboration.

In a digital environment, we observed that lack of relations created some novel challenges for the respondents. Generally, contractors that have not met physically before have less information to build an impression. An actor in project A conveyed that:

> When meeting digitally, you only get 40% of their personality, as opposed to when you meet physically. The experience of communication in a digital room versus physically is thus very different. […] It is easier when you have a face to relate to.

Without a clear notion of how your peers think, it seems like the problem-solving process becomes more tedious.

When the pandemic broke out, the design phase of project A was not initiated yet. There were still contracting meetings, which were held online: “Before you start the cooperation, there are several contractual issues that need to be clarified. In a digital environment, you do not get the same relation. […] Often, we end up discussing things that do not matter”, conveys one of the actors. Establish contractual relationships thus take more time and demand more meetings in a digital environment.

Furthermore, a proper kick-off seems to be essential to establish common goals for new projects. Project A was supposed to implement a VDC structure for the operational team. However, it was difficult without a physical kick-off: “Through a kick-off, we can gather all the subcontractors and convey our ideas with everyone’s full attention. Then, it is easier to show them the positive aspects of a new structure. These kick-offs have disappeared during the pandemic”.

Previously, the actors were used to long weekends with team-building activities to stimulate relationships and collectivist culture. Several informants conveyed that a physical meet-up was crucial for a successful digital collaboration. “The first meeting with new clients is always difficult if we have not met physically. You cannot obtain their body language and create the same connection through [Microsoft] Teams, which is important to establish a foundation for collaboration”, said one actor in project A, “if I have met the people physically, it is easier to collaborate digitally afterwards”.

Project B was set back a couple of times during the project, which put significant pressure on everyone’s delivery and project management became critical. In such stressed situations where you only rely on computer-mediated communication, our respondents explained the benefits of a good relationship for efficient collaboration: “Something is more difficult to coordinate, and when meetings are hastened, people tend to be more tense. If you know the people you work with, you have

met them personally and know how they will manage these situations. It becomes much easier". Another actor in project B also conveyed: "The risk of conflict is often lower if you know your peers, as opposed to working with new people". Participants from project A seemed to echo these observations when conducting larger meetings with a lot of new faces.

Our observations suggest that intra firm collaboration is often easier to handle than complex multidisciplinary project teams. Within the same firm, actors have the same values, follow the same procedures, and work against a common goal. An actor in project A explains why these relationships facilitate digital collaboration: "Again, it is your colleagues that you work with every day. The relationships are more relaxed, with a low threshold to speak one's mind. […] Then, the threshold to call via [Microsoft] Teams or send an email is also lower".

How the construction industry creates and maintains the relationships has changed dramatically during the pandemic. The transition from a physical work environment to computer-mediated communication seems to have raised the barriers to build good relationships with fellow contractors. "Previously, I was out on the site, talking to everyone and trying to establish relationships with all the partners. […] This aspect is gone. Now I am only communicating with one person from each firm", conveying an actor on project A. Digital meetings do not seem to give the same connection as physical meetings, which is vital in building and maintaining good relations. "You do not know the person in the same way when only communicating through a screen. In this project, I have not met any of the consultants I am working with, apart from seeing them online", explained an actor in project B.

In both projects A and B, several respondents pointed to the sudden absence of spontaneous conversations as a reason for more distant relationships in a digital environment. An informant in case B stated that:

> The coffee talk is about getting acquainted with each other. […] You will have a whole other interaction with people when being in the same room, reading each other's body language and talking about personal topics. The barriers are higher through a screen.

Hence, building relationships through personal conversations have been forgotten during the pandemic.

In both projects, our informants also experienced more professionalism in meeting culture compared to pre-Covid meetings. Meetings seem to have a stricter agenda and higher threshold to bring up unrelated topics. Although this could enhance efficiency, our observations suggest a harmful effect on personal relationships. In project B, one actor conveyed: "In larger meetings with more than ten people, the agenda is particular. Then, the personal conversations disappear. […] This is easier when we can talk to people physically, in between meetings".

In project A, some of the actors have initiated one-on-one meetings with the project leaders. Our observations suggest that these meetings partly substitute casual conversations, being a critical arena for maintaining relationships and building trust: "I'm frequently calling the project leader outside meetings also. Then, we often diverge from the professional agenda and bring up personal stuff. This helps create trust between us". Another actor has scheduled bi-weekly meetings with the project leader to align and concur on current problems: "It is an informal sit-down on [Microsoft] Teams, with more space to discuss and think about challenges. Such meetings go smoother with a loose agenda".

Due to the observed deficiencies of digital meetings, both projects believe that physical meeting structure will revert post-pandemic to facilitate better relationships. Although relationships between project leaders and subcontractors could be established digitally, physical meetings seem

more suitable to facilitate collaboration among the subcontractors. A sub-contractor in case A conveys that:

> It is easier to see how people respond and adapt accordingly in a physical environment. In our industry, being able to adapt to your peers is crucial. Then it is easier to motivate people to pull in the same direction. […] [In a project,] you need to create a collective culture quickly. Then it is essential to facilitate good interaction between people. [Microsoft] Teams is probably not the best platform for this.

Social behavior

Our results show three different challenges regarding the change in social behaviors when the team transitioned to a virtual environment. In this section, they will be presented in the following order; (1) Unsystematic video conferencing behavior, (2) Coordination issues in problem-solving processes, and (3) Increase in multitasking.

Even if many wish to collaborate physically, not everyone finds the use of video that important. Most informants in case A conveys opinions like "I do not like when people do not use cameras since it does not feel as close. You do not get the same interaction and do not know whom you are talking to", "People should use camera", and "I have been very clear in my opinion about it. I mean everyone should be on video all the time when sitting in digital meetings. I expect it". An interesting finding from case A is that even if the majority thinks that video is an essential part of communication over teams, we observed on several occasions that people did not always use it. At both the ICE- and progress meeting with ten participants each, only five people in each meeting started with their video camera on. At the ICE-meeting even several people turned off their

cameras as they were supposed to work individually with their post-it notes in Miro. Several discussions were held without the camera, so it did not seem to be a routine to have it on or off. Only one informant from case A admitted that:

> It does not matter that much to me since we have talked before [...] we can turn on the camera when we talk to each other so that you can easily understand who is talking because everybody is listening. I do not see a problem with it, but it is nice to see people of course.

Most of the team in case B also express that "it is better to see people's faces", "everyone has their camera on", "everyone uses the camera so that no one shouts out from a black corner with a comment". On the contrary, one of the informants raises the issue of multitasking and says that "it is a lot on the agenda that is not relevant for everyone. On a pressured workday it is easy to do something else on the side and turn off the camera so that no one can see it, then I listen with half an ear".

Compared to case A, fewer people were off-camera, two out of seven to be exact, but also here they had some discussions without seeing each other on camera.

We are moving on to the second social challenge - *coordination between team members*. When designing buildings, coordination between subcontractors and task collisions are common complex problems that they need to solve in the construction industry. An informant from case A, when asked if the problem-solving process had changed in any way, said "no, absolutely not" and argued that it works great because "it is an issue that concerns everyone [in the meeting], then you will not sit and do other stuff". As stated by several informants on case A there has been some issues, "there has been some bad communication between the subcontractors now" and "we have had issues with bringing up everyone's needs, and maybe we should focus more on it in the ICE-meetings".

In other words, not everyone thinks that the problem-solving process works excellent as “there are some challenges with it [coordination]. In my opinion, it is easier to give comments when you create a drawing over the table together. The less trivial ones [problems] often take a little longer”. The same informant reflects about problem-solving with digital communication compared to physical and emphasizes that:

> It is about talking about our problems. If you make a strong agenda for a meeting and are going through with it, then you do not get room to discuss and think properly so that you are on the same wavelength as the rest of the team.

Another informant agrees by saying that “it is a lot easier to spot things when you sit together and look at the same problem. Even if you share a screen digitally, you get different perceptions when you are together”.

Case B have also had their issues. During the project, they had to stop the progression due to design problems discovered late in the design phase, but luckily before it was too late. As shown in the case description, the sub-contractors are also responsible for the engineering. In the light of this, they have had issues coordinating with each other since “others do not know that an object is coming on that position [in the building], if he does not draw it in the model”. A subcontractor also addresses the problem with collisions between the different disciplines and states that “there should be an alert system”.

Informants from both cases express that they experience misunderstandings more often compared to physical teams. Misunderstandings can be a problem when solving complex problems as it is "harder to explain, and it gets a lot back and forth with specific technical details". People missing the message is one thing; another informant reveals that he is frustrated over repeating himself: "it doesn't feel like the message always gets understood, and does not get feedback

if they have understood it". Two managers conveyed that they must spend more time on each person with each activity to confirm that they have a common understanding of the activity as they have "seen that it has occurred a lot more misunderstandings".

So there have been some difficulties in coordinating to solving these complex problems, but why is it so hard to solve them digitally compared to when you meet face to face? A factor that comes up in several interviews is the need for visualization. The informants argue that “when you look at the same issue you get another interaction with other people, and get another kind of dialog”, in addition to “when we stand together it is possible to communicate if it is something we observe”. Our human minds work differently, and some people have a more remarkable problem-solving ability when they see the actual issue in front of them.

As a consequence of increasingly more digital tools, virtual teams are challenged with the notion of multitasking. In case A, an informant contemplates that “most people have several screens at their office, one with [Microsoft] Teams in the corner, one with mails and other documents, then you do not get the interaction you want”. Among the sub-contractors, a preponderance of people admit that they do not pay attention when other disciplines than their own are in focus. When asked why we got responses like “trying to squeeze in as much work as possible”, “it is a lot easier to sit in your own world [...] and do some other stuff even if some information from the meeting is nice to know”, and “it is too easy to work simultaneously while you lack focus in a meeting”. Compared to physical meetings, “people would pay more attention to what the other disciplines are doing”.

On the other hand, at project B, several informants disclose that they pay attention to the other disciplines since "when the manager asks how we are coming along, then every discipline talks for 10-20 seconds, it is not very comprehensive". Our case B observation also revealed that there

was a short and practical agenda. It seemed like participants had incorporated the meeting routines. A manager remarks that "I do not have the impression [that they multitask], when we meet up we use video and you would see if they do something else". The other manager agrees by saying, "I think it is surprising how much the team pays attention. They have been very awake".

It appears like project B has reflected over the issue of multitasking, as an informant highlights that: “To get an excellent multidisciplinary process, you need to understand what the other team members do. Going digital has possibly turned this out a bit negative when it is so easy to do other stuff at the same time”.

One informant admits that he multitasks, and another mentions that he can understand why some people choose to do it. In other words, neither project B is perfect in terms of being focused 100% of the time.

5 Discussion

As mentioned in our key findings, the structure-culture interdependency is a crucial relationship for successful collaboration in multidisciplinary teams.When working in virtual teams, our informants elaborated on the cultural challenges that arose, such as lack of relations and change in behavior. Consequently, novel challenges as multitasking, misunderstandings, and social loafing emerged in meetings.

We argue for two ways of improving the structure-culture fit: (1) changing the structure so that it reinforces the virtual culture, or (2) dilute virtual culture challenges so that it is more similar to the physical culture - so that the current structure can be appropriate. Several studies have investigated team structures and culture. However, few studies have been conducted on how these dimensions are affected when collaboration in multidisciplinary teams is forced online. For this reason, we will contribute by illuminating four critical aspects to improve structure-culture fit in virtual teams: team size, structured use of video, the multitasking paradox, and leadership style. We will delve further into the aspects mentioned above and discuss them, considering relevant theory. The discussion aims to shed light on our findings and clarify their implications for further research and for practitioners that want to utilize effective collaboration in virtual and multidisciplinary teams.

5.1 Structure-culture fit

5.1.1 Appropriate Team Size

During our research, we discovered that team size plays a critical role in the quality of communication in digital meetings, as larger meetings suffer from more changes in human behavior than small meetings. Although face-to-face communication and video conferencing are

associated with high media synchronicity, our findings present several challenges regarding team size that the informants had not experienced pre-Covid. When asking the informants whether the number of participants matters in virtual collaboration, the majority answered that smaller teams were more efficient than larger teams. Our findings echo the notion that social loafing (Alnuaimi et al., 2010), misunderstandings (DeLuca and Valacich, 2006), and multitasking (Spithoven, 2003) often emerge in digital collaboration. However, we found that these effects were more present in larger teams.

In our case study, project leaders conveyed that the purpose of larger meetings was to update progress, clarify subproblems and decide on plans. The meetings were designed to replicate ICE-meetings (Kunz and Fischer, 2011) in which all disciplines relevant to the current phase were represented. These meetings can be characterized as convergence processes (Dennis et al., 2008) and require a high degree of media synchronicity. Considering MST, we argue that the combination of video conferencing and a shared screen for visualization should promote enough synchronicity to enable convergence (DeLuca and Valacich, 2006). Hence, the challenges uncovered in larger teams may relate to other issues than synchronicity.

Our informants conveyed that large meetings often become lengthy and not always relevant to their discipline. From the subcontractors' point of view, the purpose of these meetings tended to diverge toward task management rather than clarification. According to MST (Dennis et al., 2008), most communication was thus conveyance processes which could be communicated through mediums with lower synchronicity and higher reprocessability. Furthermore, although digital tools were already implemented to streamline project management, most informants did not use them. One could argue that the findings contradict the need for lower synchronicity; however, due to lack of experience with digital tools, individuals favor familiarity with efficiency, and less synchronous

communication media has been neglected (Dennis et al., 2008). Informants also pointed to system overload (Mendelson and Pillai, 1998), in which individuals' ability to process information from multiple media is restricted. We argue that certain information needs a longer processing time to reap the benefits of expert diversity in multidisciplinary teams (Van der Vegt and Bunderson, 2005).

When we asked the informants whether they felt understood in digital meetings, consensus conveyed that misunderstandings more often occurred in larger virtual meetings. Considering the findings, we argue that misunderstanding arises due to lack of attention in larger teams (Alnuaimi et al., 2010) coupled with diverging absorptive capacity among members in the digital environment (Zahra and George, 2002). Although misunderstandings could be described by digital media's lower ability to display nonverbal cues (Dennis et al., 2008), we convey a broader structural-cultural explanation. Individuals process information differently (Massey and Montoya-Weiss, 2006), which is prominent in multidisciplinary teams. We observed through our study that operational professions had a preference towards direct knowledge (Cramton, 2001), in which problems are interpreted and solved at the construction site. On the other hand, engineers are more used to 3D visualization. In larger meetings, with participants that do not know each other, these differences are difficult to account for when communicating. Furthermore, we echo Cramton (2001) that individuals' ability to understand how team members process information is crucial to promote mutual understanding and avoid misunderstandings. Lack of human relations due to digital collaboration also amplifies these challenges (Dennis et al. 2008).

Throughout our study, informants conveyed that interactions became more complicated when meetings exceeded ten participants, echoing Alnuaimi et al. (2010) theory about team size. Smaller meetings with less than five people seem to be more efficient and easier to conduct. Shorter meetings with fewer participants also free up team members' schedules to

enable asynchronous idea generation between convergence meetings (Malhotra et al., 2007). In addition to the factors mentioned above, social loafing and multitasking were brought up as a critical dimension for lower efficiency in large virtual teams instead of smaller meetings (Alnuaimi et al., 2010). The finding further emphasizes our argument that synchronicity is also dependent on meeting structure. Chidambaram and Tung (2005) argue that when individuals feel that their contribution is less significant for the team's success, they tend to be less active in discussions. We observed that smaller meetings obliged more interactivity from participants, leading to higher synchronicity. The problems were also more complex and required presence from all the parties to reach a decision.

Although one could argue that video conferencing cannot facilitate synchronicity, we argue that the size of meetings is an equally important reason for the challenges, as mentioned earlier. On the one hand, it is more efficient to involve everyone simultaneously, but consequently, actors tend to lose attention and miss out on important information. Hence, team size should be considered with synchronicity in teamwork.

5.1.2 Structuring Video Conferencing

Our study emphasizes the use of cameras in video meetings as an important aspect of digital collaboration. Interestingly, we found conflicting results on the use of cameras in our research. On the one hand, informants consider it essential to have the camera on. However, our observations indicate that few obey this notion.

Our findings echo two theories in terms of video usage. Firstly, our informants argued that video conferencing was valuable when the team encountered complex discussions that required high synchronicity, especially when face-to-face interactions were impossible. We echo

Dennis et al. 's (2008) MST in that use of video more non-verbal cues that help mitigate the risk of misunderstandings. Multiple ways to encode information are even more crucial when team members lack solid relational ties. Secondly, our results imply that the use of video is closely related to team cohesiveness (Wendt et al., 2009). However, whether the use of video enhances team commitment or team members that are initially committed are more inclined to adopt video in meetings needs to be further explored.

Furthermore, we observed that teams did not distinguish between convergence and conveyance processes in video usage. Although Dennis et al. (2008) argue that some meetings require higher media synchronicity, team members seemed less aware of this. Recent research shows that overextended use of video conferencing can cause fatigue, as it is a more draining media channel compared to physical meetings (Fosslien and Duffy, 2020). Our study supports these findings in which informants conveyed a feeling of exhaustion with more frequent and more prolonged meetings video meetings. As a consequence, team members suffer from lapses of attention (Uncapher and Wagner, 2018). We argue that such selective attention affects media synchronicity negatively and needs to be considered when structuring meetings.

The researchers, as mentioned above, have pointed out several aspects of the use of video (Dennis et al., 2008; Fosslien and Duffy, 2020), but there is a lack of practical guidance on the systematic use of it. For this reason, taking both the upsides and downsides of video conferencing into account, we emphasize finding a middle way to benefit from videoconferencing possibilities and avoid losing focus due to fatigue. We suggest that instead of sporadic use of video where some people choose to have the camera on and others off, the team should categorize different meetings or discussions as on-zone or off-zone. Such categorization can ensure that information that requires higher synchronicity will be communicated efficiently with video.

5.1.3 Solving the Multitasking Paradox

Throughout our study, multitasking was brought up as a novel challenge in the aftermath of digital collaboration. In the literature, multitasking is one of the leading causes of the dramatic increase in productivity over the past decade, especially in organizations with extensive use of IT (Spithoven, 2003). As members of a multidisciplinary team often hold obligations beyond the single project, multitasking is a way to deal with extensive workloads. In the construction industry context, subcontractors are forced to deliver as fast as possible within a strict budget. Thus, when working on several projects simultaneously, multitasking could be beneficial as an attempt to increase personal productivity.

An increase in productivity due to multitasking sounds promising, but the productivity paradox is a two-way street. Empirical studies strongly imply that multitasking in a virtual environment increases completion time; however, it reduces task performance (Freedman, 2007; Pashler, 2000). Our informants presented several examples of incomplete tasks due to high workload that caused postponements in the projects. Although our findings suggest that this could have been avoided in a physical environment, there is no clear evidence if multitasking is the reason for lower task performance.

From a team perspective, our findings indicate that multitasking can increase productivity in low complexity tasks or meetings. Furthermore, if the meeting requires great attention and involvement, multitasking may harm task performance. To our knowledge, there is little previous research explaining how multitasking affects different types of problem-solving in virtual teams. Our findings could be viewed in conjunction with Lojeski, Reilly, and Dominick's (2007) research on innovation and multitasking. They found that lower levels of multitasking are positive for innovation; however, these benefits diminish as the degree of multitasking increases. We will emphasize that our findings

should be further researched to clarify multitasking's effect on team performance in multidisciplinary virtual teams.

5.1.4 The Dichotomy of Leadership Style

Our study suggests that leadership style could play a vital role in how problem-solving is performed in a virtual environment. Conventional wisdom from the extant literature states that interpersonal relationships are difficult to establish in virtual teams due to limited physical interaction (Jarvenpaa and Leidner 1999; Paul and McDaniel 2004). Our findings suggest that leaders could dilute these adverse effects with an appropriate leadership style. We echo Kirkman et al. (2002) that leaders need to adopt a relationship-oriented awareness and proactively reach out to team members to establish relationships. Anecdotally, informants that had a one-on-one with the project leader found common ground more often than those that did not practice this. Although "virtual get-togethers" (Malhotra et al. 2007) were not trialed in our study, several informants conveyed the lack of non-professional interactions. They longed for more social activities to establish relationships. We suggest that future research should be conducted to assess this notion further.

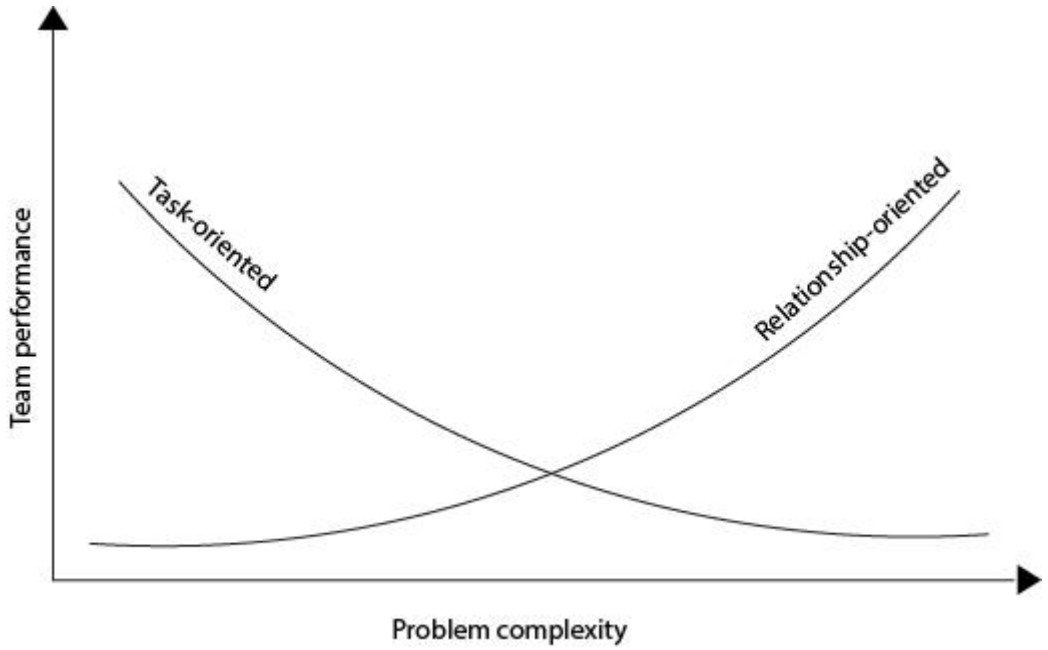

Figure 7: Leadership style in relation to problem complexity and team performance (self made but inspired from Kirkman et al. (2002)).

Although relationship-oriented leadership is acknowledged as superior to task-oriented behavior in the literature (Martin et al., 2013), we found some examples in our study in which directive leadership (Wendt et al., 2009) was more appropriate in less complex meetings (see Figure 7). Anecdotally, task-oriented leadership provides more clarity in meetings, which facilitates efficient clarification in digital meetings. We observed that when leaders were unclear and more concerned about involving other actors, such meetings were also more chaotic. Although Wendt et al. (2009) argues for a negative relationship between team cohesiveness and task-oriented leadership style, our findings suggest that professionalism could be an equally strong relational tie in a multidisciplinary team. Our study echoes Kirkman et al. (2002) in that task-based relationships could evolve when team members trust the work ethic of their coworkers.

Our findings suggest that leadership style is decisive for how meetings are structured and performed. Furthermore, we argue that task- and relationship-oriented behavior is closely related to the contradictory dilemma between rigid and flexible meeting management (Koppenjan et

al., 2011). In our study, the task-oriented style often imposed rigidity and high barriers to diverge from the agenda. While rigid meetings are crucial to prompt efficiency and avoid deep-knowledge sharing (Majchrzak et al., 2012), we also found that such structure often inhibits creativity and interpersonal conversations, which is crucial to complex problem solving (Ratcheva, 2009). The findings reemphasize the importance of alignment between leadership style and problem complexity.

In summary, we advocate that leaders need to deploy both styles to enhance team performance. Choice of leadership style is both a question about task complexity and team maturity. As shown in figure 7, we argue that relationship- and task-oriented leadership behavior is negatively correlated with team performance and problem complexity. Additionally, task-oriented behavior is vital in the inception phase (McGrath, 1991) to establish structure and professional trust (Wendt et al., 2009). However, relational awareness is the sustainable behavior for effective collaboration. Our findings are highly anecdotal and need to be further examined in future research.

5.2 Managerial Implications

Our study shows that digital collaboration could positively affect performance in multidisciplinary teams, especially for smaller teams with particular geographical dispersion. However, choosing an appropriate structure to facilitate collaboration requires understanding how the structure affects interpersonal relations and vice versa. Matching communication processes with the appropriate digital tool seems to be crucial to enable fruitful digital collaboration. Promoting and educating on computer-mediated project management tools for information sharing and asynchronous idea generation (Malhotra et al., 2007) may increase the exploitation of diversity. However, maturity level and familiarity with technology play a crucial role in deploying digital tools that practitioners

need to bear in mind. As the only non-verbal interaction, video conferencing should be focused on shared understanding and relational ties among the members. Virtual meetings should be restricted both in time and team size to allow for interaction and knowledge integration. Additionally, it is recommended to consider the use of video when structuring communication in a digital environment. Intense exposure to video meetings is proven to influence attention span and cause meeting fatigue (Fosslien and Duffy, 2020). Practitioners may increase the cultural outcome by employing a relationship-oriented leadership style; however, some more immature teams will require supervising behavior. By and large, a dedicated structure for digital collaboration may increase the likelihood of successful collaboration and enable a collective culture in a non-physical environment.

5.3 Theoretical Implications

Many existing studies in the broader literature have examined how structure and culture affect collaboration and team performance. However, questions on how the structure and culture and their interdependence changes when transitioning to a digital environment were unaddressed. We contribute to collaboration theory by discovering how virtual interaction affects the culture in multidisciplinary teams. In addition, this thesis extracts learnings from two multidisciplinary team collaborations on how the structure and culture can be aligned for effective collaboration and better team performance. We also contribute to digital transformation theory, where our findings help understand collaboration changes during digital transformations.

5.4 Limitations and Future Research

Our anecdotal conclusions provide a practical basis for understanding and influencing the interdependency between structure and culture in virtual teams. There are two significant limitations in our research. The first is that the sample is composed exclusively of the construction industry and with only two in-depth cases. Consequently, the results may not be generalizable for virtual teams in other industries or organizations. The second limitation is that this study took place in January-June 2021, and longitudinal effects have not been investigated. Understanding how teams adapt to the cultural and structural challenges in a digital environment is desirable to explore in future longitudinal studies.

As previously mentioned in the discussion, future research is needed to understand how (1) multitasking and (2) leadership styles affect team performance in multidisciplinary virtual teams. We also suggest that future research should aim to investigate digital collaboration in different types of teams. The literature might construct a generalizable understanding of the structural and cultural factors by investigating different types of teams and their virtual collaboration, as our findings only concern multidisciplinary teams.

6 Conclusion

This study aimed to investigate *how the adoption of virtual interaction affects collaboration in multidisciplinary teams,* particularly how the team structure and culture get affected by digital collaboration. Our research adds to a growing corpus of research showing that structure and culture are foundations of effective collaboration. Our main contribution is the understanding of the structure-culture alignment in a virtual environment. The results indicate that the team often attracts to a familiar structure. However, continuing with the same structure as in physical collaboration does not account for cultural changes, such as multitasking, social loafing, and lack of human relations. To successfully collaborate in virtual teams, the structure and culture need to be aligned to harvest the benefits of working digitally and preventing opposing cultural challenges. To ensure a better structure-culture fit in virtual environments, we contribute with four proposals: (1) have appropriate team size, (2) proper use of video, (3) limit but not eliminate multitasking and (4) employ appropriate leadership style.

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8 Appendices

8.1 Appendix A - The Interview Guide

The Interview Guide

1 Formal Introduction

- ☐ “This is us,” a quick intro about the authors and thesis process
- ☐ The purpose of this interview is to get an insight on how you collaborate virtually with your team, and how it differs from previously physical collaboration.
- ☐ We are recording and transcribing the interview.
- ☐ All files and transcriptions are confidential. They will not be published or handled by
- ☐ others. We will delete the files when we complete the thesis.
- ☐ Data included in the thesis is anonymized.
- ☐ Your colleagues will not see or hear this interview, and vice versa.
- ☐ Do you have any questions for us before we begin?

2 Interview Questions

2.1 Who are we talking to?

- What is your role in this project?
- For how long have you been in this project?
- How long have you been in the industry?
- How much experience do you have with online collaboration pre covid?
- What do you think is unique about the construction industry compared to other industries?

2.2 Digital tools

- How has your transition to the daily use of digital tools been? How would you compare your previous experience to now?

    - Do you believe your team has the same perception?
- How did you solve complex tasks in similar projects pre covid?
    - And how do you do it today?
- What is your biggest challenge with digital tools?
- What has positively affected your everyday work?

2.3 Communication

- How has the quality of the communication changed as you have transitioned to digital tools?
- Do you feel you spend more or less time communicating with others?
- Do you ever feel misunderstood? More than before?
    - Can you provide an example?
- How is it to build relation to others while collaborating online?
    - Does it influence you or your team in any way?
- What do you think about communication with or without using video in online meetings?
- How do digital meetings affect the team's collaboration and conflict management?
- How has covid affected the information flow in your work life?
    - Do you get less or more documents sent over by mail?
    - Do you communicate with more or less people than before?
- How do you get the information you need for the job you are going to do?
- How do you handle urgent clarifications?
- What work processes/routines do you think you will take with you after covid?

2.4 Meeting structure

- What challenges have you faced during digital meetings?
    - What is important in a meeting? What has worked before?
    - How could the meeting be organized better?
- How does a digital meeting facilitate coordination and progress planning?
- How does a digital meeting facilitate clarification issues?

- How does the meeting differ when there are many participants vs. few participants?

3 Formal Outro

Thank you for your time, one final question - do you have anything you would like to share that we have not touched upon that affects your or your team's virtual collaboration?

8.2 Appendix B - Data structure

Case	Examples of 1st Order Codes	2nd Order Code	Aggregate Dimension
A	Simpler clarification meetings works great digitally	Meeting Structure	Structure
A	I think the case company are in on something when they try to split up the larger meetings		
B	Communication have been traditional for a long time, i think virtual meetings for clarifications will increase efficiency		
B	Hope to be meeting out on the construction site soon, it is a lot easier.		
A	Digital meetings works if it is few participants and a simple agenda, not too many technical issues		
A	Short and small meetings works great digitally		
A	Hard to manage the larger meetings as everyone wants their answers		
B	Thinks it is easier for smaller projects to work in a virtual environment		
B	It's hard to communicate in larger meetings, the efficiency decreases a lot when we are over 6-8 people.		
A	Important to have one plan the subcontractors could obey		
A	Thinks cooperation would be better if the general contractor could let go and not try to micromanage		
B	We try to stay on the agenda		
B	Virtual meetings was managed more decisive as opposed to physical meetings		
A	You try to squeeze in a meeting wherever you can		
A	At lest 30% of the people have to leave on time even if we are not finished, since they have other meetings		
B	It's very easy to just send out a meeting invitation		
B	A lot more short meetings, meetings about things that you normally would have agreed upon on site		
A	Teams is great for sharing screens and documents	Digital Architecture	
A	When working with different general contractors - everyone got their own system..		
A	It is not as effective, but it has clearly given a new dimension for the general contractors, as it is a lot easier for them		
B	Great for sharing documents and make documents so that you can work in the same document at the same time		
B	You get used to Teams for communication. In the beginning there		

	were some difficulties		
A	It is a norm that everything agreed upon should be communicated by email		
A	I create my own system to keep track on information		
B	Need to search for the information i need, often difficult when it is a lot of different platforms		
B	It is hard to get the right information at the right time when working on several projects		
A	It's easier to become acquainted when you also can assess the body language	Human relations	Culture
A	In strong relations, the collaboration is more relaxed, with lower threshold to speak one's mind		
B	When you don't know each other, it is more difficult to know how your team members react in stressed situations		
B	Risk of conflict is often higher if you don't know your team members		
A	You lose the casual chat that you have in between meetings		
A	You get a different relation to people		
B	Hard to build relationships online since you get to know people easier when meeting physically.		
B	Meeting people makes better collaboration and dialog		
A	I don't like when people dont use video, it does not feel as close	Social behavior	
A	It does not matter that much to me, i know who i am talking to		
B	Everyone use video		
B	It is recommended, but not everyone does it		
A	No change in complex problem solving		
A	Everyone pays attention when solving complex problems		
A	Challenging to solve complex problems due to human interaction		
A	Need to talk about the complex problems face-to-face		
B	There should be an problem alert system		
B	Harder to solve complex problem because people use digital tools differently		
A	People are set up with several screens and do other stuff, we don't get the interaction we need		
A	People try to squeeze in as much work as possible		
A	It is very easy to start doing something else		
B	Don't have the impression of people multitasking		
B	I do something else if the meeting is about something else than my subject		
B	I understand why some people do it, when their subject is not on the agenda		

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