Computer-Supported **Hybrid** Cooperative Work

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PhD Thesis

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Abstract

This PhD examines the future of work after the COVID-19 pandemic, which introduced abrupt changes in work practices. The impacts of long-term work-from-home arrangements extend beyond the lockdown periods and have reshaped work preferences, work-life balance, organizational management, and the integration of technologies that facilitate collaboration across distances. Situated within the field of computer-supported cooperative work (CSCW), this PhD researches the nature of contemporary work practices, focusing on what is important in designing cooperative technologies for **hybrid work**. In this PhD thesis, hybrid work is defined as cooperative engagements involving at least three mutually dependent individuals distributed across various physical and digital settings, where the number of contexts is fewer than the number of individuals participating. Thus, hybrid configurations always represent both collocated and distributed individuals whose cooperative work is enabled by multiple physical and digital technologies.

To uncover different perspectives of cooperative technologies for hybrid cooperative work, the research employs a mixed-method approach, integrating qualitative insights from literature and ethnographic studies, as well as quantitative data from a survey. This PhD thesis includes five research papers that, through different research lenses, provide distinct conceptualizations of hybrid work. These papers are:

Paper I: Melanie Duckert, Louise Barkhuus, and Pernille Bjørn. 2023. Collocated Distance: A Fundamental Challenge for the Design of Hybrid Work Technologies. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 612, 1–16. https://doi.org/10.1145/3544548.3580899

Paper II: Melanie Duckert and Pernille Bjørn. 2025. Location Multiplicity: Lost Space at the Hybrid Office. In *Proceedings of ACM Human-Computer Interaction*. 9, 2, Article CSCW126 (April 2025), 25 pages. https://doi.org/10.1145/3711024

Paper III: Melanie Duckert, Charlotte Lee, and Pernille Bjørn. 2025. The Ripple Effect of Information Infrastructures. In *Computer Supported Cooperative Work (CSCW)*. Springer. https://doi-org/10.1007/s10606-024-09509-7

Paper IV: Melanie Duckert and Pernille Bjørn. 2024. Revisiting Grudin's eight challenges for developers of groupware technologies 30 years later. *i-com, CSCW special issue*, Vol. 23 (Issue 1), pp. 7-31. https://doi.org/10.1515/icom-2023-0039

Paper V: Melanie Duckert, Morten Hertzum, and Pernille Bjørn. 2024. How Distance Matters in Dynamic Work Environments. Submitted to an IS journal. (under review)

Paper I studies the nature of hybrid work to develop a conceptual definition and identify **specific characteristics** of this type of cooperative engagement. Paper II explores the **spatial challenges** in producing shared hybrid environments to identify implications for technology design and organizational structures that align with the post-pandemic challenge of re-introducing physical elements of the office space in organizational work. Paper III takes an infrastructural perspective to study the **co-evolvement of work and information infrastructures** and identifies conceptual ways that local work contexts are shaped and scoped by the broader information infrastructure on multiple

scales. Paper IV defines specific **design challenges** for developers of cooperative systems supporting work in hybrid office settings with an emphasis on technologies' reconfigurability and alignment with existing technologies. Paper V identifies and examines **factors** that are important in contemporary work environments and explores their correlations. The findings suggest the significance of organizational structures that support collocated interdependencies while still offering employees the flexibility to work from remote locations.

This PhD thesis brings together these findings and insights across the included research papers and proposes a framework of **dimensional interdependencies in hybrid work**. By conceptualizing the spectrum of cooperative work, the PhD thesis identifies unique characteristics of hybrid work, presents design propositions for technologies supporting hybrid practices, and addresses organizational complexities in managing contemporary work environments. The proposed framework unifies these perspectives, emphasizing the interdependent nature of cooperative work, the ecologies of technology artifacts supporting this work, the inherently multiple spatial contexts, and the organizational structuring – dimensions that should all be considered when designing computing technologies for hybrid cooperative work.

Keywords: hybrid work, cooperative technology, mixed-method research, conceptual frameworks

Resumé

Denne Ph.d.-afhandling udforsker fremtidens arbejde efter COVID-19-pandemien, som medførte pludselige ændringer i arbejdspraksisser. Konsekvenserne af de langvarige hjemmearbejdsbetingelser rækker ud over selve nedlukningsperioderne og har omformet arbejdspræferencer, balancen mellem arbejde og privatliv, organisationsledelse og integrationen af teknologier, der muliggør samarbejde på tværs af afstande. Med afsæt i forskningsfeltet Computer-Supported Cooperative Work (CSCW) undersøger denne Ph.d.-afhandling nutidige arbejdspraksisser med fokus på, hvad der er vigtigt i design af samarbejdsteknologier til **hybridarbejde**. I denne afhandling defineres hybridarbejde som samarbejdsrelationer, der involverer mindst tre gensidigt afhængige individer fordelt på forskellige fysiske og digitale kontekster, hvor antallet af kontekster er færre end antallet af deltagere. Dermed repræsenterer hybride konfigurationer altid *både* samlokaliserede og distribuerede individer, hvis samarbejde understøttes af adskillig fysiske og digitale teknologier.

For at afdække forskellige perspektiver på samarbejdsteknologier til hybridarbejde tager forskningen en mixed-method-tilgang, der kombinerer kvalitative indsigter fra litteratur og etnografiske studier med kvantitative data fra en spørgeskemaundersøgelse. Denne Ph.d.-afhandling inkluderer fem forskningsartikler, der gennem forskellige analytiske perspektiver bidrager med distinkte konceptualiseringer af hybridarbejde. Artiklerne er:

Artikel I: Melanie Duckert, Louise Barkhuus, and Pernille Bjørn. 2023. Collocated Distance: A Fundamental Challenge for the Design of Hybrid Work Technologies. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23).* Association for Computing Machinery, New York, NY, USA, Article 612, 1–16. https://doi.org/10.1145/3544548.3580899

Artikel II: Melanie Duckert and Pernille Bjørn. 2025. Location Multiplicity: Lost Space at the Hybrid Office. In *Proceedings of ACM Human-Computer Interaction.* 9, 2, Article CSCW126 (April 2025), 25 pages. https://doi.org/10.1145/3711024

Artikel III: Melanie Duckert, Charlotte Lee, and Pernille Bjørn. 2025. The Ripple Effect of Information Infrastructures. In *Computer Supported Cooperative Work (CSCW).* Springer. https://doi-org/10.1007/s10606-024-09509-7

Artikel IV: Melanie Duckert and Pernille Bjørn. 2024. Revisiting Grudin's eight challenges for developers of groupware technologies 30 years later. *i-com, CSCW special issue*, Vol. 23 (Issue 1), pp. 7-31. https://doi.org/10.1515/icom-2023-0039

Artikel V: Melanie Duckert, Morten Hertzum, and Pernille Bjørn. 2024. How Distance Matters in Dynamic Work Environments. Submitted to an IS journal. (under review)

Artikel I undersøger karakteristikken af hybridarbejde for at udvikle en konceptuel definition og identificere specifikke kendetegn ved denne type samarbejdsform. Artikel II udforsker de spatiale udfordringer i skabelsen af delte hybride arbejdsmiljøer for at identificere implikationer for teknologidesign og organisationsstrukturer, der adresserer post-pandemiens udfordring med at genindføre fysiske elementer af kontormiljøet i organisatorisk arbejde. Artikel III tager et infrastrukturelt perspektiv for at undersøge samspillet mellem arbejde og informationsinfrastrukturer

og identificerer, hvordan lokale arbejdspraksisser formes og afgrænses af den globale informationsinfrastruktur på flere niveauer. Artikel IV definerer specifikke designudfordringer for udviklere af samarbejdssystemer der understøtter hybridarbejde med fokus på teknologiers rekonfigurerbarhed og samspil med eksisterende teknologier. Artikel V identificerer og tester faktorer, der er vigtige i nutidige arbejdsmiljøer, og undersøger deres indbyrdes sammenhænge. Resultaterne indikerer vigtigheden af organisationsstrukturer, der understøtter samlokaliserede afhængigheder, samtidig med at medarbejdere fortsat har fleksibilitet til at arbejde fra forskellige lokationer.

Denne Ph.d.-afhandling samler fund og indsigter på tværs af de inkluderede forskningsartikler og foreslår et konceptuelt framework af dimensionelle afhængigheder i hybridarbejde. Ved at udvide den konceptuelle forståelse af spektret af samarbejdsformer identificerer Ph.d.-afhandlingen unikke karakteristika ved hybridarbejde, præsenterer designforslag til teknologier, der understøtter hybride praksisser, og adresserer organisatoriske kompleksiteter i ledelsen af nutidige arbejdsmiljøer. Det foreslåede framework samler disse perspektiver og understreger det indbyrdes afhængige forhold mellem samarbejdsarbejde, økologier af teknologiske artefakter, de iboende multiple spatiale kontekster og organisatoriske strukturer – dimensioner, der er indbyrdes forbundne i hybride konfigurationer og som tydeliggør vigtigheden af at tage kompleksiteten af hybridarbejde alvorligt.

Nøgleord: hybridarbejde, samarbejdsteknologi, mixed-method forskning, konceptuelle frameworks

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This PhD process has been shaped by the support and contributions of many people over the past three years.

Thanks to the companies involved in this research for their collaboration, providing access to data and departments, and sharing their perspectives and experiences of contemporary work. Without these valuable empirical insights, this research would not have been possible.

A big thanks to my co-authors for their contributions to the studies and papers included in this thesis. Special thanks to Charlotte Lee and Morten Hertzum for their expertise, which enabled research perspectives that would otherwise not have been possible.

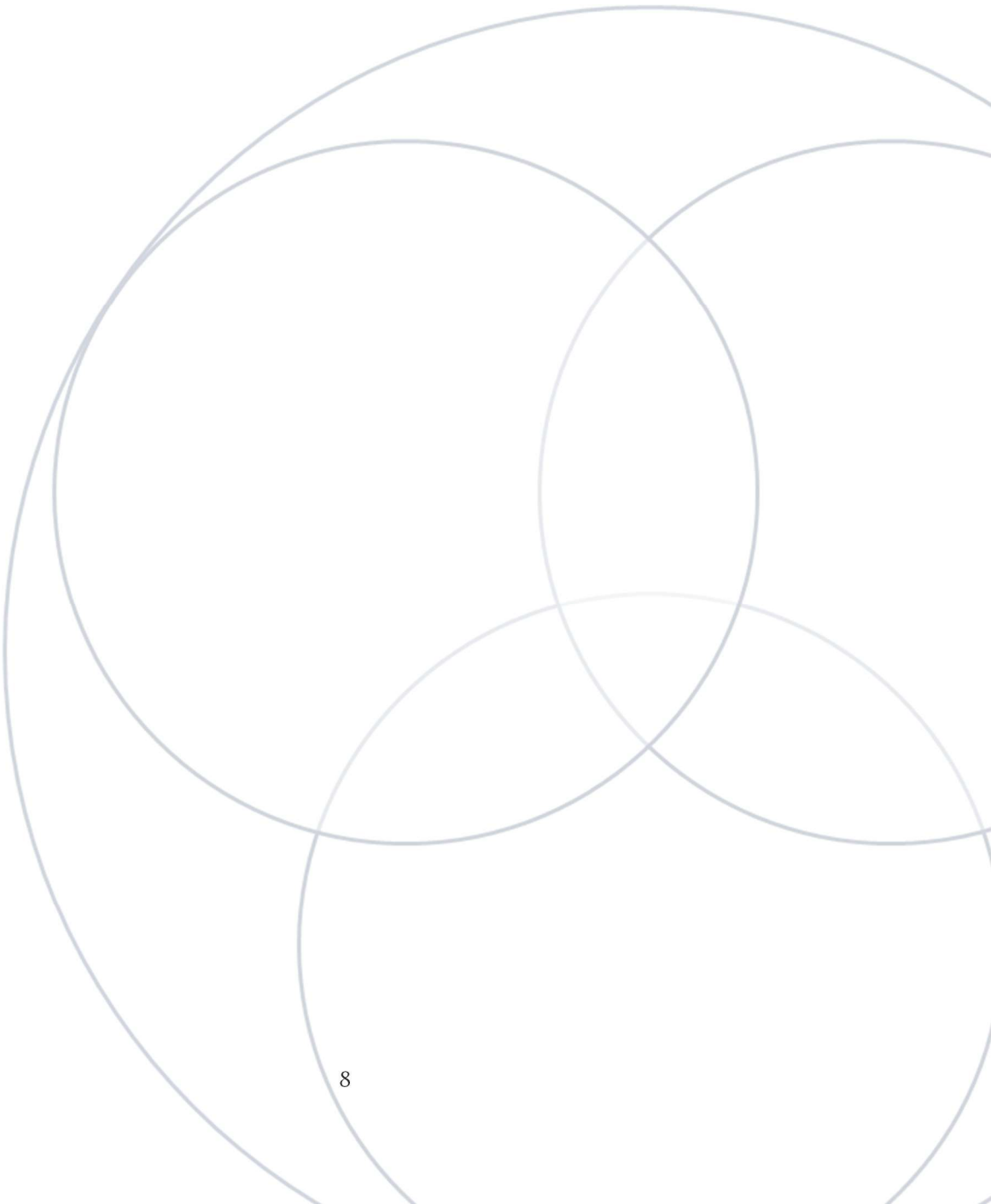
Thanks to the support from DIREC, which is funded by the Innovation Fund Denmark and has also funded the ReWork project. DIREC provided the opportunity for cross-institutional collaboration, bridging industry and academic research in a shared exploration of the future of work.

Thanks to the ReWork research project. Specifically, thanks to Louise Barkhuus for hiring me into this research community. Great thanks to Susanne Bødker, Nina Boulus-Rødje, Irina Shklovski, and Eve Hoggan for sharing their expertise and offering continuous feedback throughout the entire research process. A huge thank you to Juliane Busboom, Kellie Dunn, Qianqian Mu, and Julia Kleinau for our weekly discussions, shared frustrations, and unwavering support. It has been a privilege to be a part of this cross-institutional project.

Thanks to the PhD School for their support during this process.

My deepest thanks go to Pernille Bjørn. Thank you for agreeing to become my supervisor and for your tremendous support throughout this journey. Submitting this PhD would not have been possible without you. You have supported me in growing as a CSCW researcher, teaching me not only the craft of research but also the importance of advocating for the conditions that enable us to contribute meaningfully with what we have. I deeply appreciate all the time you have given, and I am proud to have been one of your PhD fellows. I have truly enjoyed working with you.

/Melanie



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1 Introduction

In 2020, the COVID-19 pandemic forced governments around the world to implement strategies for social distancing to reduce the risk of infections. As a result, various organizations transitioned to remote work, requiring many people to work from home. This shift redefined private spaces by turning homes into environments for diverse work practices and homeschooling. Tasks previously confined to shared workplaces were carried out from people's homes, necessitating new strategies for making collaboration successful across distances (G. M. Olson & Olson, 2000; Schmidt & Bannon, 1992). The abrupt contextual disruptions led to an accelerated digital transformation, moving various work practices online (Madsen et al., 2020). During the pandemic lockdown, both opportunities and challenges arose in managing everyday work life from home; for example, it introduced more flexibility in work-home boundaries, but the extensive use of online communication tools also led to Zoom fatigue (Chen et al., 2021; Raake et al., 2022; Rudnicka et al., 2020; Wang et al., 2021).

The pandemic circumstances brought more than just a timely scoped change in work practices; the long-term remote work conditions changed perspectives and preferences, inviting new explorations of the future of work (Busboom & Boulus-Rødje, 2023; Duckert et al., 2022; Hilberath et al., 2020; Lund et al., 2021; Teevan et al., 2022). While offices gradually reopened and, in phases, allowed more employees back into the shared workspace, organizations across different professional domains experienced that employees continue to prefer the flexibility of working from home (Appel-Meulenbroek et al., 2022; Babapour Chafi et al., 2022; Smite, Moe, Tkalich, et al., 2022; Smite et al., 2023). The pandemic-induced changes in work practices normalized digital collaboration and distributed work conditions. While remote work during the pandemic was driven by external, global, and societal factors, current explorations into continued flexible ways of working are increasingly influenced by individuals' personal preferences. In Denmark, the prevalence of remote work in 2024 mirrors the level seen during the pandemic lockdown in 2021 (Nielsen, 2024), suggesting that this way of working is continuously relevant. This prompts both researchers and industry to interrogate the nature of work in contemporary practices and what we envision for the future workplace.

New ways of working introduce new requirements for technologies that enable collaboration. Therefore, this PhD thesis centers on how contemporary work practices shape the conditions for technologies to support cooperative work in the future. Situated within the field of computer-supported cooperative work (CSCW), this research builds on existing understandings of cooperative engagements, ranging from collocated to distributed work settings. CSCW is an interdisciplinary field concerned with how computing technologies can facilitate interaction between people engaged in cooperative activities, as this cooperative work is situated within actual work practices (Ciolfi et al., 2023). This makes it relevant to explore how post-pandemic environments shape contemporary work practices to inform the development of cooperative technologies.

CSCW and related human-centered computing scholars have long explored the technology requirements for systems that not only support individuals' interaction with technology but also

facilitate work across different cooperative engagements (Grudin, 1994). Cooperative work is challenged by the need to create alignment and shared understanding among the individuals involved in the shared field of work, and these challenges are amplified when collaboration occurs across distance. Interactions that are supported by individuals sharing a geographical context in collocated work must, in distributed work, be facilitated by technology (G. M. Olson & Olson, 2000). While several researchers have participated in the discussion on why distance matters for cooperative work and what *distance* actually means (Bjørn et al., 2014; Bradner & Mark, 2002), the long-term work from home during the pandemic lockdown has reshaped how distance matters today. Collaboration across distances is becoming common supported by increased confidence in the use of cooperative technologies (Caldeira et al., 2022). Therefore, it is relevant to understand how this normalization of distributed collaboration might set different requirements for cooperative technologies in the future.

This PhD thesis aims to contribute to the discussion on future ways of working by providing new insights into the spectrum of collaboration in contemporary work practices and, in this way, identify specific ways these practices set new requirements for technologies supporting cooperative work. The continuation of remote work practices in the post-pandemic world provides flexibility for individuals' geographical locations (Liegl, 2014; Randall, 2022; Sako, 2021; Smite, Moe, Klotins, et al., 2022), thereby creating new conditions for cooperative engagements. Organizations' post-pandemic adoption of remote work options is finding new ways to align with traditional office settings and collocated work practices, leading to a combination of collocated and remote participation in cooperative engagements. Understanding the nuances of cooperative engagements that unfold *within the continuum of fully collocated and entirely distributed settings* is important for recognizing the opportunities and challenges in developing technologies that support this type of cooperative work practice.

In light of the technology-enabled normalization of distance and flexibility in geographical locations, this PhD thesis focuses on *hybrid work*, defined as cooperative engagements consisting of both collocated and remote participation. To address the overall research endeavor of understanding *what is important in designing cooperative technologies for hybrid work practices*, this PhD thesis offers new insights into contemporary work practices by conceptualizing hybrid work. The research takes a theoretical approach to develop conceptual insights into hybrid cooperative work, with the aim of identifying unique characteristics and requirements inherent in these work practices. Conceptualizing hybrid work is essential for understanding the relevant aspects of producing, navigating, and managing computer-supported hybrid collaboration. The research has employed a mix of methodological approaches to explore the opportunities and challenges of contemporary work practices from individuals' perceptions, cooperative arrangements, as well as technological and organizational implications. This has enabled this PhD to propose a coherent framework of the social and technical aspects important for designing cooperative technologies for hybrid work. Specifically, this PhD thesis presents findings on the intersection of cooperative work, the ecologies of technology artifacts supporting this work, the inherently multiple spatial contexts, and the organizational structuring – dimensions that are all seamlessly interlinked in hybrid configurations, highlighting the importance of taking the complexities of hybrid work seriously.

1.1 DEFINING HYBRID WORK

The PhD thesis introduces conceptual understandings of *hybrid work*, a term that has gained popularity in describing post-pandemic work practices across both research and industry contexts. This widespread use has led to varying interpretations of what hybrid work entails; therefore, this section presents how others have references to hybrid work and how it is defined for this PhD thesis.

In societal and organizational contexts, hybrid work has generally been used to describe post-pandemic work models. For example, public media articles refer to hybrid work when describing the continuing wish for remote work and organizations' adoption of work models that provide flexibility for employees concerning where and when they work (such as (Bang-Mørch et al., 2021; Hirsch, 2024; Medici, 2024)). Similarly, organizations refer to hybrid work models in their regulation of organizational policies, allowing employees to occasionally work remotely from home during the week (Lund et al., 2021; PricewaterhouseCoopers, 2021). The organizational and societal acceptance of the term is relevant in highlighting the current focus on hybrid work and the impact it has on organizational policies and practices. The interchangeable use of the term hybrid work with related terms such as flexible and remote work reflects the evolving language and understanding of work arrangements, pointing to the trend of redefining work life and models. This adoption of the term hybrid work suggests that ongoing interest in post-pandemic work practices is not limited to a specific configuration of cooperative engagements but extends to wider investigations into new ways of working. However, establishing a shared understanding of the terminology describing hybrid work practices is important for identifying the specific requirements that these types of engagements set for technological and organizational development.

Within the research context, different definitions of hybrid work have been introduced. For example, Smite et al. (2023) argue that *location* (where) and *work schedule (when)* are essential for theorizing hybrid work and present five modes of working: office mode, office-first, office-remote mix, remote-first, and remote. They intentionally avoid the term hybrid to reflect the variation in who is working from where in hybrid configurations. A similar definition is presented by de Souza Santos & Ralph, who distinguish between collocated (default all together), distributed (different offices always), remote-first (default all distributed), and hybrid (individuals sometimes office/home on different days) (de Souza Santos & Ralph, 2022). These conceptual definitions of hybrid work acknowledge individual preferences in work models that allow for both office and remote work. However, this PhD focused on designing technology for cooperative work; thus, it was necessary to conceptualize hybrid work in a way that allowed us to identify what is – and what is not – hybrid work scenarios.

Being concise in defining hybrid work scenarios is central, as designing for cooperative work, supported by a portfolio of different technologies, is already a complex task (Bødker, 2006). Even small changes in the geographical distribution of cooperative engagements can be pertinent to the technology required to facilitate the work. Distinguishing hybrid cooperative work from collocated and distributed work requires a definition that specifies the given work activity. Therefore, Paper I, included in this PhD thesis, introduces a conceptual definition of hybrid work by extending the foundational characterization of cooperative work by Schmidt and Bannon (1992). Paper I defines hybrid work as cooperative engagement performed across at least two contexts involving at least three individuals who are located across fewer contexts than there are people involved in the common field of work (Duckert et al., 2023). In this way, hybrid engagements *always represent both collocated and distributed* individuals who are

mutually dependent in their work. These engagements can involve both asynchronous and synchronous work, extending beyond scheduled activities such as hybrid meetings (Neumayr et al., 2018). Hybrid work involves a broad range of scenarios, from three individuals distributed across two contexts to large-scale setups, for example, involving 50 participants located in a shared office space with remote participants. The presented definition of hybrid work is broad and assumes that minor changes to the geographical distribution impact collaboration, such as if only one person in a larger group is remote or only two are collocated. Therefore, it has also been a part of this PhD to challenge and question these initial understandings in the effort to identify and theorize the unique characteristics of hybrid work.

Despite the popular use of the term, hybrid work is not new. Different domains have operated in hybrid arrangements for decades, such as the broadcasting of events on TV or radio and offshore work, both involving collaboration between individuals that are located at distributed locations (Bayerl & Lauche, 2010; Engström et al., 2010; Hepsø & Parmiggiani, 2022). Additionally, organizational work in traditional office spaces introduced remote work decades ago, with computer and communication technologies facilitating distributed collaboration (M. H. Olson, 1983). However, the pandemic forced an accelerated adoption of technology-enabled cooperative work practices, and the transition to remote work options has impacted professional domains that were previously conducted in collocated settings (pre-pandemic).

During the pandemic lockdown, different professional disciplines were impacted in different ways. For example, healthcare sectors are often more dependent on location, with some activities requiring collocation or being situated at the hospital. However, some doctors' appointments were digitalized during the pandemic lockdown and, to some degree, continue to offer these online options after the pandemic (Farzandipour et al., 2023). Other professions, such as organizational computer-based office work, experience different challenges, as these are often less dependent on location-specific tools and, therefore, have transitioned to digital practices with the use of cooperative systems for distributed collaboration. So, while hybrid cooperative work is not new, the normalization of occasional remote work produces new hybrid cooperative work practices, introducing new challenges for organizational management in structuring cooperative teams and the requirements for the technology.

1.2 RESEARCH CONTEXT

This PhD was part of a cross-disciplinary research project named ReWork, which connects researchers and practitioners from four universities and ten organizations. ReWork is funded by the Digital Research Center Denmark (DIREC) and the Innovation Fund Denmark to investigate the future of work, with a particular focus on hybrid work, in light of the changed work preferences and conditions after the COVID-19 pandemic. This exploration takes four different perspectives: multimodal, speculative, artistic, and conceptual, while this PhD focuses on conceptual framings. ReWork connects a diverse group of stakeholders across academic and industrial sectors. The industrial collaborators represent companies that either provide empirical cases of post-pandemic work environments or develop contemporary technologies, expanding from cultural institutions to global organizations and small, innovative entrepreneurial companies. This cross-disciplinary collaboration has bridged theoretical and exploratory research efforts with the industry's practical insights and case studies.

Involvement in ReWork included participation in academic and industrial workshops, as well as ongoing company visits to some of the industrial partners. This enabled engagement in broader discussions of future ways of working across different lenses. The ongoing exploration of both organizations' perspectives on hybrid work revealed diverse approaches to management in post-pandemic work conditions and the challenges and opportunities that arose. Furthermore, it allowed discussions across different research lenses on the different approaches and perspectives important for future ways of working. This has facilitated a shared space for sharing, challenging, extending, and collectively producing various research insights.

This PhD was initiated when ReWork launched in February 2022 and has, therefore, been a part of the ongoing exploration of hybrid work since the beginning of the project. In Denmark, lockdown measures commenced on March 11, 2020, mandating that all individuals who were able to work from home do so, including schools and organizations. (SSI, 2022). On February 1, 2022, all restrictions were lifted, but in the time between, a series of lockdowns were implemented to adapt to infection rates. Starting in February 2022, research within this PhD has been conducted simultaneously with societal and organizational responses and adaptations to post-pandemic changes in work practices and models. In retrospect, the immediate reactions to the lockdown work practices have changed when considering both short-term and long-term effects. For example, in the short term, organizations allowed remote work to support employees' flexibility, while in the long term, more companies have redefined organizational policies, in some cases mandating physical presence in the office. Organizations such as Zoom and Amazon are starting to require employees to be physically present at the office each day. (Goldberg, 2023; Sherman, 2024). Researching hybrid work environments has, in this way, been part of the evolving exploration of contemporary work, as it has continuously been reshaped and re-regulated in societal and organizational contexts.

1.3 AIM AND OBJECTIVES

With the overall research aim of identifying what is important in designing cooperative technologies for hybrid work practices, this PhD thesis includes five studies addressing distinct perspectives on contemporary work. The research has employed different empirical approaches, with the goal of investigating cooperative work practices as they unfold in real-world cases through diverse methodological lenses. While the initial objective was to identify unique characteristics of hybrid work, the following studies focused on uncovering how these characteristics supported and challenged the production of hybrid collaboration.

The first study defines hybrid work and identifies its unique characteristics that distinguish this type of cooperative work from collocated and distributed arrangements. Analyzing empirical cases in previously published research papers highlights the collocated context as a core characteristic of hybrid work (Paper I). The second study presents ethnographic insights into office workers' navigation of hybrid workspaces, revealing post-pandemic complications of reintroducing physical space into office work, which consequently makes workers rely on digital collaboration (Paper II). The third study takes an infrastructural perspective on cooperative work to suggest how the interconnected conglomeration of people, artifacts, and policies shapes and scopes local work contexts on multiple scales, as interdependencies can be (invisibly) placed across the infrastructure (Paper III). Based on the empirical insights, the fourth study refines historical design challenges of cooperative technologies to reflect

contemporary challenges in designing cooperative technologies for hybrid office work (Paper IV). Finally, the fifth study surveys individuals' experiences of working in contemporary work environments, suggesting that flexibility in where each worker is (and wants to be) located increases the effort required for collaboration and the use of cooperative technologies (Paper V). A list of the papers included is presented in the following section, 1.4.

To answer the overall research endeavor of what is important in designing cooperative technologies for hybrid work, this PhD thesis highlights the findings of the sub-studies suggesting that hybrid work practices are shaped by cooperative, spatial, technological, and organizational conditions. Illustrating the interdependent nature of these dimensions, the PhD thesis proposes a unified framework of dimensional interdependencies in hybrid work, integrating the conceptualization of each of the sub-studies.

The remainder of the PhD thesis presents the theoretical background of cooperative work, encompassing collocated, distributed, and hybrid work environments. This is followed by the evolution of cooperative technologies and the organizational management of cooperative environments. Next, the methodological reflections on the overall PhD process, including the different types of methods employed, are discussed. Subsequently, the findings based on the papers included are presented, along with the design propositions they respectively invite. This is followed by a discussion of the findings, which is divided into the nature of hybrid cooperative work, spatial relevancies, technology support, organizational management, and the proposed framework of dimensional interdependencies in hybrid work, unifying all the findings. Finally, the conclusion presents how this PhD contributes to the design of technologies for hybrid work environments. All the papers are attached at the end of the thesis.

1.4 PUBLICATIONS

Paper I:

Melanie Duckert, Louise Barkhuus, and Pernille Bjørn. 2023. Collocated Distance: A Fundamental Challenge for the Design of Hybrid Work Technologies. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 612, 1–16. https://doi.org/10.1145/3544548.3580899

Paper II:

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Paper III:

Melanie Duckert, Charlotte Lee, and Pernille Bjørn. 2025. The Ripple Effect of Information Infrastructures. In *Computer Supported Cooperative Work*. Springer. https://doi-org/10.1007/s10606-024-09509-7

Paper IV:

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Paper V:

Melanie Duckert, Morten Hertzum, and Pernille Bjørn. 2024. How Distance Matters in Dynamic Work Environments. Submitted to an IS journal. (under review)

During my PhD, I also contributed to the following papers that are **not** included in this thesis:

Pernille Bjørn, Kellie Dunn, and **Melanie Duckert**. Forthcoming. Hybrid Work and Cooperative Technologies. In *Human-Computer Interaction Handbook.* Fourth edition. (under submission)

Pernille Bjørn, Juliane Busboom, **Melanie Duckert**, Susanne Bødker, Irina Shklovski, Eve Hoggan, Kellie Dunn, Qianqian Mu, Louise Barkhuus, and Nina Boulus-Rødje. 2024. Achieving Symmetry in Synchronous Interaction in Hybrid Work is Impossible. *ACM Trans. Comput.-Hum. Interact.* 31, 4, Article 49 (August 2024), 34 pages. https://doi.org/10.1145/3648617

Melanie Duckert. 2024. Studying Post-Pandemic Work Practices: What Happens to Space When Work is Digitalized? *ECSCW Workshop paper* (Presented at the workshop: Data at the Workplace), June 17–21, 2024, Rimini, Italy.

Melanie Duckert. 2023. The Futures of Hybrid Work: A Socio-Technical Framework for Designing Hybrid Environments. In *Companion Publication of the 2023 Conference on Computer Supported Cooperative Work and Social Computing (CSCW '23 Companion).* Association for Computing Machinery, New York, NY, USA, 441–443. https://doi.org/10.1145/3584931.3608921

Melanie Duckert, Eve Hoggan, Louise Barkhuus, Pernille Bjørn, Nina Boulus-Rødje, Susanne Bødker, Naja Holten Møller, and Irina Shklovski. 2022. Work of the Future. In *Adjunct Proceedings of the 2022 Nordic Human-Computer Interaction Conference (NordiCHI '22).* Association for Computing Machinery, New York, NY, USA, Article 3, 1–4. https://doi.org/10.1145/3547522.3547707

Oksana Kulyk, Lauren Britton-Steele, Elda Paja, **Melanie Duckert**, and Louise Barkhuus. 2022. "You have been in Close Contact with a Person Infected with COVID-19 and you may have been Infected": Understanding Privacy Concerns, Trust and Adoption in Mobile COVID-19 Tracing Across Four Countries. *Proc. ACM Hum.-Comput. Interact.* 6, MHCI, Article 204 (September 2022), 27 pages. https://doi.org/10.1145/3546739

Melanie Duckert and Louise Barkhuus. 2022. Peripheral Awareness in Virtual Presence. *CHI 2022 Workshop paper* (Presented at the workshop: Social Presence in Virtual Event Spaces), April 30–May 05, 2022, New Orleans, LA. ACM, New York, NY, USA.

2 Theoretical Background

With the aim to explore what is important in designing cooperative technologies for hybrid work practices, the theoretical background within computer-supported cooperative work (CSCW) serves as the foundation for understanding how hybrid work practices set new requirements for conceptual understandings and technology design. This chapter begins with research on the spectrum of cooperative work to identify what distinguishes hybrid work within this spectrum. It then reflects on advancements in cooperative technologies that support various work activities across different collaborative configurations. Finally, the chapter delves into the organizational environments that shape the conditions for cooperative work and the contemporary challenges of managing hybrid work.

2.1 THE SPECTRUM OF COOPERATIVE WORK

To conceptualize hybrid work, we must first understand the foundations of cooperative work and the spectrum on which cooperative engagements can unfold. Illustrating the design space of CSCW, Grudin (1994) presents distinct considerations of individuals, groups, and organizational interactions (see Figure 1). The study of individual technology interaction focuses on user experience, whereas technologies supporting cooperative work are supplemented by challenges arising from group processes (Grudin, 1994). Cooperative work involves *at least two people who are mutually dependent in their work*, meaning that the task at hand is related in content, and all participants depend on the work of others (Schmidt & Bannon, 1992). Individuals engaged in cooperative activities are *coupled* as the work relies on the actions of others. However, the degree of coupling varies depending on the nature of the work. Cooperative work expands from small groups of people engaged in direct collaborative tasks but also extends to larger groups of people (Schmidt & Bannon, 1992) involved in more loosely coupled relations (Dourish & Bellotti, 1992; G. M. Olson & Olson, 2000).

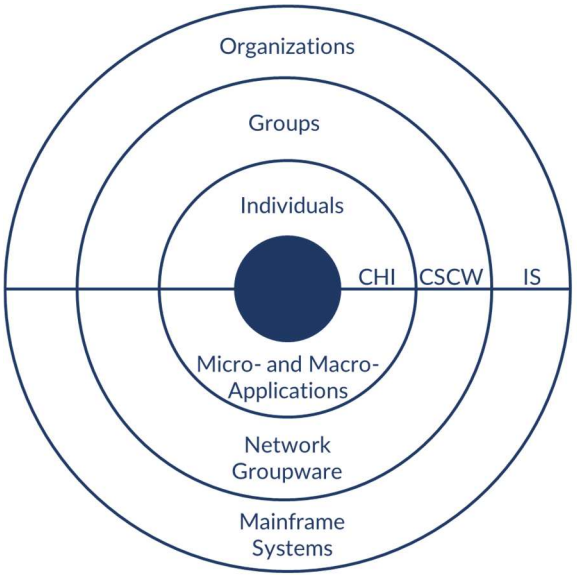


FIGURE 1. Recreation of Grudin's model for the design space of CSCW (Grudin, 1994).

Cooperative work is, in some sense, always distributed, as the work depends on knowledge, actions, qualities, etc., spread across different people and tools. To manage these interdependencies, collaboration requires articulation work (Ciolfi et al., 2023). Articulation work refers to all the work needed to solve the cooperative task at hand, including assembling, scheduling, monitoring, and coordinating (Schmidt & Bannon, 1992). This work can involve synchronous collective activities, such as a group of people planning the directions of work, but it also extends to individual interactions conducted asynchronously, such as booking a meeting room.

In parallel with articulation work, cooperative ensembles engage in relation work, referring to the effort put into creating interpersonal connections between people (Bjørn & Christensen, 2011; Christensen et al., 2014). Relation work is not necessarily related to solving the task at hand but is co-constitutive of this, covering the work of communication and interaction that takes place outside the work dialogue to construct and maintain relationships (Bjørn et al., 2024).

Cooperative engagements can be distributed across various geographical settings. In collocated work, all people involved share the same geographical location and are, therefore, within immediate proximity. Conversely, distributed work refers to cooperative arrangements where interdependent individuals are geographically separated from each other. Since they are located in distant locations, this type of collaboration sets different requirements for cooperative work, as the interactions that can take place collocatedly, such as visual connections and communication, must be supported by various technologies when people are distributed (J. S. Olson & Olson, 2014). Johansen (1988) presents the matrix of collaboration to categorize four types of cooperative engagements based on time and space, covering collocated and distributed work in synchronous and asynchronous dimensions (see Figure 2).

	SYNCHRONOUS	ASYNCHRONOUS
COLLOCATED	**Face-to-face interaction** Decision rooms, single display groupware, shared table, wall display, roomware, etc.	**Continuous task** Team rooms, large public displays, shift work groupware, project management, etc.
DISTRIBUTED	**Distributed interaction** Video conferencing, instant messaging, chat, shared screen, multi-user editors, etc.	**Communication + coordination** Email, bulletin boards, blogs, asynchronous conferencing, group calendars, workflow, version control, wikis, etc.

FIGURE 2. Replication of Johanson's Time/Space Matrix

Johanson's matrix refers to distance as a binary between collocated and distributed; however, cooperative arrangements are unfolding in varying configurations within this continuum. To nuance this perspective, Lee and Paine present the MoCA framework covering seven dimensions, all placed on a continuum (C. Lee & Paine, 2015). These include synchronicity, physical distribution, scale, communities of practice, nascence, planned performance, and turnover. Concerning space and time, the MoCA framework illustrates geographical distribution and synchronicity in a continuum instead of a binary, reflecting the variations of the geographical distribution in which cooperative groups can be located (C. Lee & Paine, 2015).

The terminology describing distributed cooperative work varies, including global, virtual, and remote teams. Global teams can be seen as internationally distributed groups that engage in a shared field of work, such as global organizations located in different countries (Maznevski & Chudoba, 2000). Such teams can face challenges in negotiating shared norms and practices that effectively support the creation of a shared understanding and language (Bjørn & Ngwenyama, 2009). Virtual teams can vary in their degree of virtuality, depending on their reliance on digital systems and their ability to meet face-to-face (Gibson & Cohen, 2003; Martins et al., 2004). Virtual teams, therefore, do not necessarily collaborate across professions and cultures as global teams do (Gibson & Cohen, 2003; Søderberg et al., 2013). In contrast, remote work can refer to the geographical location of the individuals, whereas a remote person will be distributed away from the dominant group. In fully remote work, all individuals are geographically distributed, as happened during the COVID-19 pandemic (Flügge & Møller, 2023). While these terminological definitions can describe distinct collaborative configurations, they are sometimes used interchangeably for distributed groups that do not all share the same geographical context.

Post-pandemic, hybrid work has become a popular addition to the vocabulary of cooperative engagements working across distances. Hybrid work describes the context of being in between complete remote work conditions during the pandemic and the return to the office (Hilberath et al., 2020). However, making a clear distinction of what hybrid work entails is relevant for understanding the unique characteristics and challenges in post-pandemic cooperative groups.

Neumayr et al. (2018) define hybrid work as existing in all four quadrants of Johansen's matrix (Johansen, 1988), covering both collocated and remote collaboration in both synchronous and asynchronous work. This PhD thesis focuses on cooperative engagement, and to define how hybrid work fits within this field, Paper I argues that hybrid work is a special type of collaboration positioned as a subset of cooperative and distributed work (Duckert et al., 2023). This extends the definition of Schmidt and Bannon (Schmidt & Bannon, 1992) and argues that hybrid work is *within the continuum of fully collocated and fully distributed settings*, thereby always representing both collocated and distributed participation. Figure 3 illustrates the distinction between cooperative work unfolding across collocated, distributed, and hybrid settings.

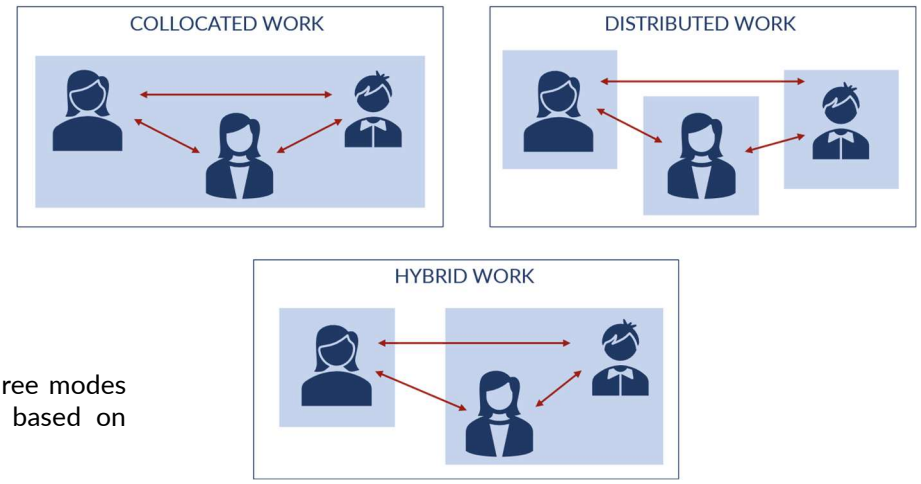


FIGURE 3. Visualization of three modes of cooperative engagements based on their geographical locations.

Research on distributed work has explored how *proximity* impacts geographical distance in cooperative work, referring to the physical distance between the individuals involved in the shared field of work (Kiesler & Cummings, 2002). For example, Claudel et al. (2017) argue that proximity affects collaboration, even on a micro-scale with people distributed within the same building. Similarly, a distance of just 30 meters has been shown to reduce and complicate communication between cooperating actors (Kiesler & Cummings, 2002; Kraut et al., 1988; J. Olson et al., 2002). This is also called the Allen Curve, which suggests a correlation between the frequency of communication and distance (Allen, 1984). Alternatively, Bradner and Mark (2002) discuss the believed distance, which, instead of proximity, refers to the impact of people's experience or presumptions about the distance between the collaborating individuals.

How distance matters in contemporary work environments is an ongoing exploration. The long-term conditions of remote work during the pandemic normalized geographical distributions in work that had previously been conducted in shared office settings. This increased confidence in the use of cooperative technologies for everyday interactions that were previously possible at the shared office (Caldeira et al., 2022). Questions are therefore raised about whether the Allen curve still remains valid in a post-pandemic era with experience in distributed collaboration on various activities (Todd, 2021). To contribute to this research, Paper V in this PhD thesis explores how distance matters in contemporary work environments and finds that engaging in geographically distributed teams does not correlate with factors such as job satisfaction. In contrast, job satisfaction does have a significant correlation with whether the office space provides an experience of increased access to relevant coworkers and an individual's personal preferences for working from the office or remotely. Therefore, regarding how distance matters today, this research suggests that distributed collaboration is common while presenting new challenges for shared, collocated spaces.

A core challenge in cooperative work is achieving common ground among the people involved in the shared field of work. Common ground refers to the information and understanding that a cooperative engagement shares. Grounding activities require articulation work, such as coordination and communication, to achieve a mutual understanding of each other's beliefs, knowledge, and assumptions (Clark & Brennan, 1991). The conditions for creating this differ depending on the cooperative setup. If all participants are collocated, they are more likely to share social settings, which can also help align expectations and experiences and establish shared territory (Kiesler & Cummings, 2002).

In distributed work, the complexities of creating common ground increase as interdependent individuals do not share context (G. M. Olson & Olson, 2000). Distance creates 'the space between' collaborative groups in which misalignments and loss of shared meaning can arise (Mark et al., 2003). However, in hybrid settings, distance can also exist within the collocated context. Paper I presents the concept of collocated distance, describing how hybrid work has inherent subgroups not only across geographical distribution but also among people sharing a geographical context (Duckert et al., 2023). While distributed work aims to connect people across distant sites, hybrid work potentially faces misalignments *both across and within these geographical contexts*.

Olsen et al. (2002) emphasize that distributed work does not match the quality of face-to-face interaction in collocated work. However, instead of striving to replicate in-person dynamics, the success of

distributed work lies in leveraging its own strengths, recognizing that mimicking collocated work is not the path to success (J. Olson et al., 2002). Similarly, hybrid work should not mimic either collocated or distributed interactions but instead be considered a distinct type of cooperative engagement (Busboom & Boulus-Rødje, 2024). In hybrid work, the challenge is to leverage the advantages of *both* collocated and distributed collaboration within a shared environment where both modes of work coexist. In this respect, this PhD thesis investigates the spectrum of cooperative work to identify how hybrid arrangements set new requirements for conceptualizations and technology support.

2.2 COLLABORATIVE COMPUTING TECHNOLOGIES

Collaborative technologies support individuals in their cooperative work practices and, in this way, facilitate the articulation of work that people must engage in as part of their common processes (Bannon, 1992; Ciolfi et al., 2023; Grudin, 1994). Technologies as computational artifacts mediate cooperative interactions within situated contexts (Ciolfi et al., 2023; Suchman, 2006). In this way, tools, technologies, and systems support cooperative work by enabling interdependent activities as they unfold in real-life practices. From the early studies of office interactions supported by one collaborative technology (Orlikowski, 1992), research has advanced to incorporate a wide array of tools that support daily workflows seamlessly. Today, technologies involved in cooperative practices are numerous, put together in different ways depending on the nature of the cooperative work, and are therefore in a "continual flux" (Schmidt & Bannon, 2013, p. 347).

The concept of *artifact ecology* refers to the relationship between various interactive artifacts (Jung et al., 2008). Bødker has studied the ecological matrix of technologies and artifacts in different research constellations and how their mobility enables dynamic change in use contexts (Bødker, 2006; Bødker et al., 2017; Bødker & Klokmose, 2012; Lyle et al., 2020). New technologies do not replace existing ones; instead, they add to the matrix of technologies to coexist with them (Bødker, 2006). Therefore, technology use cannot be seen as a constant factor but as a dynamic ecology adapted to specific work and contexts.

Explorations into social and technological challenges have only become more advanced with the increased ubiquitous presence and seamless use of technology (Greif, 2019). Both articulation work and relation work face increased challenges in distributed settings, as these processes are less spontaneous and mediated by technology (Christensen et al., 2014). Explorations of cooperative technologies study ways to connect geographically distinct sites (Bjørn & Christensen, 2011; Mark et al., 2003). In this context, Olson and Olson (2000) argued that distributed work with low coupling has a higher chance of succeeding if the work is loosely coupled and, therefore, does not require frequent interaction and detailed information. Conversely, it has also been found that the frequent use of technology for interaction motivates people to engage in collaboration despite geographical dispersion (Bjørn et al., 2014). For example, technologies such as chat systems have been found to enable successful negotiation and informal communication over a distance (Tenório & Bjørn, 2019).

Cooperative technologies supporting geographically distributed configurations, such as video conferencing systems, connect participants located across distinct sites (Esbensen et al., 2015; Hu et al., 2022; Johnson et al., 2015; Sellen et al., 1992). However, technologies for hybrid work must support both distributed and collocated activities to create shared work environments for synchronous collaboration.

Where a person is located in the hybrid setup matters for their experience, as individuals' perspectives of technology are shaped by their context (Orlikowski & Gash, 1994). For example, the opportunities to interact with technology and participate in collaboration differ depending on whether someone is a remote participant situated within the collocated domain group. Consequently, hybrid collaboration is inherently asymmetric in synchronous cooperative activities, as participants in collocated and remote locations will never have equal opportunities for participation (Bjørn et al., 2024). Designing cooperative technologies to address this asymmetry involves exploring ways to support accessibility and shared autonomy in hybrid settings (Panda et al., 2024; Tang et al., 2023). For example, researchers have investigated technologies that incorporate embodiment (M. K. Lee & Takayama, 2011; Misawa & Rekimoto, 2015) and support awareness of remote participants (Venolia et al., 2010). Although much research focuses on minimizing asymmetry in shared spaces, some studies argue that this asymmetry can be the reason a system is valued (Voida et al., 2008).

Asymmetric conditions of hybrid work are further reflected in the distinct access to physical artifacts. In this context, research explores ways that allow actions or products to exist in both the physical and digital worlds and, in this way, align digital and physical interactions (Benford et al., 2018; Benyon & Mival, 2015; Grønbæk et al., 2021). For example, collaboration technologies such as t-Room combine physical and digital work around a shared hybrid table (Hirata et al., 2008; Yamashita et al., 2011). Virtual spaces such as the Metaverse have been suggested to enable complex collaboration, coordination, and interaction across distance, however, without including physical elements (Park et al., 2023; Richter & Richter, 2024).

Empirical investigations into producing technology setups for hybrid work illustrate the complexities of managing the numerous technologies required (Bjørn et al., 2024). A challenge for hybrid cooperative technologies is, therefore, also to support cooperative work practices as they are situated within specific contexts of use. A challenge for cooperative technologies is that the extra effort required for articulation work is not necessarily beneficial for the individual who needs to do the extra work (Grudin, 1988, 1994). In the context of hybrid work, the extra work needed to produce a shared, hybrid work environment often lies with the dominant group, who need to manage extra screens, cables, cameras, etc., to allow for remote participation. The dominant, collocated group does not experience the value of the extra work required from them, but their added efforts are needed to support partially distributed collaboration. Developing cooperative technologies for hybrid work practices is challenged in the dynamic contexts in which they are used. Therefore, this PhD thesis explores how the nature of hybrid work sets unique requirements for cooperative technologies as hybrid work practices unfold in real-life contexts.

2.3 ORGANIZATIONAL ENVIRONMENTS

Cooperative work is shaped by the organizational management of work conditions (J. S. Olson & Olson, 2014). These organizational structures include, for example, the cooperative ensemble, their locations, and the spatial opportunities. Changes in cooperative practices can call for adjustments to organizational structures, as seen in the accelerated digitalization of work during the pandemic lockdown (Madsen et al., 2020). This digital transformation demonstrated collaborative work activities that can effectively occur in distributed settings, proving especially useful during the pandemic

lockdown. However, in the post-pandemic period, these practices are creating new challenges within organizational work environments.

Digital transformations can have *corollary effects* with less visible changes in organizations, such as values, norms, and rules (Orlikowski & Scott, 2023). This relates to the effects of the COVID-19 pandemic, as the post-pandemic return to the offices was not a return to the pre-pandemic status quo. Instead, the benefits experienced from remote work led to continuing wishes for work conditions that support individuals' flexibility in their locations and work lives (Hilberath et al., 2020; Krajčík et al., 2023). Workers' personal wishes for flexibility prompted companies to reconsider their values and norms concerning their organizational management of hybrid work. Offering hybrid work models with options for remote work has become an important competitive parameter for attracting new employees and increasing motivation in the workplace (Berger et al., 2021).

Depending on the organizational policies, workers can individually negotiate where they want to sit each day: at home or in the office (Landowski et al., 2024). In this way, hybrid work models can support the self-organization and empowerment of employees (Bjørn, 2016, p. 53). However, this raises organizational challenges in managing the balance between empowerment and control, as well as rationality and emotionality, in efforts to support both the individual employee and the organization (Cousins et al., 2007).

Structuring hybrid work environments has revealed complexities in the use of the office, which risks being left empty in organizations offering remote options when employees prefer to work from home (Appel-Meulenbroek et al., 2022; Smite, Moe, Tkalich, et al., 2022). In organizational office work, the office provides a shared space for interacting with colleagues but is not the *only* place for work (Anurag & Asha, 2024). Hybrid work introduces mobility into individuals' locations, even though they have a dedicated office to go to for work. In this way, hybrid workers share characteristics with mobile and nomadic workers who can be challenged in the continuous reconfiguration of space (Brown & O'Hara, 2003; Erickson & Jarrahi, 2016; A. Lee et al., 2019; Liegl, 2014). As a person works from different locations, different places "turn into office spaces" based on the way they are used, such as public cafés and living rooms used for work (Harrison & Tatar, 2008). This is possible due to digital and portable technologies such as laptops, but it also requires the workers to continuously put effort into making varying places workable. During the pandemic, it became common to dedicate specific places in their home to office spaces to support remote work practices (Breideband et al., 2022), which after the pandemic can continue to offer convenient spaces for remote work.

The individual's mobility in hybrid work can impact the requirements of the organizational office space. The materiality of a space shapes the conditions for interaction in cooperative engagements with both people and technology, as the concept of sociomateriality describes the co-constitutive relationship between social elements (e.g., relationships) and material elements (e.g., technologies) in organizational practices (Bjørn & Østerlund, 2014; Orlikowski, 2007). Therefore, how organizational spaces are designed impacts the opportunities for hybrid collaboration. Spaces utilized for remote work, such as the home and a café, likely only need to support one individual person, making technologies designed for individual interaction workable, such as using the laptop for work. In contrast, the office in hybrid work must support cooperative engagements, which likely are distributed across dynamic configurations, leading to variations in who is situated at the office. This is relevant in light of the

interest in redesigning organizational spaces to support contemporary work practices. For example, this interest was evident in the ReWork project's collaboration with industrial partners, where more of the organization was in different phases of implementing architectural renovations of their office environments. The architecture of a building can impact the conditions for interactions and collaboration (Alavi et al., 2019; Dalton et al., 2016), as this defines the material constraints that shape the conditions for producing technology-mediated cooperative spaces (Bjørn & Østerlund, 2014; Orlikowski, 2007).

Cooperative engagements can be distributed across organizational, spatial, and temporal boundaries – what Gerson (2008) refers to as the 'reach' of a task. In hybrid cooperative work, the reach of a task highlights the varying conditions under which collaboration occurs. These conditions may include whether individuals work within the same field, their prior familiarity with one another, and the work's dependency on local artifacts. Cross-organizational collaboration often involves *dyadic relations*, which are formed across different disciplines or organizational boundaries (Cummings & Kiesler, 2008). Dyadic relations can introduce challenges for cooperative practices, as participants may rely on specific software systems or have unequal access to tools. For example, specific professions depend on particular technologies, while organizations may implement distinct software systems. When tasks have a high reach – involving interdependencies across departments, locations, and technologies – cooperative work may become more complex, impacting collaboration and potential misalignments in technology use. Hybrid cooperative work is, therefore, shaped by the structuring of the tasks, which inherently creates varied requirements for technology configuration to support collaboration across boundaries.

Hybrid workspaces are produced through the entangled interrelations between spaces, work practices, and organizational relationships (Halford, 2005). Creating alignments across hybrid configurations there extends providing access to computing technologies that facilitate hybrid collaboration but is also impacted by, for example, an individual's readiness to engage in the collaboration (G. M. Olson & Olson, 2000). Hybrid work can face challenges due to the dynamic nature of these configurations, as individuals change their location over time (Afflerbach, 2020). Structuring organizational environments for hybrid work practices involves considering potential dynamic changes in collaboration readiness, along with technological, organizational, and spatial constraints. This PhD thesis explores how hybrid work and the utilization of cooperative technologies are linked to organizational structuring. Technologies embody assumptions about how they will be used; when implemented into organizations, they adapt to organizational structures just as organizations must adapt to technology (Bannon & Schmidt, 1989). Therefore, this PhD emphasizes explorations into how cooperative technologies are situated in hybrid work practices as these unfold across contemporary work environments.

3 Methodological Reflections

To conceptualize computer-supported hybrid cooperative work, this PhD thesis takes different methodological approaches to explore the nature of hybrid work, focusing on how cooperative practices unfold within contemporary work contexts. As Schmidt and Bannon (2013) emphasize, technologies should not only enable activities in theory but align with the situated and practical nature of work. Similarly, Suchman (2006) highlights how actions are dynamically shaped by the specific context, emphasizing the need for cooperative technologies to facilitate situated actions rather than imposing predefined workflows. In this respect, the research employed a mix of empirical methods, deriving from the different sub-studies but collectively includes literature study (Paper I), ethnographic methods (Paper II and III), comparative analysis (Paper IV), and survey (Paper V). The details of the methods are outlined in each of the papers included in this PhD thesis, while this chapter reflects on the motivations behind the methodological approaches and research questions, as well as the overall research endeavor of understanding what is important when designing cooperative technologies for hybrid work practices. The research relied on industry collaboration to emphasize empirical data; consequently, this chapter also reflects on how this industrial collaboration shaped the research process through negotiations of agreements and the navigation of both research and industry agendas. The chapter concludes with a reflection on adopting a theoretical, conceptual approach, which includes developing conceptualizations and considering their implications in both research and practical contexts. Figure 4 illustrates the PhD process, mapping the stages of data collection, research paper production, and ongoing theoretical conceptualization.

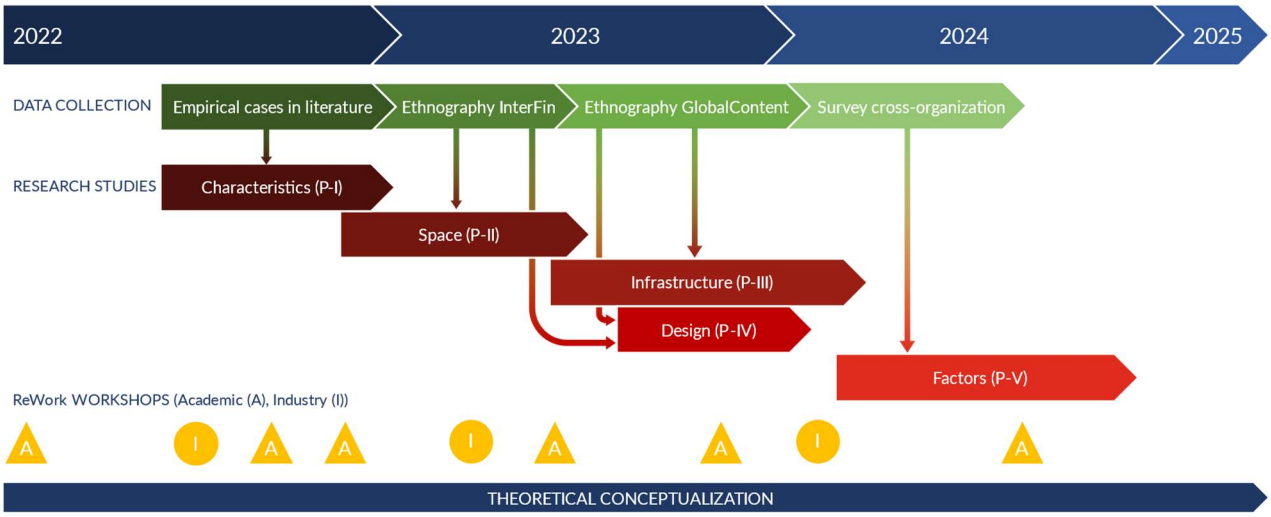


FIGURE 4. Timeline of PhD progress with data collection and studies.

3.1 CONNECTING RESEARCH QUESTIONS AND METHODS

To address the overarching research question of what is important in designing cooperative technologies for hybrid work practices, each of the five research papers employs different methodological approaches to answer distinct questions, providing empirical insights into hybrid work practices in various ways. The PhD process can be broadly divided into three methodological phases: literature, ethnographic, and quantitative, which will be elaborated upon below regarding their reasoning and connections between the different research questions, methods, and contributions. Table 1 lists the papers, their methods, and the associated research questions.

TABLE 1. List of papers along with their methods and research questions.

PAPER	METHOD	RESEARCH QUESTION
PAPER I	Empirical cases in literature.	What are the characteristics of hybrid cooperative work that introduce unique design challenges to be met by cooperative technologies?
PAPER II	Ethnographic research at InterFin, focusing on two hybrid teams.	What are the spatial challenges of producing and negotiating a shared hybrid workspace in hybrid office arrangements?
PAPER III	Ethnographic research at GlobalContent, focusing on an infrastructure project.	How does the global information infrastructure impact the nature of local work contexts?
PAPER IV	Comparative analysis of ethnographic data.	What are the challenges for developers of groupware technologies in 2024?
PAPER V	Factor analysis based on a survey distributed across five organizations.	How does distance matter to an individual's work experience in contemporary cooperative teams?

The initial goal of the research was to *identify unique characteristics* that distinguish hybrid cooperative work from fully collocated and distributed configurations. The starting point for the research was the forced 'work-from-home' situation that arose during the pandemic lockdown and which increased confidence in digital and distributed work settings (Boland et al., 2020; Caldeira et al., 2022). In our initial characterization of hybrid work, the aim was to understand the unique characteristics of these cooperative practices from data that are not affected by pandemic work conditions. It was important for us to start pre-pandemic to understand the characteristics of hybrid cooperative work that had not been affected by the long-term remote and digital work practices. Therefore, the emphasis of this work was on using knowledge from pre-pandemic empirical cases to assist us in the subsequent research. The focus of the initial characterization of hybrid work was to identify empirical cases that pre-pandemic unfolded across hybrid configurations. Therefore, our initial exploration relied on previously published literature that presented empirical cases of hybrid work, and thus, the methodological approach was to conduct a literature study to identify empirical cases of hybrid work to serve as a secondary data source to determine a definition of what entails hybrid work. Secondary data can be limited in detail compared to primary data, however, relying on published literature for analysis can provide overviews of the current state of research across broader ranges of topics (Sutton et al., 2019). Relying on literature

enabled us to look across broader professional domains to understand the characteristics of hybrid work based on cooperative work scenarios that are *traditionally hybrid*. The research from the literature study resulted in the research contribution published in Paper I.

Although a literature study allowed for the exploration of historical cases before the pandemic, identifying empirical cases in hybrid settings was not straightforward. Many papers lacked specific details about the geographical distribution of the cooperative setup, which hindered the identification of collocated, hybrid, and distributed work cases. This issue arose particularly because the terms were used interchangeably. The identification of hybrid scenarios, therefore, required a confined *conceptual definition of hybrid work* to distinguish these empirical cases from other cooperative work setups. Therefore, the paper selection process was iterative, involving multiple re-categorizations of both domain and cooperative setup. Each reading continuously shaped the conceptualization of hybrid work, leading to the definition presented in Paper I as involving at least three people who are mutually dependent in work and distributed across fewer contexts than there are people involved.

Relying on literature allowed for a comparative analysis of the characteristics of hybrid work across different professional domains. Post-pandemic discussions on hybrid work tended to focus on getting employees back into the offices (Sherman, 2024; Smite, Moe, Tkalich, et al., 2022). However, this study emphasized the analysis of cases outside the office settings to understand hybrid characteristics in various cooperative activities. Based on the conceptual definition of hybrid work, papers were selected based on their level of empirical detail to categorize their professional domain and cooperative configuration, allowing for a comparative analysis of what characterized the cooperative work in hybrid arrangements. Paper I presents a comparative analysis of empirical cases from four professional domains: healthcare, entertainment, office, and out-of-office. The comparative analysis indicated that the *collocated context* in hybrid distribution is essential. In this way, the literature-based study laid the foundation for characterizing hybrid work scenarios and the direction of the following studies. Yet this method only provided limited details of insights into the cooperative practices. To achieve a higher level of detail in the empirical data, this research was followed by an ethnographic data collection.

The second phase of the research process relied on ethnographic data collected through interviews, observations, and documents. Ethnographic methods have the goal of exploring work practices as they naturally occur (Blomberg & Karasti, 2013; Randall et al., 2007) and have been core in this PhD to produce an understanding of how cooperative practices are enabled or constrained in current technology use and work environments. While the literature study offered insights across various professional domains, the ethnographic work focused on the office environment. This focus aligned with the wider attention from both society and the organizations involved in the ReWork project. Additionally, office work was the predominant topic in the literature study, with numerous papers addressing both social, cooperative, and technological challenges in this type of work. Since the literature study emphasized challenges in collocated environments, the ethnographic study centered on shared office space. Thus, we started identifying relevant empirical cases from the ReWork companies that could serve as a case environment and field site for ethnographic exploration of the contemporary challenges in hybrid collaborative work.

The ethnographic data included in this PhD derives from two organizations, pseudo-named InterFin and GlobalContent, on which three papers have been published (reflections on this industry

collaboration are presented later in this method chapter). Framed within CSCW, the aim of the ethnographic work was to uncover the reasoning behind cooperative practices and how computing technologies enabled and constrained hybrid collaboration. The conceptual definition established in Paper I, along with the fact that this literature study examined pre-pandemic cases of hybrid work in office environments, enabled us to enter the field site with a pre-existing understanding of collaborative contexts in hybrid offices. This was valuable for the ethnographic work to determine whether the workers practiced hybrid work and to explore the reasoning behind *why* they acted as they did. Ethnographic work on hybrid practices covers both the exploration of the physical activities at the office and the digital interaction in the virtual space, requiring varying strategies for the collection of data (Jordan, 2009; Ruhleder, 2000). Therefore, the method to study hybrid practices took different approaches to uncover and observe hybrid work through different methods, including observations of teams, meeting rooms, individual physical and digital interactions, as well as interviews with workers and managers. Unlike the literature study, which only provided a snapshot of the work settings as the authors scoped it, the ethnographic research provided a temporal perspective of the cooperative work. This ethnographic, temporal perspective has contributed to the nuance of hybrid work in uncovering how the context that these cooperative practices are situated within changes on a day-to-day basis.

To investigate the nature of hybrid work, the analytical process centered on capturing the *participants (who), their locations (where), cooperative activity (what), and the cooperative technologies (how)*. This process involved iterative mapping of observation notes using post-its on whiteboards. As more ethnographic data were collected, the analysis expanded, with Papers II to IV offering distinct perspectives from the analysis of computer-supported hybrid cooperative work. Figure 5 illustrates this analytical process for all three papers based on ethnography.

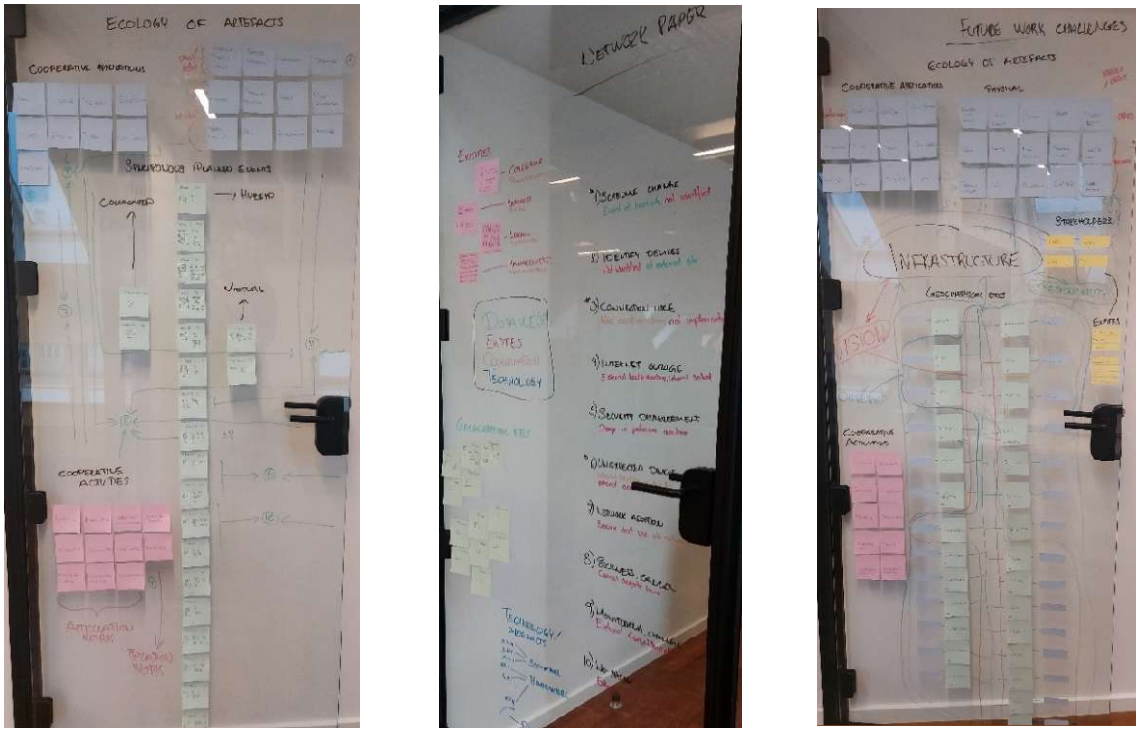


FIGURE 5. Visualization of the analytical process applied to the ethnographic data. The first image (right) corresponds to Paper II, the second to Paper III, and the third to Paper IV.

Paper II draws on ethnographic data from InterFin, focusing on cooperative teams' spatial challenges in producing shared, hybrid work environments. By analyzing the relevance of *where* each worker is located on different days, this paper revealed the continuous changes in cooperative setups, such as the weekly changes in who is placed where on which day, which challenges the utilization of physical technologies. Paper III is based on ethnography at GlobalContent to explore the nature of the work itself, emphasizing the role of infrastructure in shaping hybrid cooperative work. This infrastructural perspective was enabled by collaboration with Charlotte Lee, a professor at the University of Washinton. Charlotte Lee's expertise in empirical studies of information infrastructures allowed this study to investigate how global infrastructure and local work contexts co-evolve. Paper IV integrates empirical data from both organizations, combining insights to conduct a comparative analysis of cooperative technologies. This paper focuses on the contemporary design challenges for developing cooperative technologies supporting hybrid work. In this way, the three papers apply distinct analytical lenses to ethnographic data, with the aim of providing a nuanced understanding of computer-supported hybrid cooperative work. These three lenses are visualized in Figure 6.

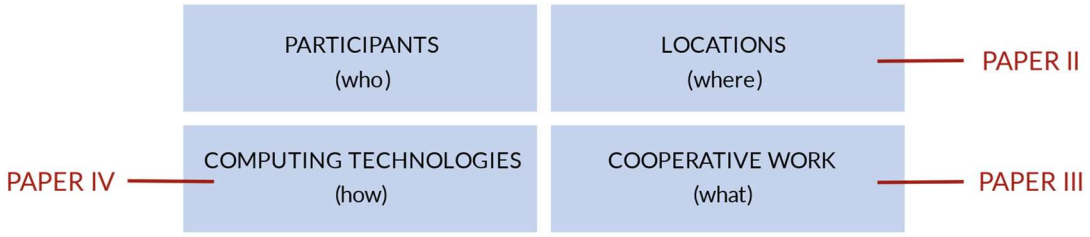


FIGURE 6. Analytical research lenses applied in the ethnographic-based research papers.

The third phase of the research took a quantitative approach and, different from the other studies, Paper V builds on survey data. Papers I to IV to different qualitative perspectives to explore cooperative engagements, work activities, geographical locations, and cooperative technologies. This ethnographic work further revealed the complexities of the organizational structuring of hybrid work conditions. While empirical data can provide insights into important factors of hybrid work, it cannot necessarily reveal the relationship between these factors, and to what extent the extra effort required from hybrid work is worth it. On this basis, the core of this quantitative study was to explore how to *capture the dynamics of hybrid work in a quantifiable way that can inform organizational management*. This was relevant because, throughout the empirical investigation, questions emerged about how organizations should structure their hybrid work models. For example, this included the implementation of policies to manage these work modes and the implementation of cooperative technologies to facilitate hybrid collaboration, such as meeting room equipment.

Turning the empirical data into quantifiable measurements was conducted in collaboration with Morten Hertzum, who is a professor at Roskilde University. This collaboration enabled a combination of Morten Hertzum's expertise in quantitative methods and our empirical insights into hybrid cooperative practices. Learning how we can measure and quantify hybrid work required several iterations of discussions to create a shared goal of something measurable while still unpacking the complexities of hybrid work. Recognizing that hybrid work may be more complex than distributed

work, the aim of this study was to identify and investigate factors that highlight the uniqueness of hybrid work in comparison to existing knowledge on distributed work.

Factor correlations can provide insights into connections between constructs and help assess the empirical validity of a theoretical framework (DeVellis & Thorpe, 2021). Thus, this method enabled us to compare how unique factors of hybrid work relate to factors of distributed work. To address the complexities of distributed cooperative work, this study builds on the Distance Framework (G. M. Olson & Olson, 2000), which presents five recognized factors relevant to the success of distributed work and has also been quantified previously (Caldeira et al., 2022). The quantification involved identifying the unique characteristics of hybrid work, which could be transformed into measurable factors and thereafter refined into survey items to evaluate their applicability. This process involved multiple iterations of discussions and external testing, refining both the factors and their survey items. Figure 7 illustrates this process by demonstrating the progression from the initial factors assessed by the ReWork project group to the surveyed factors tested again by ReWork and, finally, the refined factors after the analysis. The initial factors capturing hybrid work included location, distance, and temporal multiplicity (first column in Figure 7), which, through iterations of tests and discussions, were converted into location flexibility, collaboration effort, and collaboration technologies to enhance clarity and alignment (second column in Figure 7). These factors were surveyed with the idea of representing the hybrid characteristics. However, the factor analysis showed that the survey items did not predict the factors as initially anticipated, leading to a reevaluation of how certain factors define cooperative work and how others represent external influences on that cooperative work (third column in Figure 7).

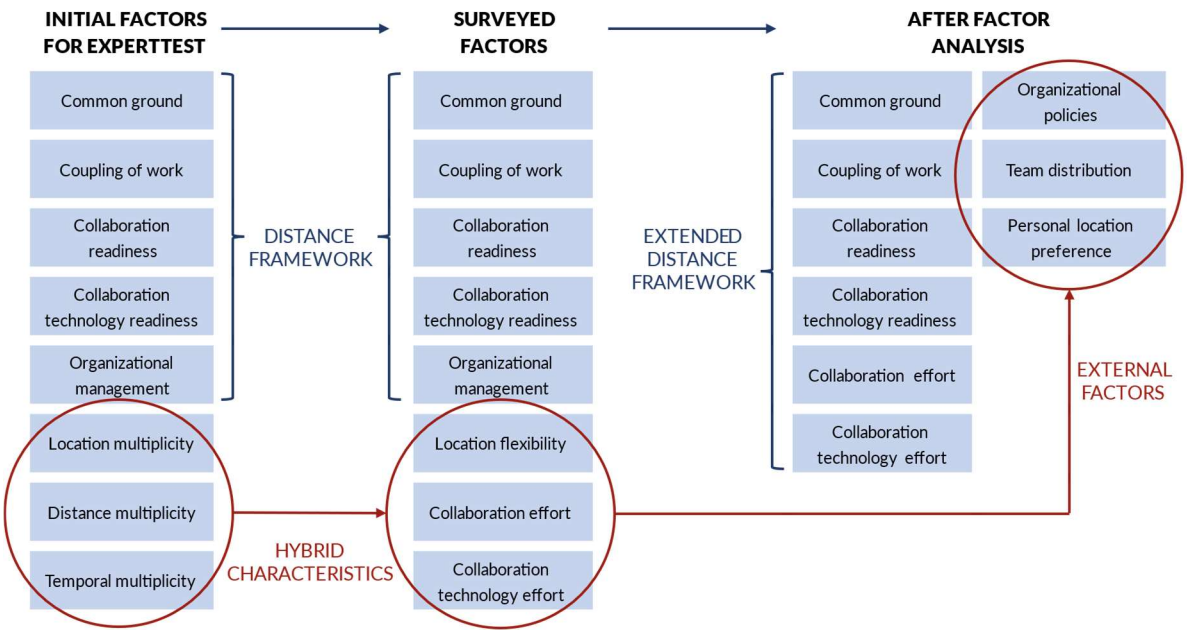


FIGURE 7. Research progress in factor development.

Quantitative methods differ from qualitative approaches in that they provide measurable and generalizable insights into patterns and relationships, but they do not capture the depth and contextual nuance typically offered by qualitative research. While the current version of Paper V does not reveal specific insights into the organizational management of hybrid work, which was the initial goal to explore quantitatively, the study shed light on the importance of remote options for the contemporary work environment. Capturing the nuances of hybrid collaboration quantitatively proved difficult due to the nature of the survey method. Specifically, translating our definition of hybrid work — emphasizing cooperative work — into a survey format presented challenges, as surveys primarily capture individual perceptions and offer limited opportunities for context. To address this challenge, potential directions for such studies could focus on the individual's role and location within cooperative work rather than the hybrid context as a whole. For instance, investigating how individuals experience remote work, their work locations, and the value they derive from having remote work opportunities could provide insights into contemporary work and organizational considerations.

Employing different methodological approaches allowed for a multifaceted exploration of technology support and organizational structures of hybrid cooperative work. Each method contributed to empirical insights – literature studies framed broad characteristics, ethnographic research provided contextual depth, and quantitative analysis enabled generalizability. Engaging with these different methods involved continuous reflections on how methodological choices shape the knowledge produced. This process also highlighted the limitations of each approach, particularly the challenges of transforming qualitative insights into quantitative measures. Navigating these complexities has provided insights into potential (re)directions in future studies that can be shaped by the methodological approach – such as surveys focusing on individual perceptions.

3.2 RESEARCHING ACROSS INDUSTRY AND RESEARCH AGENDA

To base the conceptualizations on empirical data, the PhD research involved collaboration with various industrial organizations both in and outside the ReWork project. The papers included in this PhD feature empirical data from a total of seven different organizations, with the empirical cases detailed in their respective papers. Two organizations were studied using ethnographic methods, while five were involved in collecting quantitative data by survey distribution. The industry's motivation for collaboration differed from the research motivation; the PhD process consequently involved navigating across industry and research agendas, influencing data collection, shaping the research approach, and conceptualizing the findings.

Through the engagement with the organizations, it was evident that the industry's motivation emerged from concerns about creating enabling conditions for their employees after the pandemic. The companies engaged in ethnographic research, InterFin and GlobalContent, and other industrial partners of the ReWork project (presented in the joined ReWork paper (Bjørn et al., 2024)) faced challenges in structuring work environments that support remote work options in combination with traditional office settings. For example, different investments were made in restructuring organizational policies regulating employees' physical presence, building new office environments, and investing in advanced technology, all to support post-pandemic work practices with the aim of encouraging physical presence. During the ethnographic data collection, one of the managers explained that the organizational

management and structuring of hybrid work models felt like navigating blindly due to a lack of knowledge about the best solutions. On this ground, collaboration and research were defined together with the companies and evolved over time. For example, early in the research, policies demanding physical presence in the office were minimal. However, today, three years after the pandemic, these policies and regulations for employees' remote work options have become more widely implemented and strictly defined.

The methodological approaches were shaped by the negotiation of agreements with the different organizations. The agreements with InterFin and GlobalContent differed regarding the allowed access to employees within the organizations. InterFin is a partner in the ReWork project, while the agreements with all other organizations involved in both ethnography and survey were added and negotiated later throughout the research process. InterFin restricted access to one department and specific areas of the building due to their handling of personal data but did not require anonymity. In contrast, GlobalContent required complete anonymity due to the nature of its organizational structure and work content but provided broader access to its buildings, documents, and departments. These varying conditions enabled different types of empirical exploration. The limitation to one department at InterFin allowed for an in-depth focus on individual and team perspectives in hybrid environments. Therefore, the research questions addressed in this ethnographic work focused on individuals' movements across different work locations and the complexities teams face in producing shared hybrid workspaces. Conversely, broader access within GlobalContent facilitated an emphasis on work processes and interdependencies beyond specific teams, revealing connections outside the immediate scope of work. This allowed for research questions focusing on the nature of work, which involves cross-organizational collaboration. The requirements of anonymity constrained the research to not disclose specific details of the company and its work. Although this did not affect the analytical process, it influenced the level of detail that could be shared and communicated, which consequently shaped the perspectives on what could be explored. For example, the research focus at GlobalContent, as presented in Paper III, remained on infrastructural transformations and team collaboration, as technical details and related cooperative challenges could be discussed without revealing specific information, thus maintaining confidentiality while still exploring key aspects of the research findings.

The industry collaboration was an iterative process involving continuous engagement with various informants from the organizations. The collaboration typically began with managers' perspectives on organizational management, including negotiation of access to data and employees. This was followed by the collection of ethnographic data with a focus on cooperative interaction and work activities. Consequently, different informants participated throughout the process, ranging from workers involved in daily cooperative tasks to managers overseeing organizational structure. Understanding these diverse needs and contexts was essential for exploring cooperative practices and sometimes conflicting interests regarding work conditions, such as regulations on physical office presence. This dual perspective offered insights into the varying needs and viewpoints, occasionally highlighting the challenges of balancing flexibility and stability for cooperative groups and organizational management.

In this relation, the industry collaboration revealed that *hybrid work is often an emotional topic*. Hybrid work reflects employees' personal preferences for working from home, which can conflict with

organizations' preferences for physical presence in the office, potentially managed with policies regulating employees' flexibility in choosing their work locations. Misalignment between personal preferences and organizational management can provoke emotional discussions. For example, such discussions were observed in situations where there were disagreements about whether employees complied with the enforced regulations and whether the specific policies were "correct," particularly regarding different perspectives on whether remote options are a privilege or a right. To address these sensitivities during the ethnographic work, questions on organizational policies and personal location preferences were raised only outside the shared office environments. Additionally, this sensitivity was evident in the negation with managers, as the explorations into organizational management sometimes resulted in companies declining to participate in the study. For example, one company refused to distribute the survey presented in Paper V within the organization because it included questions about whether the organization had policies allowing employees to occasionally work from home. The organization was concerned that addressing this topic in the survey would reopen contentious debates, as hybrid work policies had been a source of internal discussions in the years following the pandemic. The company was particularly apprehensive that such questions might imply a willingness to change its policies, which it wanted to avoid. In these ways, the PhD research has been shaped by the ongoing navigation between industry and research agendas, which has influenced both the types of data that could be collected and, consequently, the research questions that could be addressed, as well as the overall scope of the research focus.

3.3 IMPLICATIONS OF THEORETICAL CONCEPTUALIZATIONS

Theoretical conceptualizations contribute to structuring key aspects of complex phenomena, creating a shared language and discourse of future explorations. In this PhD, the aim of working with theoretical conceptualization was to identify core aspects of hybrid work practices and, in doing so, propose considerations for designing cooperative technologies in this context. Concepts are terminological definitions of specific phenomena, practices, or other aspects of realities developed to describe essential characteristics. Conceptualizations are common in CSCW research; for example, core concepts such as *articulation work* provide insights into the work required for engaging in cooperative practices (Schmidt & Bannon, 1992; Strauss, 1988). By introducing concise terminology, concepts help highlight important characteristics of phenomena and guide future directions.

Conceptualizations can emerge from different sources, such as empirical data or literature. Each paper in this PhD presents concepts that identify significant characteristics of hybrid work practices, informed by both empirical data and theoretical insights. Papers I to III were empirically driven with an inductive approach to let the conceptualizations ground in the analysis of empirical data. The concepts developed in these papers focus on the core characteristics of hybrid cooperative practices, including the geographical distribution of cooperative engagements (Paper I), the individuals' locations (Paper II), and the nature of the work (Paper III). All these concepts are context-dependent, deriving from hybrid practices. Differently, Papers IV and V are theoretically driven, focusing on technology design (Paper IV) and effort in engaging in collaboration in contemporary work environments (Paper V). Theoretically driven concepts are developed from established research, which can often provide broader, more generalizable ideas. However, this generality can make them less responsive to specific contexts, requiring adaptation to align with specific scenarios or practices.

Concepts can serve as sensitizing concepts guiding explanation and understanding (Bowen, 2006, 2019; Randall et al., 2007). Sensitizing concepts are interpretive tools that focus attention on framing questions and research directions. In this way, concepts can facilitate shared understanding across disciplines, which is particularly relevant to CSCW's interdisciplinary nature. As interpretive tools, concepts invite multiple perspectives and implications; this PhD aimed to explore conceptualizations from three perspectives: research, technology, and industry. From a research perspective, concepts suggest new objectives for studies. To exemplify, the concept of collocated distance, developed in Paper I, shaped subsequent ethnographic explorations by guiding the focus of attention to the collocated context during the ethnographic work. From a technology perspective, concepts inform design propositions. All concepts included in this PhD thesis suggest design propositions for cooperative technologies supporting hybrid work (a list of these design propositions is presented in Findings, chapter 0). However, the development of these propositions differed depending on the method for developing the concept. For example, Paper IV revises existing research on design challenges and, on this basis, presents concepts that explain design challenges that can almost directly be translated into design propositions. In contrast, empirically driven concepts, such as those presented in Papers I to III, emerged from observations of specific contexts, offering detailed, practice-based insights that required additional interpretation to inform design exploration. This work involved a reinterpretation of the concept, which based on empirical findings across all data, could transform these insights into design propositions. From an industrial and practical perspective, concepts can provide insights into employees' cooperative practices, supporting their structuring of organizational management. This sometimes necessitated reworking the findings to adjust the perspective on results that may not align with research agendas but can instead inform organizational management. For example, the presentation of conceptualizations of hybrid work facilitated discussions of potential misalignments between organizational management and hybrid cooperative work practices.

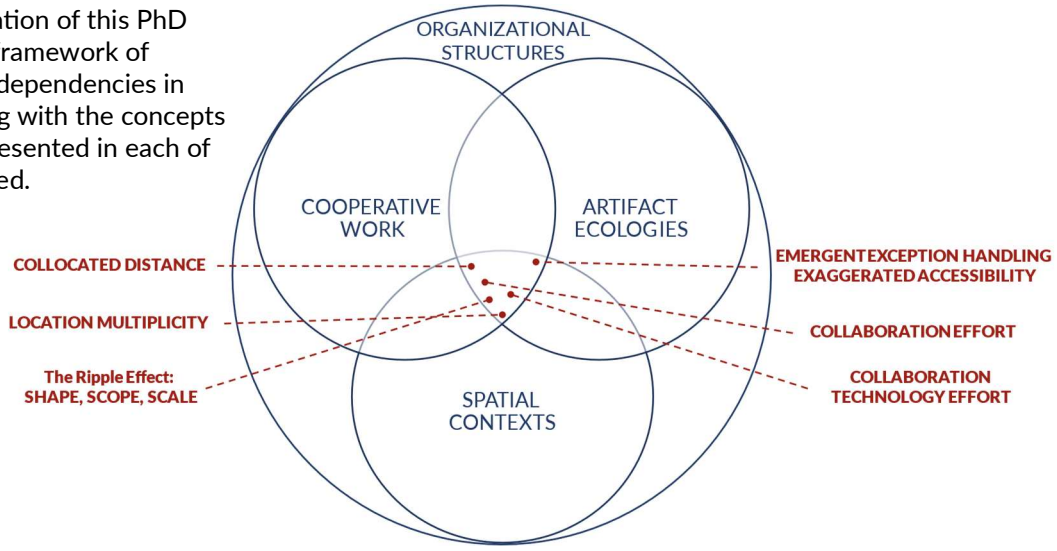
In this way, this PhD has viewed concepts through three interconnected lenses, each offering a distinct perspective that demonstrates the interplay between theoretical insights and empirical data. A concept describing a particular cooperative practice can act as a lens to assess whether a given technology adequately supports that practice and vice versa. By bridging observed practices and design explorations, this PhD's conceptualizations aimed to suggest insights into research objectives, guide technology design, and reshape organizational practices.

Frameworks often build on conceptualizations by illustrating relationships between concepts and connecting interrelated aspects into a cohesive model. Frameworks, like concepts, can derive from various research data and are flexible, allowing for modifications as new insights emerge. For example, Paper V extends the Distance Framework (G. M. Olson & Olson, 2000) to address contemporary characterizations of organizational work. The original Distance Framework includes four interrelated concepts important for success in distributed work; Paper V adds two new concepts based on empirical data and recent literature, demonstrating the continued relevance of the framework in contemporary work environments.

Differently, the framework proposed in this PhD thesis was developed using a bottom-up approach. This process was informed by the concepts presented in all five papers, as well as empirical data and previous research. Developing conceptual understandings requires an iterative approach

grounded in empirical explorations to ensure credibility (Glaser & Strauss, 2017). This methodological approach involved analyzing connections between concepts, identifying overlaps, and addressing misalignments. By iteratively refining the relationships between the concepts presented in the included papers, the framework was shaped to reflect the interdependencies and complexities inherent in hybrid work practices. In this way, the framework proposed in this PhD thesis highlights *dimensional interdependencies in hybrid work*, suggesting what should be considered when designing cooperative technologies for hybrid work practices. The research conducted throughout the PhD process emphasized the interconnected nature of hybrid work in which cooperative work, spatial contexts, ecologies of computing technologies, and organizational structures are mutually dependent in complex ways. The framework illustrates these interdependencies, offering a structured perspective on what is important when designing for hybrid work. The framework aims to serve as a conceptual tool for both research and industry. For research agendas, it identifies concepts and dimensions relevant to designing cooperative technologies. For industry, it highlights the importance of considering the interconnection between the structuring of cooperative engagements, organizational policies, and office space, as well as the implementation of technology. By illustrating the interrelationship of these dimensions, the framework contends that none of them can be viewed in isolation; instead, they must be considered together within their broader context. The framework is illustrated in Figure 8 but elaborated in the Discussion, chapter 5.5.

FIGURE 8. Illustration of this PhD thesis' proposed framework of dimensional interdependencies in hybrid work, along with the concepts developed and presented in each of the papers included.



The work on theoretical conceptualizations in this PhD aimed to capture the unique characteristics of hybrid cooperative practices, providing a shared language for bridging research and industry perspectives. The relevance of the conceptualizations has been validated in the research context through peer-reviewed publications, while in the industry context, it involved presentations for managers. Research findings were shared with managers from the industry collaborators upon completing a study, which involved discussion of the practical implications. This feedback fostered discussions and refinement of insights to ensure the relevance of both theoretical and practical contributions. For instance, this PhD's proposed framework of dimensional interdependencies in hybrid work was presented to GlobalContent, which sparked discussion on potential challenges in their current redesigning of meeting rooms and investment in technologies.

In this way, the concepts and frameworks developed throughout this PhD aim to bridge research across industry and academic agendas, highlighting the interplay between dimensional interdependencies that are crucial for understanding and designing for hybrid work. By integrating insights from empirical data, theory, and previous research, this work seeks to contribute to the broader research effort to conceptualize hybrid work, offering insights into research on future ways of working, practical approaches in organizations, and the design of cooperative technologies.

4 Findings

To conceptualize computer-supported hybrid cooperative work, five papers have been developed to present different investigations into what is important in hybrid work practices. Each of the papers included explores distinct areas of cooperative engagements, all contributing to identifying important aspects to consider when designing cooperative technologies for hybrid work. This chapter elaborates on each of the paper's contributions and concludes with an overview of how the theoretical concepts invite design propositions. Table 2 provides an overview of the five papers' focus and contributions.

TABLE 2. List of publications and their respective research questions and contributions.

PAPER	RESEARCH QUESTION	CONTRIBUTION(S)
PAPER I: Collocated Distance: A Fundamental Challenge for the Design of Hybrid Work Technologies	What are the characteristics of hybrid cooperative work that introduce unique design challenges to be met by cooperative technologies?	1. Presents a conceptual definition of hybrid work as at least three people who are mutually dependent in their work while being distributed across fewer contexts than there are individuals involved, yet not all collocated. 2. Categorizes empirical cases from the literature on hybrid cooperative work into the four domain fields: health, performance, office, and out-of-office. 3. Identifies *collocated distance* as a unique design challenge in hybrid work technologies, highlighting the potential misalignment among subgroups within a shared geographical location.
PAPER II: Location Multiplicity: Lost Space in the Hybrid Office	What are the spatial challenges of producing and negotiating a shared hybrid workspace in hybrid office arrangements?	1. Presents a temporal perspective for studying hybrid work in office environments, reflecting the daily variations in cooperative settings. 2. Identifies *location multiplicity* as an inherent characteristic of hybrid work, describing how individuals move across multiple locations, thereby making hybrid configurations malleable. 3. Presents a design challenge for cooperative technologies in creating stability and predictability across spatial and temporal dimensions in hybrid work arrangements.

PAPER III: The Ripple Effect of Information Infrastructures	How does the global information infrastructure impact the nature of local work contexts?	1. Explores the connectedness between local work contexts and global information infrastructures. 2. Suggests that the co-evolvement of work and information infrastructures requires an infrastructural perspective in CSCW studies to understand how work practices are impacted by the characteristics of the information infrastructure. 3. Proposes *the ripple effect* of information infrastructures to shape and scope local work contexts across multiple scales, requiring an extended peripheral perception to identify (invisible) interdependencies outside the immediate scope of work.
PAPER IV: Revisiting Grudin's Eight Challenges Developers of Groupware Technologies 30 Years Later	What are the challenges for developers of groupware technologies in 2024?	1. Introduces empirical data on hybrid work practices into the analysis of Grudin's original challenges. 2. Categorizes the design challenges into cooperative, social, and organizational. 3. Presents a refined list of contemporary challenges for groupware developers, revising the cooperative challenges to *emergent exception handling* and *exaggerated accessibility* to align with the multifaceted and simultaneous use of cooperative technologies in hybrid work.
PAPER V: How Distance Matters in Dynamic Work Environments	How does distance matter to an individual's work experience in contemporary cooperative teams?	1. Extends the original Distance Framework by adding two new factors: *collaboration effort* and *collaboration technology effort*, reflecting the complexities of collaborating across dynamic configurations. 2. Shows the six collaboration factors of the Extended Distance Framework to predict 24% of the variation in job satisfaction. 3. Demonstrates that distance affects both team dispersion and the role of the office, while only office-related factors impact job satisfaction.

4.1 COLLOCATED DISTANCE IN HYBRID ARRANGEMENTS

Paper I studies the characteristics of hybrid work based on empirical cases from previously published papers across different professional domains. Through the selection process of empirical cases, a conceptual definition of hybrid work was developed to identify which cases were in hybrid settings. The definition suggests that hybrid cooperative work involves at least three individuals who are mutually engaged in a shared field of work while being geographically distributed across fewer contexts than there are individuals involved, yet who are not all collocated. Based on a detailed analysis of the cooperative work in the empirical cases across the four research papers, Paper I argues that hybrid work inherits the characteristics and challenges of both cooperative and distributed work, thereby placing hybrid work as a subset. Furthermore, the paper presents examples of hybrid scenarios where technologies connect geographically distributed sites but do not address the misalignment between collocated participants sharing a geographical site. Based on these insights, the paper introduces the concept of *collocated distance* as a unique challenge in hybrid work, illustrating that subgroups are created both across and within collocated contexts due to geographical locations and technology use.

Collocated distance refers to situations in hybrid work where collocated subgroups cannot be assumed to have a shared understanding, even though these individuals share a geographical context. One geographical site can host individuals with varying opportunities to access information, tools, and other people. Therefore, the design of cooperative technologies for hybrid work should support collaboration across geographically distributed borders and bridge collocated distances within subgroups that share geographical locations.

4.2 THE ILLUSION OF THE HYBRID OFFICE

Paper II explores the spatial challenges of producing shared, hybrid workspaces in the post-pandemic office. Through empirical ethnographic exploration, the paper presents the contemporary challenges of navigating *location multiplicity* in hybrid work. Taking a temporal perspective, hybrid work is not simply a matter of a *location binary* where individuals choose between home and office. In practice, hybrid work represents location multiplicity, separated across several ‘homes’ and office spaces. Locations in hybrid work include individuals' home spaces and various office areas, such as different floors of the office and sometimes even different buildings. Navigating location multiplicity challenges the production of a hybrid workspace due to the continuous reconfiguration of the cooperative setup, creating a lack of consistency, stability, and predictability. Remote work options create flexibility for individuals, yet consequently, team members rarely know where their coworkers are geographically located. The paper demonstrates that workers risk disconnecting from the physical space and instead rely on the stability of the digital space to decrease their dependency on specific locations.

Paper II suggests that designing hybrid cooperative technologies is challenged by integrating both physical and digital components into a shared workspace. To take advantage of physical opportunities and geographical collocation, work should be able to persist beyond spatial and temporal borders. The use of physical components at one site (e.g., writing on a whiteboard) often disappears by the next day, which complicates their integration, as hybrid cooperative groups may be distributed differently the next time they need to access the work. Based on these insights, the paper suggests that cooperative technologies for hybrid work should be location-independent, enabling access to work regardless of the specific collaborative configurations on different days.

4.3 WORKING WITHIN INFORMATION INFRASTRUCTURES

Paper III investigates the socio-technical aspects of working within interconnected infrastructures. The findings are based on ethnographic explorations of an infrastructure project conducted from one office location but having a global impact. The paper suggests that *the ripple effect of information infrastructures* calls for an extended infrastructural perspective when studying local work contexts, as global information infrastructures shape and scope local work contexts at multiple scales. Local work is embedded into the information infrastructure, making work and infrastructure interconnect and continuously co-evolve as the work progresses. An extended peripheral perception is needed to understand and identify peripheral – and sometimes invisible – interdependencies, such as people, artifacts, and policies that are relevant to the work, even though they might not be visible.

Exploring how local work contexts are interrelated to the larger setup is relevant for hybrid work, as hybrid environments unfold in multiple locations where people and technologies are situated. An individual's vision from one local context is constrained by the hybrid distributed setup, leading to potentially important interdependencies being placed out of sight, scaling the local work context. The paper provides empirical insights into how cooperative technologies for hybrid work must be scalable and flexible to support the evolving nature of work. As the scope of interdependent people, artifacts, and policies changes, cooperative technologies need to adapt dynamically to the evolving work context. This adaptability must support continuous collaboration among relevant individuals, accommodating the co-evolution of work and infrastructure.

4.4 CHALLENGES FOR DEVELOPERS OF GROUPWARE TECHNOLOGIES

Paper IV revises Grudin's (1994) eight challenges for groupware developers to reflect the contemporary challenges of hybrid work environments. During the past 30 years, technologies have increasingly advanced and become seamlessly integrated into organizational work practices, becoming an indispensable part of the work. The paper categorizes the original design challenges into cooperative challenges (no. 4 and 5), social challenges (no. 1, 2, and 3), and organizational challenges (no. 6, 7, and 8) to explore which aspects have changed. The paper argues that while the main arguments of the social and organizational challenges remain the same, the cooperative challenges have changed in light of contemporary work practices. The original challenges argued that groupware technologies' are challenged in accommodating exception handling and improvisation (Grudin, 1994). Differently, this paper suggests that digital applications are used in various ways for different purposes, requiring ongoing adjustments of the technology, consequently revising this challenge to support *emergent exception handling*. Moreover, the challenge of accessibility is revised from handling unobtrusiveness and integration to instead handling *exaggerated accessibility*, as contemporary work practices are supported by multiple technologies in parallel, simultaneous use. This simultaneous use challenges the continuous reconfiguration of technologies and work required to create boundaries of technologies in practice, risking mental overload from constantly shifting between multiple interrelated contexts, applications, and devices.

4.5 DYNAMIC DISTANCE IN HYBRID WORKPLACES

Paper V explores how distance matters to individuals' work experiences in organizational cooperative teams. The paper suggests that distance has become a dynamic condition in hybrid environments as a consequence of employees alternating between multiple home and work locations on different days. The paper builds on a survey developed from the Distance Framework (G. M. Olson & Olson, 2000). Based on the empirical insights produced as part of the previous papers and literature, the paper introduces two new factors extending the original Distance Framework: *collaboration effort* and *collaboration technology effort*. These two factors reflect the effort required in collaborating within dynamically distributed teams, as well as the malleable requirements that this creates for producing appropriate technology setups.

To explore individuals' experiences of working in organizational teams, the paper investigates the relationships among the six collaboration factors, as well as five external factors and job satisfaction. The findings indicate that distance in contemporary work environments impacts not only the geographical separation within hybrid and distributed teams but also the role of the office. Being involved in geographically distributed teams has no significant relation to job satisfaction. In contrast, the experience of the office's ability to support access to relevant colleagues, as well as employees' personal preferences for working from the office or remotely, significantly impacts job satisfaction. Based on an equal distribution between respondents preferring to work from the office and those working remotely, the paper highlights the relevance of exploring ways that organizational offices can support dynamically distributed teams while still providing hybrid work models. In this relation, the dynamic changes in the geographical distribution of organizational teams suggest the need for cooperative technologies that support collaboration, regardless of whether an individual is engaged in hybrid cooperative work remotely or as part of a collocated subgroup, with the goal of reducing collaboration effort.

4.6 DESIGN PROPOSITIONS

Each paper presents conceptual insights into the nature of hybrid work. These conceptualizations invite different design propositions relevant to the design of hybrid cooperative technologies. Table 3 lists the papers included along with their conceptualizations and related design propositions.

TABLE 3. List of concepts and their design proposition for hybrid cooperative technologies.

PAPER	CONCEPT	DESIGN PROPOSITION
PAPER I	Collocated distance	To support hybrid work, technologies should support collaboration both across geographically distributed sites and *within* collocated contexts.
PAPER II	Location multiplicity	To support hybrid work, technologies should be location-independent.
PAPER III	Ripple effect	To support hybrid work, technologies should be scalable and flexible, supporting dynamic adaptation to changing work contexts and the evolving scope of relevant interdependencies.
PAPER IV	Emergent exception handling	To support hybrid work, technologies should be reconfigurable to accommodate ongoing emergent use, thereby reducing the need for exception handling.
	Exaggerated accessibility	To support hybrid work, technologies should align with the existing ecology of artifacts, supporting multiple, parallel, and different usages of applications and devices simultaneously.
PAPER V	Collaboration effort	Hybrid work increases collaboration effort.
	Collaboration technology effort	To support hybrid work, technologies should support the individual in engaging with relevant coworkers independently on whether they are remote or collocated with others, reducing collaboration effort.

5 Discussion

The overall research aim of this PhD was to explore what is important in designing cooperative technologies for hybrid work through empirical studies on contemporary work practices. In this endeavor, five papers have been included in this PhD thesis, each addressing a distinct perspective on cooperative technologies and hybrid work practices. The findings of these studies reveal insights into dimensional interdependencies in hybrid work environments, inviting new conceptualizations and design considerations. This chapter discusses the characteristics of hybrid cooperative work, the spatial conditions for collaborating in hybrid configurations, and the technological and organizational implications that arise. Finally, it proposes a unified framework, emphasizing how these dimensions are mutually dependent and, therefore, cannot be considered in isolation when designing cooperative technologies for hybrid work practices.

5.1 Characteristics of Hybrid Cooperative Work

Understanding the characteristics of hybrid work is essential for identifying how this specific type of cooperative engagement sets unique requirements for cooperative technologies. This PhD examined the nature of hybrid work as these cooperative actions are situated in practice, which is particularly relevant as the term has gained popularity in describing varying post-pandemic work models that integrate remote work with pre-pandemic collocated practices. This PhD's characterization of *hybrid* work is shaped by various empirical scenarios from both ethnographic work and research papers published before the pandemic. On this basis, the PhD thesis suggests a conceptual definition of hybrid work that places this type of cooperative engagement within the continuum of collocated and distributed work. Further, it highlights the importance of the collocated context, which multiplies when taking a temporal perspective on hybrid work.

To develop a concise definition of which cooperative engagements are hybrid – and which are not - Paper I investigates the characteristics of hybrid work across empirical historical cases within different domains. This is particularly relevant for identifying empirical cases, as there often are no clear terminological distinguishments between cases being presented as, for example, virtual, remote, distributed, and hybrid. Paper I builds on the CSCW definition of cooperative work as at least two people who are mutually dependent in their work (Ciolfi et al., 2023; Schmidt & Bannon, 1992). In this way, we define hybrid work as at least three interdependent individuals who are distributed across at least two contexts, yet fewer than there are individuals involved. This definition suggests hybrid work to encompass all cooperative settings within the continuum of solely collocated and fully distributed work arrangements, thereby always representing both collocated and distributed subgroups. This assumes that only minor changes in the geographical distribution will impact the collaboration, for example, in scenarios where only one person is remote while ten people are collocated. This definition shares characteristics with Neumayr et al. (2018, 2022), who argue that hybrid work encompasses both collocated and remote collaboration in synchronous and asynchronous work. While hybrid work is not

new (M. H. Olson, 1983), distinguishing cooperative settings in specific details of the ratio of how many are collocated versus remote was not necessarily common but interchangeably used to present virtual, remote, and distributed work.

This PhD thesis suggests that particularly the *collocated context is a unique challenge in hybrid work environments*, making it important to differentiate between hybrid and distributed contexts. Commonly, research on distributed work explores ways to facilitate collaboration across geographically distant sites (Mark et al., 2003; G. M. Olson & Olson, 2000). However, Paper I demonstrates that distance in hybrid arrangements also exists within the collocated context. Geographical distribution creates subgroups in cooperative engagements (Cramton & Hinds, 2004); in hybrid arrangements, these subgroups are created both *across* geographical distances and *within* collocated contexts. Paper I introduces the concepts of *collocated distance* to describe this characteristic of hybrid work arising from collocated individuals having varying opportunities for accessing relevant coworkers, technologies, and artifacts. In this way, the collocated subgroups in hybrid work cannot be assumed to have a shared understanding even though they share the same location context. Achieving common ground is always challenging in cooperative work (Clark & Brennan, 1991), but these challenges are amplified in distributed configurations (G. M. Olson & Olson, 2000). Establishing a shared understanding across hybrid distributions can present additional complexities, as hybrid work inherently creates asymmetric conditions in work (Bjørn et al., 2024). Hybrid configurations always consist of both collocated and distributed individuals who will never have the same options for information access or engaging in collaboration. These unequal opportunities make hybrid work differ from fully collocated or complete remote arrangements where all participants have symmetric opportunities and constraints for engaging in work.

Building the conceptual definition of hybrid work on historic cases allowed for exploration across various cooperative engagements within different professional domains that naturally unfold in hybrid settings. For example, as presented in Paper I, emergency call cases involve individuals distributed across the ambulance, the call center, and the emergency location itself (Paoletti, 2009) or live streaming of sports events where reporters and camera operators are positioned at various locations despite being in close proximity (Engström et al., 2010). Paper I's historic approach to characterizing hybrid work allowed us to look beyond cooperative practices influenced by the pandemic, where, in particular, computer-based office work underwent an accelerated digital transformation (Madsen et al., 2020; Smite, Moe, Klotins, et al., 2022). The hybrid office has received attention in both broader society and the media after the COVID-19 pandemic, particularly with a focus on empty offices and remote work policies (Appel-Meulenbroek et al., 2022; Smite, Moe, Tkalich, et al., 2022). These concerns were shared by the industry partners involved in this PhD and the ReWork project. Therefore, the ethnographic work focused on hybrid work in organizational office settings as these are situated in real-world contexts.

Hybrid office work blends the flexibility of remote work with the structure of traditional office environments. Research on hybrid office work presents various cooperative distributions based on individual preferences or opportunities for commuting to the office or working remotely throughout the week (de Souza Santos & Ralph, 2022; Smite et al., 2023). In line with these perspectives on potential weekly changes in individual locations, Paper II extends the "time snapshot" of hybrid configurations in Paper I by taking a temporal perspective to understand the challenges of producing a shared

workspace for hybrid cooperative work. The paper presents the concept of *location multiplicity* to describe how remote options in hybrid work introduce multiple potential geographical sites into the hybrid setup because individuals change working from the office and from home. These dynamic changes in hybrid configurations can complicate cooperative work in hybrid arrangements. *While hybrid work, with remote options, provides flexibility for the individual, it can, for the group, generate unpredictability and instability.* Individuals often move between locations over time by changing their work locations weekly or even daily, making it difficult to predict where relevant coworkers will be located at a given moment. Cooperative activities vary in their level of coupling and the related dependency on interaction frequency, while tightly coupled work can pose challenges in geographically distributed collaboration (G. M. Olson & Olson, 2000). In hybrid work, all types of work must be conducted in these malleable settings where the human configuration of the cooperative engagements might change daily. Therefore, this PhD thesis argues that, in hybrid work, the temporal perspective on configuration change cannot be neglected, as the geographical distribution of the same cooperative group will vary depending on the specific day and time.

5.2 SPATIAL MULTIPLICITIES IN HYBRID CONFIGURATIONS

An inheritable characteristic – and core challenge – of hybrid work is the multiplicity of spatial contexts in hybrid environments. Paper I suggests that hybrid work always represents at least two distinct contexts, while Paper II extends this by adding a temporal perspective, revealing that location multiplicity in hybrid work adds more potential contexts in hybrid environments as people can fluctuate between various locations during a week. The possibility of 'working from anywhere' (Sako, 2021; Smite, Moe, Klotins, et al., 2022) creates multiple potential spaces in hybrid environments, which all represent contextual constraints. This PhD research indicates that spatial multiplicities in hybrid work impact both an individual's work in leveraging physical opportunities and the requirements of organizational space.

Remote options make hybrid workers share characteristics with mobile workers, who often move across different locations for work. Mobile workers often need to reconfigure their activities and technology setups to adapt to the changes in spatial conditions (Brown & O'Hara, 2003; Erickson & Jarrahi, 2016). Harrison and Tatar's (2008) examination of space is introduced with the example of the place called 'café' being supplanted by the place 'office' as people bring their laptops to work in these places while drinking coffee. In this way, spaces are construed by the people, activities, and artifacts in use, which, through social interaction, put value into the embodied experience of a specific place (Harrison & Tatar, 2008). This is relevant in the examination of location multiplicity in hybrid work, as individuals move across several places that turn into offices in their embodied experience and use of it. In their use, several places that are otherwise designed for different purposes create several workspaces; for example, 'home spaces' turn into 'office spaces' when individuals work from home (Breideband et al., 2022, 2023; Ciolfi et al., 2020). Working from these different places can increase the effort required by the individual worker who continuously needs to configure their setup. This dynamic configuration can relate to both technological, organizational, and contextual constraints, which can set different requirements for technology support (Erickson & Jarrahi, 2016). For example, the conditions for working remotely from home are different from the conditions at the office. In this relation, Paper V introduces the concepts of *collaboration effort* and *collaboration technology effort*, reflecting the work

required for engaging in the continuous reconfiguration to adapt to the specific cooperative contexts that change over time – both when the individual person changes location and when one of the relevant coworkers does.

Besides the multiplicity of physical spaces covering the organizational offices and private home spaces, hybrid practices are further shaped by the digital cyberspace (Halford, 2005). Paper II presents a case of hybrid workers who rely on the digital space for their shared work, facilitating a collaborative virtual environment (Benford et al., 2001). During the pandemic lockdown, they abruptly transitioned all their work activities online, creating a common information space (Bannon & Bødker, 1997), which existed solely in the digital space. For example, these workers, before the pandemic, utilized the office's whiteboard to provide an overview of work progress and project management, just as they conducted teaching-related activities in physical meeting rooms. During the pandemic, this was digitalized, with whiteboards being replaced by digital Kanban boards and teaching activities facilitated through Microsoft Teams. While this was an effective strategy during the pandemic, these digital practices continued after the lockdown regulations eased. Relying on digital applications enabled by individual computing devices allows the individual person to access the work and engage in collaboration independent of their location, as well as this location's spatial conditions. However, Paper II exemplified how this strategy also can invite new challenges in *re-introducing the physical space* in return to the office after the pandemic. In this empirical case, the workers continue to rely on the stability of online and individual technologies, as this allows them to disconnect from the constraints set by the physical space. Although this organizational office was architecturally designed with affordances aiming to integrate both physical and digital collaboration, the workers' actual practices did not align with the pre-defined opportunities set by the physical space. Instead, leveraging the opportunities of the physical space increased the required collaboration effort and collaboration technology effort, as the individual person had to reconfigure their work every time they changed their activity, group, or location.

Hybrid practices can impact the requirements for the physical space, as organizational office spaces must facilitate collaboration for different activities unfolding in varying configurations – for example, maybe one day, only one person is located at the office site, while the next day, 20 people are on-site. The spatial multiplicity of hybrid work creates malleable team configuration, which increases the required collaboration effort in navigating and producing hybrid workspaces. The empirical case in Paper II demonstrates a newly renovated office that is designed for specific activities with five different types of meeting areas for cooperative activities. However, the fact that the office was designed for pre-defined actions with specific activities instead led to a 'lost space' where these opportunities were never utilized – instead, all workers individually engaged in digital work from their personal computers at their own desks, engaging in digital work. The architecture and materiality of a space impact the constraints of the cooperative work (Alavi et al., 2019; Orlikowski, 2007). Designing without pre-defined boundaries has the potential to support flexible use (Bjørn & Østerlund, 2014). In line with this, this PhD thesis suggests that *physical spaces for hybrid work should be designed to dynamically support the malleability of hybrid cooperative work* without setting pre-defined boundaries for specific work activities and collaborative configurations. Embedding dynamics into the fabric of office buildings may support flexibility in use, thereby reducing the collaboration effort and technology effort required from individuals engaging in physical, collocated interactions in hybrid work.

5.3 EMERGING TECHNOLOGIES FOR FUTURE WORK PRACTICES

Hybrid work practices are supported by diverse technologies that enable individuals to participate in collaborative activities and interactions across various collaborative configurations, reflecting changes in both work activities and geographical distributions. In this way, computer-supported work is not merely about human interaction with a single device or technology but involves individuals switching between multiple devices and applications, forming ecologies of artifacts (Lyle et al., 2020). These technology artifacts are multiple in quantity but can also serve multiple functions for different purposes (Bjørn & Hertzum, 2011). This PhD research particularly emphasizes findings indicating that hybrid work practices should be supported by cooperative technologies that simultaneously support both collocated and distributed collaboration, facilitate individuals in transitioning across different locations, and enable continuous adaptation to the specific work context (e.g., changes in the people involved).

Starting with the latter, Paper IV explores contemporary design challenges in cooperative technologies for hybrid work, based on two empirical cases in office settings where work relies on various digital tools and computing devices, such as laptops and meeting room equipment. The paper highlights the importance of technologies to support *reconfigurability and alignment with existing artifacts*. The need for reconfigurability emerges from hybrid practices being supported by digital technologies for various types of cooperative activities. For example, Paper IV demonstrates how MS Teams facilitates diverse cooperative activities, such as presentations, brainstorming, and social activities. These practices are enabled by MS Teams' ability to continuously adjust subgroups involved in the work concerning both communication and information sharing.

In relation to this, Paper III emphasizes that the scope of relevant individuals in cooperative work evolves over time, requiring technologies to dynamically adapt to shifting work contexts. The paper illustrates how a local work context is shaped across multiple scales through interdependencies with external people, technologies, and policies. Consequently, cooperative technologies should accommodate continuous adjustment of relevant individuals (such as subgroups in MS Teams) and establish connections *beyond local boundaries*. As interdependencies extend beyond local work contexts, cooperative technologies should support collaboration among individuals with differing local constraints, such as varying organizational affiliations and access to technologies. Organizational structures and unique local characteristics — such as distinct practices, technologies, and policies — affect the reach of cooperative technologies, influencing how well they support collaboration across work settings (Gerson, 2008). Therefore, cooperative technologies for hybrid work should often account for the constraints tied to interdependencies that are outside the immediate scope of work. For example, a hybrid cooperative activity may be facilitated by MS Teams yet involve cross-organizational work where one participant relies on MS Teams while another only has access to Zoom.

Cooperative technologies for distributed work facilitate collaboration across distances (G. M. Olson & Olson, 2000). However, this PhD thesis suggests that cooperative technologies for hybrid work should *support collocated and distributed collaboration simultaneously*. The empirical findings highlight the importance of where people situate their bodies in hybrid environments, with emphasis on the *collocated context*. Hybrid collaboration involves people and technologies located across multiple sites, which can change over time. This malleable nature of hybrid configurations introduces dynamic

changes in collocated settings that must be considered in the implementation of technologies. However, this collocated context is sometimes neglected in cooperative technologies for distributed collaboration.

Research on emerging technologies for distributed collaboration covers, for example, 'Perspectives', which aims to increase symmetric participation and accessibility in hybrid meetings (Tang et al., 2023). Similarly, Reilly et al. (2015) explore how to create a blended physical and digital project room for shared work activities. With a focus on integrating bodily elements into hybrid environments, explorations investigate ways to give a remote person a physical presence in the collocated context (M. K. Lee & Takayama, 2011; Misawa & Rekimoto, 2015), which can also increase awareness of the remote participant (Venolia et al., 2010). However, these explorations into cooperative technologies primarily focus on *connecting geographically distributed sites without supporting collocated interactions*. Unlike fully distributed configurations, hybrid work inherently includes collocated subgroups. Papers I and II demonstrate that when technologies support distributed collaboration but neglect to facilitate collocated interaction simultaneously, there is a risk that users will not take advantage of their collocation. Instead, they may rely on digital practices, collaborating as if they were working entirely remotely, even when they are situated within a shared geographic site.

Paper II's conceptualization of location multiplicity in hybrid work suggests that cooperative technologies should be location-independent, allowing people and artifacts to remain connected across time and space. Advanced technologies for hybrid collaboration, such as Hybridge and Perspectives (Panda et al., 2024; Tang et al., 2023), aim to support equal opportunities for engagement. However, these technologies require individuals to be physically present at specific locations. As hybrid work offers flexibility for individuals' locations, these configurations are, unlike cases on distributed work that represent a constant in the distributed configurations (Bjørn & Christensen, 2011), not always located at the same location. This inconsistency in hybrid configurations likely increases the required collaboration technology effort when using location-specific technologies.

While the empirical data in this PhD does not include organizational offices using similar emergent technologies, Paper IV provides an example of other advanced technologies that remain unused due to their location dependency. The paper exemplifies that engaging with these technologies increases the collaboration technology effort because it does not extend the existing artifact ecologies that the workers already rely on in their hybrid practices. Artifact ecologies are dynamic and adapt to changes in work practices (Bødker & Klokmose, 2012). However, cooperative technologies for hybrid work must adapt not only to changing work activity but also to changing human configurations. Consequently, Paper IV argues that hybrid work technologies should align with the existing artifact ecology, providing seamless reconfiguration of the technology setup supporting their next activity.

The flexibility individuals can have in choosing their own locations creates cooperative conditions that continuously change. This means that even in routine work involving the same task, the same people, and at the same time, the collaboration can unfold in different ways due to changes in geographical distributions. This malleability requires an increased collaboration technology effort to continuously adapt the technology setups. To support these dynamics of hybrid work, activity-based computing offers a perspective where multiple technologies support mobility within specific collaborative activities (Bardram, 2005). This emphasis on technologies being tailored for specific activities across diverse work contexts can align with the notion of location independence.

Being a remote worker in a distributed collaboration can involve several challenges for participating in hybrid cooperative work (Bjørn et al., 2024; Ciolfi et al., 2020; M. K. Lee & Takayama, 2011). However, in hybrid configurations, the additional effort required to integrate remote participants into the hybrid collaboration often falls on the collocated group, for example, in managing extra cameras and microphones. Cooperative work inherently requires articulation work, and it is not uncommon that the value of this extra effort is not experienced by those who must perform it (Grudin, 1994; Schmidt & Bannon, 1992). Yet the inherent asymmetry of hybrid work means that even when individuals invest in additional collaboration effort and collaboration technology effort for creating technology setups supporting hybrid collaboration, they rarely achieve equal conditions for participation (Bjørn et al., 2024). This PhD thesis suggests that to reduce collaboration effort and collaboration technology effort, *cooperative technologies for hybrid work should be location-independent while still facilitating both collocated and distributed interactions simultaneously.* In doing so, these technologies can support individuals in engaging in cooperative work, regardless of whether they or their relevant coworkers are remote or collocated, thereby reducing the effort required for hybrid collaboration.

5.4 ORGANIZATIONAL STRUCTURING OF CONTEMPORARY WORK ENVIRONMENTS

Collaborating with the industry during this PhD process has demonstrated organizational challenges in structuring and managing conditions that support hybrid work practices. Organizational management is essential for facilitating cooperative engagements (J. S. Olson & Olson, 2014). In this context, this PhD research focuses on office settings (e.g. flexible seating), the distribution of cooperative engagements (e.g., team configurations), and organizational policies (e.g., remote work regulations). The findings suggest that organizational structures for hybrid work should emphasize management practices that ensure access to relevant interdependencies within organizational spaces, thus enabling collocated interactions within relevant subgroups while still maintaining remote work options.

Cooperative engagements can be hybridly distributed in organizational office work, with teams collaborating across different countries, as demonstrated by InterFin in Paper II. Additionally, hybrid teams can exist in organizational teams that have access to a shared site for collocated collaboration, while remote options permit occasional distribution, as shown in the organization GlobalContent in Paper III. The comparative analysis in Paper IV indicates that both cases experience similar challenges in hybrid collaboration due to inconsistencies in team configuration resulting from remote options. The flexibility of individuals' locations in hybrid work means that workers do not always experience improved access to their relevant colleagues when they are at the office – not even when the organization operates from a single office location. In relation to this, Paper V suggests that geographical distribution within a team does not relate to an individual's job satisfaction; however, being in an office that does not facilitate access to colleagues is correlated with lower job satisfaction.

The management of hybrid cooperative engagements can be challenged in balancing empowerment and control (Cousins et al., 2007). Policies on remote work dictate physical presence at the office; however, the structure of these policies can provide less flexibility for employees. The empirical data in this PhD covers different examples of organizational policies that regulate employees' work locations. Paper II presents an organization with defined regulations that were continuously adjusted in the time after the pandemic. Paper III reflects an organization with no regulations, and Paper

V shows this survey data to represent employees where two out of three are employed in an organization with regulations. Misalignment between work practices, personal preferences, and organizational management can affect individual work experiences (Berger et al., 2021). For example, Paper II presents a case in which organizational policies required physical presence at the office most of the time. However, the cooperative teams were globally distributed, meaning a team would never be fully collocated and would always require technology support for collaboration. In this case, one of the workers reported feeling lonelier at the office compared to working remotely, as the work, in practice, involved sitting at the desk with headphones on to participate in digital collaboration throughout the whole day. The office did not provide the contextual conditions needed to support the work; for example, it was designed as one large open space, which posed challenges with noise. Furthermore, it did not support greater access to relevant interdependencies, as the work was conducted online with coworkers located across various distributed sites. In this way, this empirical case illustrates how organizational management, in an attempt to support hybrid collaboration by enforcing physical presence at the office sites, may misalign with how this hybrid work unfolds in practice.

Professional relationships are shaped by various factors, including prior experiences, the frequency of interactions, and the coupling of work (Christensen et al., 2014; Cummings & Kiesler, 2008; Tenório & Bjørn, 2019). In hybrid collaboration, the strongest ties may not always be among collocated workers, as relationships exist across both collocated and distributed settings, as well as across professional disciplines (Cummings & Kiesler, 2008). Professional relationships, for example, formed through tightly coupled work, can exist between coworkers located in different countries, as was the case in Paper II. Maintaining these relationships requires workers' engagement in relation work (Bjørn & Christensen, 2011), and in this case, the worker engaged in relational activities with distributed coworkers, such as having virtual coffee. This illustrates the worker's emphasis on fostering relationships through digital interactions with those involved in tightly coupled work. In contrast, the organizational office only provided the option for collocation with coworkers involved in rare or loosely coupled work. Therefore, supporting collocated interaction in hybrid work goes beyond simply enabling shared geographical presence; it also involves facilitating meaningful access to relevant interdependencies.

This PhD thesis suggests that providing remote options is important in contemporary work environments, with Paper V showing an equal distribution between employees who prefer to work remotely and those preferring to work at the office. However, remote options increase the instability and unpredictability of cooperative teams. Therefore, this PhD thesis also suggests that the *organizational structuring of hybrid work should create an experience of stability in the cooperative constraints and support increased access to relevant interdependencies*. For example, flexible seating policies *increase instability*, while offices that support collocation with *relevant* coworkers, potentially across different organizational associations, can support hybrid work environments.

5.5 DIMENSIONAL INTERDEPENDENCIES IN HYBRID WORK

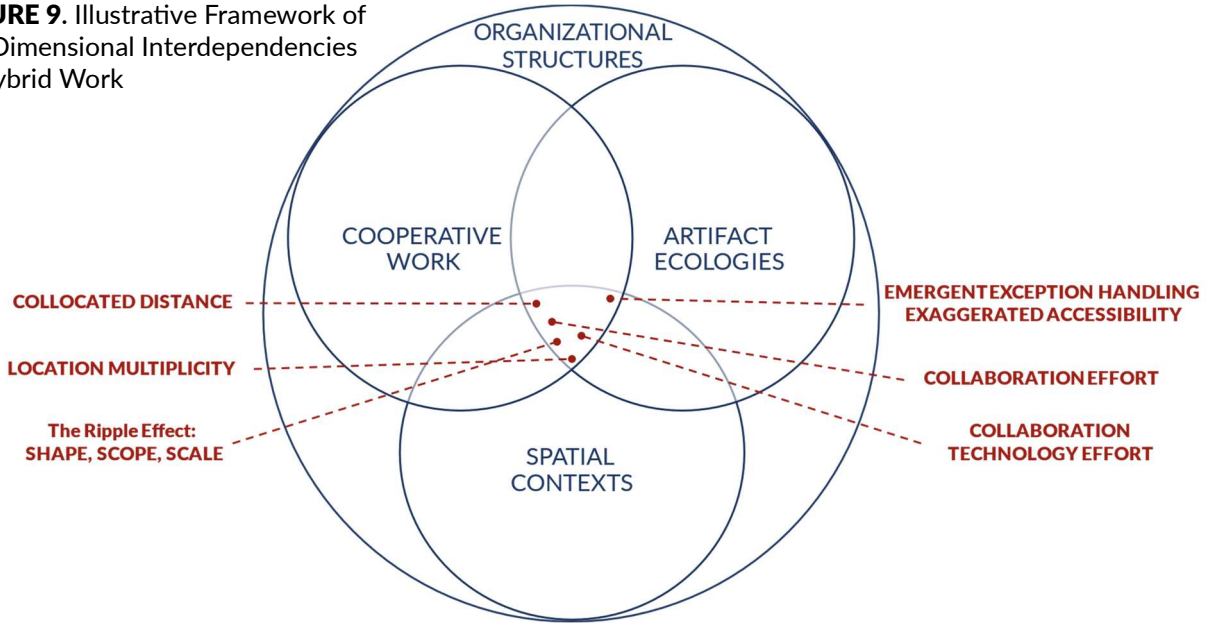
This PhD research has taken different methodological and analytical perspectives on hybrid cooperative work. Each of the five papers included in this PhD thesis explores distinct aspects of contemporary work practices, covering the nature of the work and the cooperative, organizational, and technological configurations. These dimensions are intrinsically interdependent, so to confine them into one

conceptual model, this PhD thesis proposes a framework that integrates social and technical insights, unifying the PhD research and the inherent relations revealed in the papers that mutually shape hybrid cooperative work practices.

A coherent framework for hybrid work aims to illustrate socio-technical complexities in contemporary work, which is relevant for structuring and designing for hybrid work. Notable CSCW frameworks, such as Johansen's matrix for cooperative activities based on time and space (Johansen, 1988), which have been updated for hybrid work (Neumayr et al., 2018), categorize activity types and their technology support. Lee and Paine's (2015) model of coordinated actions nuance the conceptualization of cooperative work by present dimensions placed on a continuum. Further, Olson and Olson present the Distance Framework of important factors for success in distributed work. Paper V of this PhD thesis extended this framework to reflect the required collaboration effort and collaboration technology effort that are necessitated to engage in the dynamic conditions set by hybrid configurations. Each of these frameworks illustrates different conceptual relations of computing technologies for cooperative engagements. The aim of the framework proposed in this PhD thesis is to illustrate the relationships between the conceptualizations developed throughout the research process. In this way, the framework unifies empirical insights and theoretical concepts, building on previous research to illustrate the dimensional interdependencies relevant to designing cooperative technologies for hybrid work.

The framework development involved synthesizing theoretical concepts, empirical practices, and organizational approaches across each of the five papers included in this PhD thesis. This analysis emphasized the inherent multiplicity and dynamics in hybrid cooperative work, leading this PhD thesis to propose four dimensional interdependencies in hybrid work: *cooperative work*, *spatial contexts*, *artifact ecologies*, and *organizational structures*. Each of the papers included addressed distinct questions but collectively demonstrated the interdependence of these dimensions in hybrid work. The discussion examined hybrid work from these different perspectives; however, none of these dimensions can be fully understood in isolation. Therefore, this PhD thesis proposes that designing technologies for hybrid work should consider all four dimensions to align with how hybrid work unfolds in situated work contexts. Figure 9 illustrates the proposed framework, highlighting the interconnections between cooperative work, spatial contexts, artifact ecologies, and organizational structures. The following elaborates on how these dimensions extend existing research and their interdependencies.

FIGURE 9. Illustrative Framework of the Dimensional Interdependencies in Hybrid Work



Cooperative work in hybrid work environments involves at least three mutually dependent individuals who are distributed across fewer contexts than there are participants involved. Yet, this group is never fully collocated, making hybrid work always consist of both collocated and distributed individuals. This definition of hybrid work extends the definition of cooperative work (Schmidt & Bannon, 1992), and in this relation, the PhD research explored how this revision calls for new conceptualizations and design requirements. Paper I suggests that distance in hybrid cooperative work exists across and within geographically distributed subgroups. Further, Papers II and V suggest that hybrid work practices require all work, independent of the degree of coupling, to be conducted across dynamic configurations.

Spatial contexts are inherently multiple in hybrid work. Spatial and material opportunities shape the conditions of interaction and collaboration (Bjørn & Østerlund, 2014; Orlikowski, 2007; Suchman, 2006). Paper II argues that people's changing locations in hybrid work add continuous readjustment in the relevant spatial contexts. Paper III illustrates how this evolving scope of spatial contexts scales a specific work task due to potentially interdependent people, technologies, and policies placed out of sight. In hybrid work, aligning cooperative work with spatial opportunities is a continuous adjustment adapting to multiple local contexts.

Artifact ecologies are core in supporting hybrid work with cooperative practices being supported by multiple technologies. Contemporary practices involve people switching between multiple devices and applications, creating dynamics in artifacts ecologies (Bødker & Klokmose, 2012). Paper IV suggests hybrid work requires reconfigurability to accommodate ongoing adjustments of the setup, as well as rebounding of technologies in practice. Technologies for hybrid work are multiple and together enable work in hybrid settings. Papers II and V suggest that dynamics in spatial contexts call for technologies that enable work independently of the individuals' location while seamlessly extending existing technology portfolios in both remote and collocated contexts.

Organizational structures shape the conditions for cooperative work, influencing how individuals interact and collaborate. Managing these structures involves negotiating and defining roles,

locations, policies, and access to technology (J. S. Olson & Olson, 2014). Paper II illustrates the organizational challenge of aligning policies across individual flexibility and shared stability in cooperative engagements. Paper V suggests that the management of hybrid work should pay attention to providing organizational spaces that support increased access to relevant interdependencies while still providing the options of remote work for individuals.

Illustrating the dimensional interdependencies in hybrid work aims to inform future theoretical and practical explorations into cooperative technologies for hybrid work. Theoretically, the proposed framework synthesizes insights from the concepts developed in each of the five papers included in the PhD thesis. *Collocated distance* (Paper I), as well as *collaboration effort* and *collaboration technology effort* (Paper V) extend research on collaboration across geographical distance (Mark et al., 2003; G. M. Olson & Olson, 2000), highlighting the importance of the increased complexities of collaboration across multiple collocated and distributed subgroups in hybrid work. Emergent exception handling and exaggerated accessibility (Paper IV) support research on artifact ecologies (Bødker & Klokmose, 2012; Lyle et al., 2020), which, together with Paper II, highlight the complexities of producing and navigating technology configurations that support existing artifacts, while enabling digital and physical cooperative practices simultaneously. The ripple effect of working within information infrastructures (Paper III) extends research on infrastructural perspectives (Monteiro et al., 2013; Star, 2002) by suggesting ways in which local work activities are shaped and scopes on multiple scales by the information infrastructure in which the work unfolds, requiring an extended peripheral perception to identify interdependencies that are, sometimes invisibly, placed outside the immediate scope of work.

Together, the dimensional interdependencies contribute to research on the design of cooperative technologies (Panda et al., 2024; Smite et al., 2023; Tang et al., 2023) by proposing that hybrid work's inherent characteristics of dynamics and multiplicity require all four dimensions to be considered when designing for hybrid work.

Practically, the framework highlights dimensional interdependencies that are relevant when making organizational changes to hybrid work structures, such as implementing new technologies or adjusting organizational policies. To evaluate this practical relevance and applicability, the framework, along with conceptualizations from the five papers included in this PhD thesis, was presented to one of the industry collaborators, GlobalContent. This organization was actively exploring how to redesign office spaces and determine what technologies to implement in meeting rooms. They expressed that the framework's emphasis on dimensional interdependencies clarified why simply introducing advanced technologies into meeting rooms would not necessarily support hybrid work without also reconsidering cooperative and organizational structures. Organizing hybrid work goes beyond providing technological support for synchronous hybrid meetings — it also requires considering the collaboration and technology effort required to accommodate the dynamic configurations and spatial contexts of hybrid work.

Future research could test the framework by validating its applicability. For example, new studies could expand the framework by exploring the concepts' relevance for hybrid work in domains outside the office, thus enriching the understanding of hybrid practices in other work contexts. While hybrid workers share similarities with nomads (Brown & O'Hara, 2003; Liegl, 2014) and data workers (Flügge

& Møller, 2023), the empirical data in this PhD research is limited to cooperative practices with low location dependency. Job professionals, such as healthcare workers, may rely on equipment located at specific sites, which makes their cooperative work more location-dependent and may require different approaches to designing cooperative technologies. Although this PhD research aimed to bridge industry and research agendas, the conceptualizations are based on empirical data, including ethnographic work conducted only at organizational offices, as well as existing research discussions. To further assess the framework's applicability, it could be tested in organizational interventions to explore its role in implementing new technologies and restructuring policies or cooperative setups.

6 Conclusion

This PhD researched the nature of hybrid cooperative work with the aim of identifying what is important in designing cooperative technologies for hybrid work practices. The COVID-19 pandemic introduced new ways of working with an accelerated digitalization of work practices and the normalization of flexibility in work locations. Through theoretical conceptualizations, this PhD addressed the unique characteristics of hybrid cooperative work, design challenges for hybrid practices, and organizational structuring for contemporary ways of working. The PhD employed a mixed-method approach, emphasizing empirical explorations into contemporary work. This involved qualitative studies of empirical cases in literature, ethnography at two distinct organizations, quantitative data from five organizations, and engagement in research activities across academic and industrial organizations.

The PhD thesis comprises five research papers, each examining different facets of computer-supported hybrid work practices. Paper I defines hybrid work and identifies the unique characteristic of collocated distance in hybrid work. Paper II addresses spatial challenges from a temporal perspective, introducing the concept of location multiplicity in hybrid work. Paper III investigates how local work practices can have, sometimes invisible, interdependencies across the information infrastructure in which the work is articulated. Paper IV presents contemporary design challenges for developers of cooperative technologies for hybrid work. Finally, Paper V examines collaboration effort and collaboration technology effort as important factors for contemporary work environments.

Collectively, the papers contribute to the field of computer-supported cooperative work (CSCW) by proposing conceptualizations of hybrid work. These findings suggest that technologies for hybrid work should simultaneously support both collocated and distributed collaboration while still being location-independent. Further, technologies should be reconfigurable to accommodate the dynamic nature of hybrid configurations, with a focus on reducing collaborative effort and collaborative technology effort.

To answer the overall research endeavor of what is important in designing cooperative technologies for hybrid work practices, this PhD thesis proposes a conceptual framework of four dimensional interdependencies in hybrid work: cooperative work, spatial contexts, artifact ecologies, and organizational structures. The framework emphasizes the multiplicity of spatial contexts and dynamic configurations in hybrid work, contributing to existing research by illustrating how these dimensional interdependencies shape hybrid work practices. This emphasizes the relevance of considering all four dimensions when designing computing technologies for hybrid cooperative work.

References

Afflerbach, T. (2020). Theory: Challenges for Cooperation. In *Hybrid Virtual Teams in Shared Services Organizations. Practices to Overcome the Cooperation Problem* (pp. 9–50). Springer. https://doi.org/10.1007/978-3-030-34300-2_2

Alavi, H. S., Churchill, E. F., Wiberg, M., Lalanne, D., Dalsgaard, P., Fatah gen Schieck, A., & Rogers, Y. (2019). Introduction to Human-Building Interaction (HBI): Interfacing HCI with Architecture and Urban Design. *ACM Transactions on Computer-Human Interaction*, *26*(2), 6:1-6:10. https://doi.org/10.1145/3309714

Allen, T. j. (1984). *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information Within the Ramp;d Organization.* Massachusetts Institute of Technology.

Anurag, B. L., & Asha, N. (2024). Impacts of Pandemic on Office Space and Work Culture—A Review. In R. D. Nandineni, S. Ang, & N. B. Mohd Nawawi (Eds.), *Sustainable Resilient Built Environments* (pp. 1127–1142). Springer Nature. https://doi.org/10.1007/978-981-99-8811-2_90

Appel-Meulenbroek, R., Kemperman, A., Water, A., Weijs-Perrée, M., & Verhaegh, J. (2022). How to attract employees back to the office? A stated choice study on hybrid working preferences. *Journal of Environmental Psychology*, *81*, 101784. https://doi.org/10.1016/j.jenvp.2022.101784

Babapour Chafi, M., Hultberg, A., & Bozic Yams, N. (2022). Post-Pandemic Office Work: Perceived Challenges and Opportunities for a Sustainable Work Environment. *Sustainability*, *14*(1), Article 1. https://doi.org/10.3390/su14010294

Bang-Mørch, U., Pedersen, S. L., & Steffensen, S. (2021, January 22). *Medarbejdere skal arbejde hjemme – også efter corona: 'Folk er mere produktive derhjemme'*. DR. https://www.dr.dk/nyheder/regionale/syd/medarbejdere-skal-arbejde-hjemme-ogsaa-efter-corona-folk-er-mere-produktive

Bannon, L. J. (1992). Perspectives on CSCW: From HCI and CMC to CSCW. *Proceedings of EWHCI'92, East - West International Conference on Human-Computer Interaction, St. Petersburg, Russia*, 148–158.

Bannon, L. J., & Bødker, S. (1997). Constructing Common Information Spaces. In J. A. Hughes, W. Prinz, T. Rodden, & K. Schmidt, *Proceedings of the Fifth European Conference on Computer Supported Cooperative Work* (pp. 81–96). Springer Netherlands. https://doi.org/10.1007/978-94-015-7372-6_6

Bannon, L. J., & Schmidt, K. (1989). *CSCW: Four Characters in Search of a Context.* https://dl.eusset.eu/items/6d7cbaa8-e9e5-4cb8-84d0-5a016a5083bc

Bardram, J. E. (2005). Activity-based computing: Support for mobility and collaboration in ubiquitous computing. *Personal and Ubiquitous Computing*, *9*(5), 312–322. https://doi.org/10.1007/s00779-004-0335-2

Bayerl, P. S., & Lauche, K. (2010). Technology Effects in Distributed Team Coordination—High-Interdependency Tasks in Offshore Oil Production. *Computer Supported Cooperative Work (CSCW)*, *19*(2), 139–173. https://doi.org/10.1007/s10606-010-9107-x

Benford, S., Greenhalgh, C., Rodden, T., & Pycock, J. (2001). Collaborative virtual environments. *Commun. ACM*, *44*(7), 79–85. https://doi.org/10.1145/379300.379322

Benford, S., Koleva, B., Preston, W. W., Angus, A., Thorn, E.-C., & Glover, K. (2018). Customizing Hybrid Products. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–12. https://doi.org/10.1145/3173574.3173604

Benyon, D., & Mival, O. (2015). Blended Spaces for Collaboration. *Computer Supported Cooperative Work (CSCW)*, *24*(2–3), 223–249. https://doi.org/10.1007/s10606-015-9223-8

Berger, S., Weber, F., & Buser, A. (2021). *Hybrid Work Compass: Navigating the future of how we work.*

Bjørn, P. (2016). New Fundamentals for CSCW Research: From Distance to Politics. *Interactions (ACM SIGCHI)*, *23*(3), 50–53. https://doi.org/10.1145/2903753

Bjørn, P., Busboom, J., Duckert, M., Bødker, S., Shklovski, I., Hoggan, E., Dunn, K., Mu, Q., Barkhuus, L., & Boulus-Rødje, N. (2024). Achieving Symmetry in Synchronous Interaction in Hybrid Work is Impossible. *ACM Trans. Comput.-Hum. Interact.*, *31*(4), 49:1-49:34. https://doi.org/10.1145/3648617

Bjørn, P., & Christensen, L. R. (2011). Relation work: Creating socio-technical connections in global engineering. *Proceedings of the 12th European Conference on Computer Supported Cooperative Work, 24-28 September 2011*, 133–152. https://www.academia.edu/8863478/Relation_work_Creating_socio_technical_connections_in_global_engineering

Bjørn, P., Esbensen, M., Jensen, R. E., & Matthiesen, S. (2014). Does distance still matter? Revisiting the CSCW fundamentals on distributed collaboration. *ACM Transactions on Computer-Human Interaction*, *21*(5), 26. https://doi.org/10.1145/2670534

Bjørn, P., & Hertzum, M. (2011). Artefactual Multiplicity: A Study of Emergency-Department Whiteboards. *Computer Supported Cooperative Work (CSCW)*, *20*(1), 93–121. https://doi.org/10.1007/s10606-010-9126-7

Bjørn, P., & Ngwenyama, O. (2009). Virtual team collaboration: Building shared meaning, resolving breakdowns and creating translucence. *Information Systems Journal*, *19*(3), 227–253. https://doi.org/10.1111/j.1365-2575.2007.00281.x

Bjørn, P., & Østerlund, C. (2014). *Sociomaterial-Design: Bounding Technologies in Practice*. Springer Publishing Company, Incorporated.

Blomberg, J., & Karasti, H. (2013). Reflections on 25 Years of Ethnography in CSCW. *Computer Supported Cooperative Work*, *22*(4–6), 373–423. https://doi.org/10.1007/s10606-012-9183-1

Bødker, S. (2006). When second wave HCI meets third wave challenges. *Proceedings of the 4th Nordic Conference on Human-Computer Interaction: Changing Roles*, 1–8. https://doi.org/10.1145/1182475.1182476

Bødker, S., & Klokmose, C. N. (2012). Dynamics in artifact ecologies. *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, 448–457. https://doi.org/10.1145/2399016.2399085

Bødker, S., Lyle, P., & Saad-Sulonen, J. (2017). Untangling the Mess of Technological Artifacts: Investigating Community Artifact Ecologies. *Proceedings of the 8th International Conference on Communities and Technologies*, 246–255. https://doi.org/10.1145/3083671.3083675

Boland, B., Smet, A. D., Palter, R., & Sanghvi, A. (2020). Reimagining the office and work life after COVID-19. *McKinsey & Company*.

Bowen, G. A. (2006). Grounded Theory and Sensitizing Concepts. *International Journal of Qualitative Methods*, *5*(3), 12–23. https://doi.org/10.1177/160940690600500304

Bowen, G. A. (2019). Sensitizing Concepts. *SAGE Research Methods Foundations*. https://www.academia.edu/41101347/Sensitizing_Concepts

Bradner, E., & Mark, G. (2002). Why Distance Matters: Effects on Cooperation, Persuasion and Deception. *CSCW '02: Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work*, 226–235. https://doi.org/10.1145/587078.587110

Breideband, T., Moulder, R. G., Martinez, G. J., Caruso, M., Mark, G., Striegel, A. D., & D'Mello, S. (2023). 'Location, Location, Location': An Exploration of Different Workplace Contexts in Remote Teamwork during the COVID-19 Pandemic. *Proceedings of the ACM on Human-Computer Interaction*, *7*(CSCW1), 71:1-71:22. https://doi.org/10.1145/3579504

Breideband, T., Sukumar, P. T., Gloria, M., Megan, C., Sidney, D., & D., S., Aaron. (2022). Home-Life and Work Rhythm Diversity in Distributed Teamwork: A Study with Information Workers during the COVID-19 Pandemic. *Proceedings of the ACM on Human-Computer Interaction*, *6*(CSCW1), 1–23. https://doi.org/10.1145/3512942

Brown, B., & O'Hara, K. (2003). Place as a Practical Concern of Mobile Workers. *Environment and Planning A: Economy and Space*, *35*(9), 1565–1587. https://doi.org/10.1068/a34231

Busboom, J., & Boulus-Rødje, N. (2023). Planning for hybrid cooperation—A design driven exploration. *Proceedings of 21st European Conference on Computer-Supported Cooperative Work, ECSCW*. https://doi.org/10.48340/ecscw2023_ep02

Busboom, J., & Boulus-Rødje, N. (2024). The Quest for 'How to do Hybrid right': Moving Beyond Compensating Asymmetries to Experience-Driven Cooperation. *Proc. ACM Hum.-Comput. Interact.*, *8*(CSCW2), 444:1-444:30. https://doi.org/10.1145/3686983

Caldeira, C., R.B. de Souza, C., Machado, L., Perin, M., & Bjørn, P. (2022). Crisis Readiness: Revisiting the Distance Framework During the COVID-19 Pandemic. *Computer Supported Cooperative Work (CSCW)*. https://doi.org/10.1007/s10606-022-09427-6

Chen, Z., Cao, H., Deng, Y., Gao, X., Piao, J., Xu, F., Zhang, Y., & Li, Y. (2021). Learning from Home: A Mixed-Methods Analysis of Live Streaming Based Remote Education Experience in Chinese Colleges during the COVID-19 Pandemic. *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–16. https://doi.org/10.1145/3411764.3445428

Christensen, L. R., Jensen, R. E., & Bjørn, P. (2014). Relation Work in Collocated and Distributed Collaboration. In *Proceedings of the 11th International Conference on the Design of Cooperative Systems* (COOP '14, pp. 87–101). Springer. https://doi.org/10.1007/978-3-319-06498-7_6

Ciolfi, L., Gray, B., & Pinatti de Carvalho, A. F. (2020). Making Home Work Places. *Proceedings of the 18th European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-Centred Computing on the Design of Cooperation Technologies - Exploratory Papers, Reports of the European Society for Socially Embedded Technologies*. https://doi.org/10.18420/ECSCW2020_EP10

Ciolfi, L., Lewkowicz, M., & Schmidt, K. (2023). Computer-Supported Cooperative Work. In J. Vanderdonckt, P. Palanque, & M. Winckler (Eds.), *Handbook of Human Computer Interaction* (pp. 1–26). Springer International Publishing. https://doi.org/10.1007/978-3-319-27648-9_30-1

Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. In *Perspectives on socially shared cognition* (pp. 127–149). American Psychological Association. https://doi.org/10.1037/10096-006

Claudel, M., Massaro, E., Santi, P., Murray, F., & Ratti, C. (2017). An exploration of collaborative scientific production at MIT through spatial organization and institutional affiliation. *PLOS ONE*, *12*(6), e0179334. https://doi.org/10.1371/journal.pone.0179334

Cousins, K. C., Robey, D., & Zigurs, I. (2007). Managing strategic contradictions in hybrid teams. *European Journal of Information Systems*, *16*(4), 460–478. https://doi.org/10.1057/palgrave.ejis.3000692

Cramton, C. D., & Hinds, P. J. (2004). Subgroup dynamics in internationally distributed teams: Ethnocentrism or cross-national learning? *Research in Organizational Behavior*, *26*, 231–263. https://doi.org/10.1016/S0191-3085(04)26006-3

Cummings, J. N., & Kiesler, S. (2008). *Who collaborates successfully? Prior experience reduces collaboration barriers in distributed interdisciplinary research*. 437–446. https://doi.org/10.1145/1460563.1460633

Dalton, N. S., Schnädelbach, H., Wiberg, M., & Varoudis, T. (Eds.). (2016). *Architecture and Interaction*. Springer International Publishing. https://doi.org/10.1007/978-3-319-30028-3

de Souza Santos, R. E., & Ralph, P. (2022). A grounded theory of coordination in remote-first and hybrid software teams. *Proceedings of the 44th International Conference on Software Engineering*, 25–35. https://doi.org/10.1145/3510003.3510105

DeVellis, R. F., & Thorpe, C. T. (2021). *Scale Development: Theory and Applications*. SAGE Publications.

Dourish, P., & Bellotti, V. (1992). Awareness and coordination in shared workspaces. *Proceedings of the 1992 ACM Conference on Computer-Supported Cooperative Work - CSCW '92*, 107–114. https://doi.org/10.1145/143457.143468

Duckert, M., Barkhuus, L., & Bjørn, P. (2023). Collocated Distance: A Fundamental Challenge for the Design of Hybrid Work Technologies. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–16. https://doi.org/10.1145/3544548.3580899

Duckert, M., Hoggan, E., Barkhuus, L., Bjørn, P., Boulus-Rodje, N., Bødker, S., Holten Møller, N., & Shklovski, I. (2022). Work of the Future. *Adjunct Proceedings of the 2022 Nordic Human-Computer Interaction Conference*, 1–4. https://doi.org/10.1145/3547522.3547707

Engström, A., Juhlin, O., Perry, M., & Broth, M. (2010). Temporal Hybridity: Mixing Live Video Footage with Instant Replay in Real Time. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1495–1504. https://doi.org/10.1145/1753326.1753550

Erickson, I., & Jarrahi, M. H. (2016). Infrastructuring and the Challenge of Dynamic Seams in Mobile Knowledge Work. *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*, 1323–1336. https://doi.org/10.1145/2818048.2820015

Esbensen, M., Tell, P., Cholewa, J. B., Pedersen, M. K., & Bardram, J. (2015). The dBoard: A Digital Scrum Board for Distributed Software Development. *Proceedings of the 2015 International Conference on Interactive Tabletops & Surfaces*, 161–170. https://doi.org/10.1145/2817721.2817746

Farzandipour, M., Nabovati, E., & Sharif, R. (2023). The effectiveness of tele-triage during the COVID-19 pandemic: A systematic review and narrative synthesis. *Journal of Telemedicine and Telecare*, 1357633X2211502. https://doi.org/10.1177/1357633X221150278

Flügge, A. A., & Møller, N. H. (2023). The Role of Physical Cues in Co-located and Remote Casework. *Computer Supported Cooperative Work (CSCW)*, *32*(2), 275–312. https://doi.org/10.1007/s10606-022-09449-0

Gerson, E. M. (2008). Reach, Bracket, and the Limits of Rationalized Coordination: Some Challenges for CSCW. In *Resources, Co-Evolution and Artifacts* (pp. 193–220). Springer London. https://doi.org/10.1007/978-1-84628-901-9_8

Gibson, C. B., & Cohen, S. G. (Eds.). (2003). *Virtual teams that work: Creating conditions for virtual team effectiveness* (1st ed). Jossey-Bass.

Glaser, B., & Strauss, A. (2017). *Discovery of Grounded Theory: Strategies for Qualitative Research*. Routledge. https://doi.org/10.4324/9780203793206

Goldberg, E. (2023, August 7). Even Zoom Is Making People Return to the Office. *The New York Times*. https://www.nytimes.com/2023/08/07/business/zoom-return-to-office.html

Greif, I. (2019). How we started CSCW. *Nature Electronics*, *2*(3), Article 3. https://doi.org/10.1038/s41928-019-0229-y

Grønbæk, J. E., Saatçi, B., Griggio, C. F., & Klokmose, C. N. (2021). MirrorBlender: Supporting Hybrid Meetings with a Malleable Video-Conferencing System. *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. https://doi.org/10.1145/3411764.3445698

Grudin, J. (1988). Why CSCW applications fail: Problems in the design and evaluation of organizational interfaces. *Proceedings of the 1988 ACM Conference on Computer-Supported Cooperative Work - CSCW '88*, 85–93. https://doi.org/10.1145/62266.62273

Grudin, J. (1994). Groupware and social dynamics: Eight challenges for developers. *Communications of the ACM*, *37*(1), 92–105. https://doi.org/10.1145/175222.175230

Halford, S. (2005). Hybrid workspace: Re-spatialisations of work, organisation and management. *New Technology, Work and Employment*, *20*(1), 19–33. https://doi.org/10.1111/j.1468-005X.2005.00141.x

Harrison, S., & Tatar, D. (2008). Places: People, Events, Loci – the Relation of Semantic Frames in the Construction of Place. *Computer Supported Cooperative Work (CSCW)*, *17*(2), 97–133. https://doi.org/10.1007/s10606-007-9073-0

Hepsø, V., & Parmiggiani, E. (2022). From Integrated to Remote Operations: Digital Transformation in the Energy Industry as Infrastructuring. In P. Mikalef & E. Parmiggiani (Eds.), *Digital Transformation in Norwegian Enterprises* (pp. 21–41). Springer International Publishing. https://doi.org/10.1007/978-3-031-05276-7_3

Hilberath, C., Kilmann, J., Lovich, D., Tzanetti, T., Bailey, A., Beck, S., Kaufman, E., Khandelwal, B., Schuler, F., & Woolsey, K. (2020). *Hybrid Work is the New Remote Work.*

Hirata, K., Harada, Y., Takada, T., Aoyagi, S., Shirai, Y., Yamashita, N., Kaji, K., Yamato, J., & Nakazawa, K. (2008). t-Room: Next Generation Video Communication System. *IEEE GLOBECOM 2008 - 2008 IEEE Global Telecommunications Conference*, 1–4. https://doi.org/10.1109/GLOCOM.2008.ECP.1058

Hirsch, L. (2024, October 12). Executives and Research Disagree About Hybrid Work. Why? *The New York Times*. https://www.nytimes.com/2024/10/12/business/dealbook/executives-and-research-disagree-about-hybrid-work.html

Hu, E., Azim, M. A. R., & Heo, S. (2022). FluidMeet: Enabling Frictionless Transitions Between In-Group, Between-Group, and Private Conversations During Virtual Breakout Meetings. *CHI Conference on Human Factors in Computing Systems*, 1–17. https://doi.org/10.1145/3491102.3517558

Johansen, R. (1988). *GroupWare: Computer Support for Business Teams*. The Free Press.

Johnson, S., Rae, I., Mutlu, B., & Takayama, L. (2015). Can You See Me Now? How Field of View Affects Collaboration in Robotic Telepresence. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 2397–2406. https://doi.org/10.1145/2702123.2702526

Jordan, B. (2009). Blurring Boundaries: The 'Real' and the 'Virtual' in Hybrid Spaces. *Human Organization*, *68*(2), 181–193.

Jung, H., Stolterman, E., Ryan, W., Thompson, T., & Siegel, M. (2008). Toward a framework for ecologies of artifacts: How are digital artifacts interconnected within a personal life? *Proceedings of the 5th Nordic Conference on Human-Computer Interaction: Building Bridges*, 201–210. https://doi.org/10.1145/1463160.1463182

Kiesler, S., & Cummings, J. N. (2002). What do we know about proximity and distance in work groups? A legacy of research. In *Distributed work* (pp. 57–80). Boston Review. https://doi.org/10.7551/mitpress/2464.001.0001

Krajčík, M., Schmidt, D. A., & Baráth, M. (2023). Hybrid Work Model: An Approach to Work–Life Flexibility in a Changing Environment. *Administrative Sciences*, *13*(6), Article 6. https://doi.org/10.3390/admsci13060150

Kraut, R., Egido, C., & Galegher, J. (1988). Patterns of contact and communication in scientific research collaboration. *Proceedings of the 1988 ACM Conference on Computer-Supported Cooperative Work*, 1–12. https://doi.org/10.1145/62266.62267

Landowski, M., Effert, J.-S., Günther, F., Tebart, M., & Moerike, F. (2024). Beyond Hallway Chats? Negotiating Content Awareness in Hybrid Work Practices. *Proceedings of Mensch Und Computer 2024*, 508–513. https://doi.org/10.1145/3670653.3677523

Lee, A., Toombs, A., Erickson, I., Nemer, D., Ho, Y., Jo, E., & Guo, Z. (2019). The Social Infrastructure of Co-spaces: Home, Work, and Sociable Places for Digital Nomads. *Proceedings of the ACM on Human-Computer Interaction*, *3*, 1–23. https://doi.org/10.1145/3359244

Lee, C., & Paine, D. (2015). From the matrix to a model of coordinated action (MoCA): A conceptual framework of and for CSCW. *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*, 179–194. https://doi.org/10.1145/2675133.2675161

Lee, M. K., & Takayama, L. (2011). 'Now, i Have a Body': Uses and Social Norms for Mobile Remote Presence in the Workplace. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 33–42. https://doi.org/10.1145/1978942.1978950

Liegl, M. (2014). Nomadicity and the Care of Place—On the Aesthetic and Affective Organization of Space in Freelance Creative Work. *Computer Supported Cooperative Work (CSCW)*, *23*(2), 163–183. https://doi.org/10.1007/s10606-014-9198-x

Lund, S., Madgavkar, A., Manyika, J., Smit, S., Ellingrud, K., & Robinson, O. (2021). *The future of work after COVID-19*. McKinsey & Company. https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19

Lyle, P., Korsgaard, H., & Bødker, S. (2020). What's in an Ecology? A Review of Artifact, Communicative, Device and Information Ecologies. *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society*, 1–14. https://doi.org/10.1145/3419249.3420185

Madsen, S., Haslan, C. R., & Nielsen, J. A. (2020). *Accelerated Digital Transformation: The Case of The Online University Caused By Covid-19*. 16.

Mark, G., Abrams, S., & Nassif, N. (2003). Group-to-Group Distance Collaboration: Examining the "Space Between". In K. Kuutti, E. H. Karsten, G. Fitzpatrick, P. Dourish, & K. Schmidt (Eds.), *ECSCW 2003* (pp. 99–118). Springer Netherlands. https://doi.org/10.1007/978-94-010-0068-0_6

Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual Teams: What Do We Know and Where Do We Go From Here? *Journal of Management*, *30*(6), 805–835. https://doi.org/10.1016/j.jm.2004.05.002

Maznevski, M. L., & Chudoba, K. M. (2000). Bridging Space Over Time: Global Virtual Team Dynamics and Effectiveness. *Organization Science*, *11*(5), 473–492. https://doi.org/10.1287/orsc.11.5.473.15200

Medici, A. (2024, August 21). *The post-Covid workplace is dominated by hybrid work. Here's how to make it work.* The Business Journals. https://www.bizjournals.com/bizjournals/news/2024/08/21/hybrid-work-jobs-covid-tips-2024.html

Misawa, K., & Rekimoto, J. (2015). ChameleonMask: Embodied Physical and Social Telepresence Using Human Surrogates. *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, 401–411. https://doi.org/10.1145/2702613.2732506

Monteiro, E., Pollock, N., Hanseth, O., & Williams, R. (2013). From Artefacts to Infrastructures. *Computer Supported Cooperative Work*, *22*(4–6), 575–607. https://doi.org/10.1007/s10606-012-9167-1

Neumayr, T., Jetter, H.-C., Augstein, M., Friedl, J., & Luger, T. (2018). Domino: A Descriptive Framework for Hybrid Collaboration and Coupling Styles in Partially Distributed Teams. *Proceedings of the ACM on Human-Computer Interaction*, *2*(CSCW), 128:1-128:24. https://doi.org/10.1145/3274397

Neumayr, T., Saatci, B., Rintel, S., Klokmose, C. N., & Augstein, M. (2022). *What was Hybrid? A Systematic Review of Hybrid Collaboration and Meetings Research* (arXiv:2111.06172). arXiv. https://doi.org/10.48550/arXiv.2111.06172

Nielsen, S. B. (2024, August 24). *Vi arbejder mere hjemmefra. Men to ting bekymrer arbejdsgivere og fagforening*. DR. https://www.dr.dk/nyheder/indland/vi-arbejder-mere-hjemmefra-men-ting-bekymrer-arbejdsgivere-og-fagforening

Olson, G. M., & Olson, J. S. (2000). Distance matters. *Human-Computer Interaction*, *15*(2–3), 139–178. https://doi.org/10.1207/S15327051HCI1523_4

Olson, J. S., & Olson, G. M. (2014). Working Together Apart: Collaboration over the Internet. *Synthesis Lectures on Human-Centered Informatics*, *6*(5), 1–151. https://doi.org/10.2200/S00542ED1V01Y201310HCI020

Olson, J., Teasley, S., Covi, L., & Olson, G. (2002). The (currently) unique value of collocated work. *Distributed Work*, 113–135.

Olson, M. H. (1983). Remote office work: Changing work patterns in space and time. *Communications of the ACM*, *26*(3), 182–187. https://doi.org/10.1145/358061.358068

Orlikowski, W. J. (1992). Learning from Notes: Organizational issues in groupware implementation. *Proceedings of the 1992 ACM Conference on Computer-Supported Cooperative Work*, 362–369. https://doi.org/10.1145/143457.143549

Orlikowski, W. J. (2007). Sociomaterial Practices: Exploring Technology at Work. *Organization Studies*, *28*(9), 1435–1448. https://doi.org/10.1177/0170840607081138

Orlikowski, W. J., & Gash, D. C. (1994). Technological frames: Making sense of information technology in organizations. *ACM Transactions on Information Systems*, *12*(2), 174–207. https://doi.org/10.1145/196734.196745

Orlikowski, W. J., & Scott, S. V. (2023). The Digital Undertow and Institutional Displacement: A Sociomaterial Approach. *Organization Theory*, *4*(2), 26317877231180898. https://doi.org/10.1177/26317877231180898

Panda, P., Tankelevitch, L., Spittle, B., Inkpen, K., Tang, J., Junuzovic, S., Qi, Q., Sweeney, P., Wilson, A. D., Buxton, W. A. S., Sellen, A., & Rintel, S. (2024). Hybridge: Bridging Spatiality for Inclusive and Equitable Hybrid Meetings. *Proc. ACM Hum.-Comput. Interact.*, *8*(CSCW2), 501:1-501:39. https://doi.org/10.1145/3687040

Paoletti, I. (2009). Communication and Diagnostic Work in Medical Emergency Calls in Italy. *Computer Supported Cooperative Work (CSCW)*, *18*(2–3), 229–250. https://doi.org/10.1007/s10606-009-9091-1

Park, H., Ahn, D., & Lee, J. (2023). Towards a Metaverse Workspace: Opportunities, Challenges, and Design Implications. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–20. https://doi.org/10.1145/3544548.3581306

PricewaterhouseCoopers. (2021). *The Future of Work: Changing Places: How hybrid working is rewriting the rule book* [Industrial report]. PricewaterhouseCoopers. pwc.com.au/futureofwork

Raake, A., Fiedler, M., Schoenenberg, K., De Moor, K., & Döring, N. (2022). *Technological Factors Influencing Videoconferencing and Zoom Fatigue* (arXiv:2202.01740). arXiv. http://arxiv.org/abs/2202.01740

Randall, D. (2022). Made to Work: Mobilising Contemporary Worklives: Breda Gray, Luigina Ciolfi and Fabiano Pinatti di Cavarhlo, Routledge. 2020: 220 pages. *Computer Supported Cooperative Work (CSCW)*, *31*(3), 555–560. https://doi.org/10.1007/s10606-022-09431-w

Randall, D., Harper, R., & Rouncefield, M. (2007). *Fieldwork for Design*. Springer London. https://doi.org/10.1007/978-1-84628-768-8

Reilly, D., Echenique, A., Wu, A., Tang, A., & Edwards, W. K. (2015). Mapping out Work in a Mixed Reality Project Room. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 887–896. https://doi.org/10.1145/2702123.2702506

Richter, A., & Richter, S. (2024). Hybrid work – a reconceptualisation and research agenda. *I-Com*, *23*(1), 71–78. https://doi.org/10.1515/icom-2023-0027

Rudnicka, A., Newbold, J. W., Cook, D., Cecchinato, M. E., & Cox, A. L. (2020). Eworklife: Developing effective strategies for remote working during the COVID-19 pandemic. *The New Future of Work Symposium*, 13.

Ruhleder, K. (2000). The Virtual Ethnographer: Fieldwork in Distributed Electronic Environments. *Field Methods*, *12*(1), 3–17. https://doi.org/10.1177/1525822X0001200101

Sako, M. (2021). From remote work to working from anywhere. *Communications of the ACM*, *64*(4), 20–22. https://doi.org/10.1145/3451223

Schmidt, K., & Bannon, L. J. (1992). Taking CSCW Seriously Supporting Articulation Work. *Computer Supported Cooperative Work*, *1*, 7–40.

Schmidt, K., & Bannon, L. J. (2013). Constructing CSCW: The First Quarter Century. *Computer Supported Cooperative Work (CSCW)*, *22*(4–6), 345–372. https://doi.org/10.1007/s10606-013-9193-7

Sellen, A., Buxton, B., & Arnott, J. (1992). Using spatial cues to improve videoconferencing. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 651–652. https://doi.org/10.1145/142750.143070

Sherman, N. (2024, September 17). *Amazon tells staff to get back to office five days a week* [Website]. BBC. https://www.bbc.com/news/articles/czj99ln72k9o

Smite, D., Christensen, E., Tell, P., & Russo, D. (2023). The Future Workplace: Characterizing the Spectrum of Hybrid Work Arrangements for Software Teams. *IEEE Software*, *40*, 34–41. https://doi.org/10.1109/MS.2022.3230289

Smite, D., Moe, N. B., Tkalich, A., Hanssen, G. K., Nydal, K., Sandbæk, J. N., Aamo, H. W., Hagaseth, A. O., Bekke, S. A., & Holte, M. (2022). *Half-Empty Offices in Flexible Work Arrangements: Why are Employees Not Returning?* (arXiv:2208.12797). arXiv. https://doi.org/10.48550/arXiv.2208.12797

Smite, D., Moe, N., Klotins, E., & Gonzalez-Huerta, J. (2022). From forced Working-From-Home to voluntary working-from-anywhere: Two revolutions in telework. *Journal of Systems and Software*, *195*, 111509. https://doi.org/10.1016/j.jss.2022.111509

Søderberg, A.-M., Krishna, S., & Bjørn, P. (2013). Global Software Development: Commitment, Trust and Cultural Sensitivity in Strategic Partnerships. *Journal of International Management*, *19*(4), 347–361. https://doi.org/10.1016/j.intman.2013.04.004

SSI. (2022, April). *Tidslinje for covid-10*. Statens Serum Institut. https://www.ssi.dk/-/media/arkiv/subsites/covid19/presse/tidslinje-over-covid-19/covid-19-tidslinje-for-2020-2022-lang-version---version-1---april-2022.pdf

Star, S. L. (2002). Infrastructure and ethnographic practice: Working on the fringes. *Scandinavian Journal of Information Systems*, *14*(2), 107–122.

Strauss, A. (1988). The Articulation of Project Work: An Organizational Process. *The Sociological Quarterly*, *29*(2), 163–178. https://doi.org/10.1111/j.1533-8525.1988.tb01249.x

Suchman, L. (2006). *Human-Machine Reconfigurations: Plans and Situated Actions* (2nd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511808418

Sutton, A., Clowes, M., Preston, L., & Booth, A. (2019). Meeting the review family: Exploring review types and associated information retrieval requirements. *Health Information & Libraries Journal*, *36*(3), 202–222. https://doi.org/10.1111/hir.12276

Tang, J. C., Inkpen, K., Junuzovic, S., Mallari, K., Wilson, A. D., Rintel, S., Cupala, S., Carbary, T., Sellen, A., & Buxton, W. A. S. (2023). Perspectives: Creating Inclusive and Equitable Hybrid Meeting Experiences. *Proceedings of the ACM on Human-Computer Interaction*, *7*(CSCW2), 351:1-351:25. https://doi.org/10.1145/3610200

Teevan, J., Baym, N., Hecht, B., Jaffe, S., Nowak, K., Sellen, A., & Yang, L. (2022). *Microsoft New Future of Work Report 2022* (Microsoft Research Tech Report MSR-TR-2022-3). https://aka.ms/nfw2022

Tenório, N., & Bjørn, P. (2019). How a geographically distributed software team managed to negotiate successfully using chat technology. *Revista Tecnologia e Sociedade*, *15*(37), Article 37. https://doi.org/10.3895/rts.v15n37.8655

Todd, S. (2021, September 21). *Hybrid Working and the Allen Curve for Office Communication*. DuoMe Blog. https://duome.co/blog/hybrid-working-communication

Venolia, G., Tang, J., Cervantes, R., Bly, S., Robertson, G., Lee, B., & Inkpen, K. (2010). Embodied Social Proxy: Mediating Interpersonal Connection in Hub-and-Satellite Teams. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1049–1058. https://doi.org/10.1145/1753326.1753482

Voida, A., Voida, S., Greenberg, S., & He, H. A. (2008). Asymmetry in media spaces. *Proceedings of the 2008 ACM Conference on Computer Supported Cooperative Work*, 313–322. https://doi.org/10.1145/1460563.1460615

Wang, Y., Liu, Y., Cui, W., Tang, J., Zhang, H., Walston, D., & Zhang, D. (2021). Returning to the Office During the COVID-19 Pandemic Recovery: Early Indicators from China. *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–6. https://doi.org/10.1145/3411763.3451685

Yamashita, N., Kuzuoka, H., Hirata, K., Aoyagi, S., & Shirai, Y. (2011). Supporting fluid tabletop collaboration across distances. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2827–2836. https://doi.org/10.1145/1978942.1979362

Appendices

PAPER I

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Collocated Distance:
A Fundamental Challenge for the Design of Hybrid Work Technologies.

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Collocated Distance: A Fundamental Challenge for the Design of Hybrid Work Technologies

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ABSTRACT

After the pandemic, it is urgently important to explore the special challenges which arise with hybrid work. Through cross-case analyses of published papers, we propose *collocated distance* as a design challenge uniquely relevant for hybrid cooperative technologies. We identify and conceptualize collocated distance as a design challenge that arises in hybrid work situations, where at least three actors are mutually dependent in their work while being located within fewer contexts than the number of actors. Collocated distance reminds us that when designing hybrid technologies, we must not only focus on creating technologies that support the work across geographical locations but equally pay attention to the relations and possible disconnections which exist locally between collocated actors. When designing cooperative technologies supporting distributed work, often focus is on the boundaries *between* geographical contexts – however, in hybrid work, we must not forget to pay attention to the *collocated* boundaries within the same context.

CCS CONCEPTS

• **Human-centered computing** → Collaborative and social computing; Human computer interaction (HCI).

KEYWORDS

hybrid work, distributed work, cooperative work

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1 INTRODUCTION

Collaboration across geography is a core interest in CHI and CSCW research [33, 44]. The dedication to find ways to design technologies that allow for cooperative actors to be mutually dependent upon each other in a common field of work [93] despite being dispersed geographically, has received increased attention with the COVID-19 pandemic [81]. With the pandemic, we witnessed how the long-term research endeavor produced significantly important results in designing digital technologies allowing people across the globe to work from home. The infrastructures of working and teaching remotely during the pandemic included cooperative technologies such as Teams and Zoom [26]. These CSCW systems provide technology support for awareness [34, 47, 49, 52, 92] and/or coordination [40, 47] reducing the efforts of articulation work [22, 45, 97] for the distributed actors. The spatial opportunities and resources available, as well as the distance produced as part of the place-based activities, matter for how actors can cooperate through digital means [38, 51]. How we design and use technologies supporting cooperation across geography therefore shapes the potential of collaboration in important ways.

The pandemic introduced new ways of working, and as health restrictions are being lifted in most countries, several organizations are using the pandemic to reflect and rethink the nature of the workplace, including the use of cooperative technologies [105, 108]. Some employees are requesting to work remotely, while others want to return to the office. How work will be organized in the future is still being considered in many organizations. In this paper, we explore a particular type of cooperation emerging after the pandemic: The cooperative setup characterized by hybrid work. As a starting point, *we define hybrid work as situations where at least three actors are located at fewer geographical sites than the number of actors (but not all collocated), and all actors are mutually dependent in their work.* Hybrid work is then situations where at least one of the geographical sites includes multiple collocated people. We acknowledge that hybrid work in this definition is a large spectrum of different types of work. Our definition builds upon the assumption that even if one person is becoming remote in a large group of people, it impacts the type of collaboration that can take place. Similarly, if all but two people are distributed in a large cooperative remote setup, it also impacts the conditions for cooperative work. The research question guiding our work is: What are the characteristics of hybrid cooperative work that introduce unique design challenges to be met by cooperative technologies?

Hybrid work has multiple overlapping characteristics with distributed work, however, to fully understand which characteristics are unique for hybrid work, we decided to analyze previously published papers that provide detailed empirical cases of hybrid work. We collected papers published at CHI, CSCW, GROUP, ECSCW, and JCSCW, all top research venues that have included research pertaining to cooperative technologies and practices over the last decades. Our selected papers were then grouped into four domain areas: Healthcare, Performance, Office, and Non-Office work, each

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providing a number of papers that described rich empirical details on cases of hybrid work.

Based upon cross-case analysis of the selected papers, we make three contributions identifying the design challenges for hybrid work technologies: Firstly, supporting previous research [29, 35], we identified two core design challenges for hybrid work technologies, 1) the increased complexities involved in creating common ground in hybrid work settings, and 2) the increased complexities involved in balancing sub-group dynamics in hybrid work. Secondly, we identified a new design challenge that is uniquely relevant when designing hybrid work technologies compared to distributed work technologies. We label this challenge *collocated distance*. Collocated distance reminds us to not only focus our designs on mediating the geographical boundaries across sites, but also explore the collocated boundaries which exist in a hybrid setup and use these collocated boundaries as a design characteristic for hybrid technologies. Finally, we propose an analytical framework for hybrid work as a subset of distributed work and cooperative work, which we hope can help others continue the work of understanding the unique characteristic of hybrid work with the aim of designing hybrid work technologies.

The paper is structured as follows; First, we introduce prior work on cooperation and distributed work, while situating our research in the broader literature on computer supported cooperative work. Secondly, we introduce our strategies for selecting and analyzing the literature. Then we introduce the results of our analysis zooming in on the four selected empirical cases. Finally, we discuss and theorize the characteristics of hybrid work by visualizing hybrid work as a subset of both distributed work and cooperative work developing the concept of collocated distance.

2 FROM DISTRIBUTED WORK TO HYBRID WORK: DISCONTINUITIES AND SHARED MEANING

While in this paper, we generally refer to distributed work as situations where multiple people are working together while being geographically distributed, distributed work has been explored under different headings in the literature such as virtual teams [42], Far-flung teams [71], Global virtual teams [1], Virtual Learning teams [20], etc. It is therefore important that we start by clarifying the vocabulary – and make clear which dimensions are involved when we refer to distributed work.

Distributed work is cooperative work [93] and as such is defined by situations where at least two people are mutually dependent in their work and thus engage in cooperative work requiring articulation work. This means that distributed work situations take place within professional domains, and the activities which are involved are shaped by these domains, e.g., in terms of professional language and vocabulary [87]. What gets excluded by this definition is casual interactions or social interactions without a common field of work. Interdependence, domain, and professional language are all important aspects of distributed work. What makes distributed work as professional work interesting is that the dependencies shape and create cooperative engagement in important ways. It is the dependencies that require coordination [40] and it is the dependencies in work that requires actors to find and develop strategies for creating mutual awareness [47] as an approach to reduce the efforts of articulation work [92].

Distributed work is geographically distributed. Distance often refers to the geographical distance [82], while the discussion about how we define geographical distance and where the boundaries between collocation and distribution exist remains. Geographical distance matters, yet it is important to acknowledge that the perception of distance might in many cases be even more pertinent in shaping the collaboration [23]. Geographical distance can in the 'smallest' definition include actors being distributed across different floors – and there is work that shows that even a few meters [30] can create distance among collaborators. Geographical distance can also include actors which are in different countries and even on different continents. This type of work is often referred to as far-flung teams [70] or global virtual teams [58] and in some cases also specified by the domain such as 'software development' like global software development [54]. When the geographical distance is high, then additional aspects such as temporal, cultural, and geo-political concerns also enter the scene [14–16, 76]. Thus, while 'small scale' geographical distance matters, the larger geographical distance often includes additional dimensions that need to be taken into consideration when designing technologies to support such work. The complexities clearly arise when extending the geographical distance by introducing additional concerns, and when we design technologies for both distributed and hybrid work, it is crucial that we examine all the potential complexities of the specific setup. Distance is not just about 'the number of meters' but includes various dimensions or discontinues which can be pertinent.

Distributed work is characterized by various dimensions and discontinuities. Rather than considering complexities emerging in distributed work as a binary – where they either exist or do not exist – Mary Beth Watson-Manheim et al. focus on the organizational context and suggest conceptualizing these complexities in terms of dimensions [103]. They offer the following potential discontinuities/continuities which are important to consider for distributed work: Organizational affiliations, Work group membership, Physical locations, Temporal locations, Tasks, or Projects [103]. Their argument is that each example of a distributed work setting can have different discontinuities/continuities across these different dimensions. Focusing on work practices and coordinative actions, Charlotte Lee and Drew Paine [62] similarly propose a conceptualization for coordinative action suggesting the following dimensions: Synchronicity, Physical distribution, Scale, Numbers of Communities of Practices, Nascence, Planned permanence, and Turnover. They argue that each of these dimensions matters for the challenges of coordinative action. Following this way of thinking, we attempt to pay attention to the various types of dimensions or discontinuities that might arise in concrete situations of distributed work as critically important to consider, when designing cooperative technologies for such work.

The main challenge in distributed work is establishing a shared meaning context to develop and maintain common ground. One of the main challenges in cooperative work is establishing and maintaining a shared meaning context [18, 111]. A shared meaning context in distributed work is a conglomeration of pieces from the various contexts that collaborators bring with them into the distributed

work setting such as the professional context, the local context, and the distributed context [18]. Each context has assigned languages and practices, which need balancing during the cooperative engagements and can analytically be divided into the work practice level (work practices and professional language), the organizational level (norms and procedures), and the life world level (taken-for-granted assumptions) [18, 74–76]. Professional disciplines shape work in important ways as the work practices, policies, protocols, and procedures emerge out of long-term disciplinary endeavors [13, 41, 53, 99]. Disciplinary activities also create specific coordinative artefacts and stipulate how such artefacts are to be used in certain activities [8, 17, 91, 94]. While communication breakdowns often manifest within the cooperative practices, in many cases potential breakdowns are grounded at a different analytical level. The shared meaning context allows and supports actors involved in distributed work to develop common ground [29, 81] and share mutual knowledge [31]. What makes common ground difficult in distributed work is the challenges in establishing a shared meaning context, by which the grounding practices can be based – especially in situations of multiple interlinked discontinuities and where the geographical distance implicates a diverse set of additional complexities such as differences between the global north and the global south [15, 21, 74, 86]. Without a shared meaning context, the conditions to have a cooperative situation based on trust, commitment, and cultural sensitivity is challenged [96]. In addition, challenges related to technology use and technology readiness [75, 81], and whether such technologies support or constrain the distributed work [19], might arise.

We explore the characteristics of *hybrid work* as a subset of distributed work and where all the above considerations and challenges might be pertinent. Hybrid work is a special type of distributed work where at *least three people are geographically distributed on fewer sites than the number of participants and are mutually dependent in their work and thus engage in cooperative work requiring articulation work*. In this way, the geographical distribution is an important part of the definition and an important analytical lens for our examination. However, we are very aware that distance is more than geography, thus an important part of our analytical lens is to identify and bring into the analysis other discontinuities and dimensions which add to the complexity of the cases of hybrid work. Further, we will take a work practice perspective and focus our analysis on the discontinuities shaped by geography, time, national culture, organizational culture, work practices, professional disciplines, technologies, and languages. While each of these dimensions might not be relevant in all cases of hybrid work, we will explore whether they are available in the selected papers – and make them relevant for our analysis. Finally, using common ground and grounding activities as an analytical lens allows us to dive directly into the situations which often end in communication breakdowns, thus revealing the underlying assumptions and infrastructure which keeps collaboration afloat.

3 METHOD

In order to explore the characteristics of hybrid work with the aim of identifying the special design challenges to be met by cooperative technologies, we decided to search existing literature and identify previously published empirical cases on hybrid work arrangements, in human computer interaction and computer supported cooperative work. The purpose was to learn from past studies that might provide empirical data about hybrid work – without necessarily having a focus on the nature of hybrid work arrangements. When we began our literature search, we assumed that while the increased interest and focus on new forms of work – remote work and hybrid work – has been spurred by the COVID-19 pandemic, the organizational structure of working across geographical sites in different constellations is not new but has in fact been a research interest for decades. It would therefore be beneficial to investigate historic cases from the past to learn from previous work, before initiating new empirical studies and design new cooperative technologies facilitating hybrid work after the pandemic.

Interestingly, most research on geographically distributed work does not make a distinction between distributed work where all participants are geographically dispersed, and hybrid work situations. So, when searching for literature, we had to come up with a working definition that allowed us to identify and select cases. In this process, it became clear to us what distinguishes distributed work from hybrid work: The difference lies in when the number of geographical sites is fewer than the number of actors involved, and hybrid work has a minimum of three actors involved.

Our main methodological strategy for selecting papers was to look for papers that described empirical cases where at least three actors were involved in a common field of work while being geographically distributed across fewer geographical sites than the number of actors – and where the paper produced enough insights into the empirical data that we were able to explore the characteristics of hybrid work as emerging in the case.

An interesting part of the process of developing an appropriate definition for our literature search, was that it allowed us insights into the diverse nature of which empirical cases of hybrid work entails. To challenge our assumptions and pre-established understandings of hybrid work, we sought to identify cases that were different in nature (across different domains and types of work) to challenge and extend our definition of hybrid work beyond office work as part of our theorizing. However, since most of the cases of hybrid work in the literature were in an office environment, it was important for our method to also identify cases of hybrid work that did not take place in an office environment. From this perspective, we were excited to identify empirical cases outside of the office. These cases took place within different domains such as healthcare, performance, or different types of industrial settings. What makes these types of empirical cases interesting is that the work described includes physical artefacts, mobility, and activities that often are not present in office work. We now continue by describing in detail, how we searched and selected literature, as well as how we analyzed the data.

3.1 Data Collection

The identification of literature on hybrid work was inspired by a scoping study [2] where we iteratively identified relevant cases using the definition of hybrid work. In this process, we continuously became familiar with the scale, domains, topics, and diverse nature of cases – using these insights to iteratively search in new

ways. The iterative approach enabled us to produce an overview of prior literature while identifying certain categories which help us navigate the material.

Using EUSSET Digital Library (DL) and ACM Digital Library (DL), we searched for full papers. In the EUSSET DL we focused our search on ECSCW and JCSCW papers, while in the ACM DL we focused on publications from ACM CSCW, ACM CHI, and ACM GROUP conferences. We excluded workshops, posters, and position papers from our searches. The search terms we used included "hybrid", "tech" and "work", however, we extended the search to include papers using synonyms to hybrid such as "remote" and "virtual" to not miss relevant papers.

We used different search conditions in the two libraries; initially, the EUSSET DL gave 101 search results, and the searches across the ACM DL provided 7,389 papers. The first author skimmed through the titles of the ACM DL papers and discovered that many of the papers did not include hybrid cooperative work. To scope the ACM DL papers, we required the first search term (hybrid* OR remot*) to be mentioned in either the title or abstract of the paper. The search for papers mentioning virtual work was conducted separately as too many papers studied virtual reality technologies (VR) and focused on neither collaborative nor distributed work, therefore, either "work" or "team" had to be in the abstract too. This reduced our search results to 731 ACM DL papers. Combining the results from EUSSET DL and ACM DL the total number of papers after the initial searches was 832.

The first author then skimmed through the abstracts to determine whether the papers in fact provided empirical data on hybrid work cases. Surprisingly, it turned out that several of the papers were not focusing on hybrid cooperative work. Reading through the abstracts manually (in some cases also skimming the introduction and method section to confirm), papers that presented research with a focus on a work context supported by a hybrid/remote/virtual technology, were selected. During this stage, for example, papers focusing on a learning environment [12] or families [39, 106] were excluded. Further, it also turned out that there were papers that did not focus on cooperative hybrid work, but instead on hybrid combinations, e.g. of woodwork and carpentry [69]. The result of this sorting exclusion was a selection of 209 papers for detailed analysis, see Figure 1.

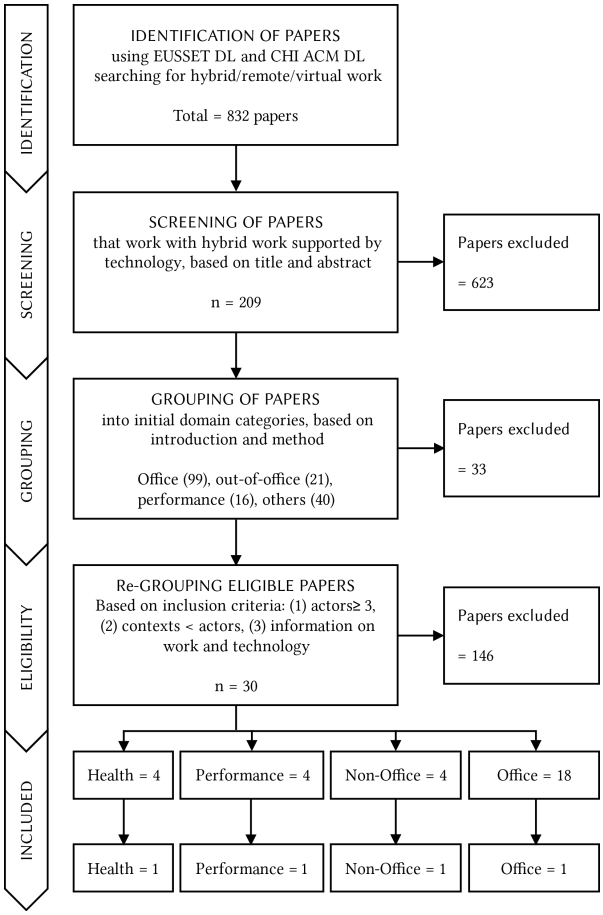

Figure 1: Literature selection process

3.2 Data Analysis

All 209 papers were downloaded and imported into Nvivo. Further, the first author created various spreadsheets for detailed analysis, note taking, and categorization. The classification work was done iteratively, where emergent categories were grouped and re-grouped. The purpose of the categorization was to identify what kind of papers had been published on hybrid work while also developing classifications for the domains and types of empirical cases. This selection process was based on the introduction and method sections of the papers. A few of the papers did not present enough information to place them into any kind of category or domain and did not provide data allowing for new analysis and were therefore removed. What was important to us at this stage was to have a diverse set of papers that presented different types of hybrid work from different domains. This meant that papers presenting empirical material and data from new types of settings went through extra scrutinizing to determine if they would extend our classifications of hybrid work. However, our selection criteria which said that the paper needed to have enough empirical data from a 'real-life' case sometimes meant that we had to leave papers behind, which otherwise had provided insights into an interesting domain [7, 43]. To get an overview of the content of the remaining papers, these were grouped into initial domain categories based on the introduction and method section. At this stage we had a total of 176 papers and the emergent categories of empirical cases were: Office work (99 papers); Out-of-office (21 papers); Performance (16 papers), and other (40 papers).

The diverse nature of the cases helped us to become more explicit in our definition of hybrid work and forced us to develop concrete ways to determine whether the cases were on hybrid work or something else such as individual work, distributed work, or independent system design. We also learned that laboratory studies did not provide much insight into the nature of hybrid work, since these often were done out of context and not in a real-life situation. In this iteration of the data analysis, we developed four criteria for the inclusion/exclusion of papers:

Table 1: Categorization of research papers studying Hybrid work build upon domains.

Domain	Reference	Method	Topic
Health (4)	Luk et al. (2008) [67]	Field study	Remote expertise sharing
	Mentis et al. (2020) [78]	Ethnographic study	Remote expertise in surgery
	Nardi et al. (1994) [80]	Field study	Coordination in surgical team
	Paoletti (2009) [83]	Ethnographic study	Emergency calls
Performance (4)	Baker et al. (1999) [5]	Case studies	Media production
	Bakhuus & Rossitto (2016) [10]	Case study	Theater
	Cai et al. (2021) [25]	Empirical study	Musicians
	Engström et al. (2010) [36]	Ethnographic study	Broadcasting of television
Non-Office (4)	Bayerl & Lauche (2010) [11]	Field study	Offshore oil production
	Luik et al. (2019) [66]	Empirical study	Virtual hubs
	Lukosch et al. (2015) [68]	Empirical study	AR in security domain
	Rae & Neustaedter (2017) [85]	Field study	Telepresence robots at CHI
Office: System focus (10)	Castellani et al. (2009) [27]	Field study	Trouble shooting
	Grønbæk et al. (2021) [46]	Qualitative study	Video-conference system
	Lee & Takayama (2011) [63]	Empirical study	Mobile remote presence
	McGregor et al. (2019) [77]	Ethnographic study	Chat use at work
	Misawa & Rekimoto (2015) [79]	Test study	Telepresence system
	Ruhleder & Jordan (1999, 2001) [88, 89]	Empirical study	Technology generated delays
	Tang & Isaacs (1992) [100]	Empirical study	Video conference rooms
	Tutt et al. (2007) [101]	Empirical study	Group-to-group collaboration
	Venolia et al. (2010) [102]	Ethnographic study	Telepresent co-worker
	Yamashita et al. (2011) [104]	Test study	Tabletop collaboration
Office: Collaboration focus (8)	Avram et al. (2009) [3]	Field study	Distributed software company
	Bjørn & Christensen (2011) [107]	Ethnographic study	Meetings in global engineering
	Doherty et al. (2012) [32]	Field study	Localization teamwork
	Huysman et al. (2003) [57]	Exploratory study	Virtual team communication
	Kipp et al. (2008) [59]	Project study	Collaborative working
	Mark et al. (1999) [73]	Empirical study	Virtually collocated teams
	Mark et al. (2003) [72]	Empirical study	Group-to-group collaboration
	Saatçi et al. (2020) [90]	Field study	Global software company

1. The empirical case must be a situation where at least three actors (actors ≥ 3) are involved in a common field of work
2. The empirical setting must include geographical distribution; however, the geographical sites must be fewer than the number of actors (if actors = 3 the geographical sites = 2)
3. The empirical case must include information about the technology used to facilitate the hybrid work situations (either an existing or new technology)
4. The paper must present sufficient empirical data and analysis of the cooperative work for us to be able to use it for our cross-case analysis.

Based on this, we removed papers that introduced system design without a clear connection to a hybrid work situation [4, 24, 55, 61, 65, 84, 95] and papers that turned out to focus on the individual person rather than the cooperative practice [6] such as a focus on distractions during remote meetings [64]. The result was 30 selected papers.

3.3 Data Sources

Through in-depth reading of the 30 selected papers, we categorized these papers into four main categories of hybrid work domains: Healthcare (4); Performance (4); Non-office work (4); and Office work (18). Office work was further divided into two sub-categories namely papers focusing on the system (10) and papers focusing on the cooperation (8). While some of the papers overlap in the domain categories – for example, papers working within the health domain can study work that took place in an office at a hospital – we grouped the papers based on their main research focus. The categories of domains were therefore not exclusive, but instead a strategy for us to analytically explore the diverse nature of hybrid work. The papers can be seen in Table 1.

3.4 Selected Empirical Cases

Based upon all the papers, we selected four papers with empirical cases for the detailed analysis, one from each of our classifications of hybrid work: Healthcare [83], Performance [36], Non-office work [11], and Office work [72]. When selecting the four papers, we aimed for significantly diverse empirical studies concerning scale, time sensitivity, professional work, technologies, and geography. Moreover, when there were several cases from a certain category, we selected the papers with the most detailed empirical descriptions.

Before presenting the results of our analysis, we will briefly present the context of the four selected empirical cases.

Emergency call: Our first selected case is Paoletti's [83] study of *Communication and Diagnostic Work in Medical Emergency Calls*. The context of the study is an emergency dispatch control room that received an emergency call from a factory reporting an injured person. The situation includes eight actors distributed over four geographical sites. The cooperative situation revolves around the situation where a caller reports an accident in a factory by calling the emergency call center and interacting with the operators. Two operators divide the tasks between them including tasks such as interviewing the caller, diagnosing the situation, and taking decisions. Later a second caller, who is also present at the factory, calls to report the same accident. It is the operator's role to coordinate the appropriate medical assistance to the patient. This coordination involves an ambulance and a helicopter with different medical providers onboard.

Ice hockey game: The second selected case is a study of live broadcasting of an ice hockey game by Engström et al. [36], titled *Temporal Hybridity: Mixing Live Video Footage with Instant Replay in Real Time*. The work situation involves 16 actors placed in four different geographical sites. Five actors with different professional backgrounds are placed in a bus outside the arena, three camera operators are inside the arena, and two commentators are in the arena studio. The focus in on the coordinative activities when mixing live and prerecorded images from the game, which need to be broadcasted to the audience. Thus, the cooperative work centers around decisions on what to broadcast, using which camera angles, supporting which kind of comments, and when to replay match activities.

Oil production: The third selected case is from the paper *Technology Effects in Distributed Team Coordination – High-Interdependency Tasks in Offshore Oil Production* by Bayerl and Lauche [11]. The data report a case where 78 actors were located on two geographical sites: Offshore and onshore. The 52 actors are onshore and professionally act as support engineers or take on managing roles. The 26 technicians are team leaders and engineers all located offshore. The main cooperative activities are to optimize the production and maintenance of the offshore installation. The cooperative focus is on how technology affected the distributed team coordination in these high-interdependent tasks within the offshore oil production domain.

Office work: The fourth selected case is by Mark et al. [72] and studies *Group-to-Group Distance Collaboration* within space mission design. The collaboration consisted of four distributed engineering teams with respectively 1, 9, 12, and 24 collocated actors. The purpose of the collaboration was to connect different professional expertise in working towards a shared goal for the research, and through this invent and develop new technologies within space-based scientific research. The focus is on the gap which exists in the "space between" the groups, and how this space is affected by the distance between the actors.

All the empirical cases reported in the selected papers were conducted at least ten years ago, and interestingly they are still relevant today despite the technological opportunities have evolved. Within the health domain category, current research is still addressing the challenges and advances of tele-triage [109]. Within performance, the increasing popularity of esports events has challenged the digital setup for live-streaming events [112] which also impact other sports disciplines. Current research also still explores the challenge of designing digital technologies to enable remote operation on offshore platforms [110], and in general the COVID-19 pandemic has increased the interest in remote and hybrid work technologies. All these studies demonstrate that the challenges in hybrid work persist and despite the technological opportunities are evolving, we are yet to fully understand the basic nature of hybrid work with the aim of designing hybrid technologies. We in this paper, try to extend this current research by learning from the past.

4 RESULTS

4.1 The Hybrid Work Arrangements

One of the essential dimensions in hybrid work centers on the actors involved in the cooperative work. Therefore, we initiate our analysis by focusing on the actors. We explored questions such as: Who are the actors? What are their professional disciplines? How do the actors' individual, yet interdependent, professional practices unfold during the accomplishment of the cooperative activity?

We begin by looking at the study by Paoletti [83] on communication challenges related to emergency operators' diagnosis work. The paper introduces empirical data on a hybrid work arrangement where all actors are geographically distributed on fewer sites than the number of actors. All actors are dependent on collaboration with others and the work is characterized by interdisciplinary cooperation organized in time-dependent work activity. The empirical data demonstrate how the cooperative work is challenged by the professional disciplines of the actors (factory worker, emergency phone operator, medical doctor), consequentially leading to wrong decision-making. Let us take a closer look.

The situation starts when a factory worker calls the emergency call center to report the accident at the factory and request an ambulance. The call is received by two operators on duty at the call center. One operator receives the information from the factory worker while the other operator dispatches an ambulance to the factory. To do medical assessment and diagnosis appropriately the operators need precise information from the factory worker, and they follow a protocol (script) for receiving emergency calls. Decision-making is dependent on information provided by the caller, and ambulances cannot be dispatched without knowing what type of medical help is requested. In the example analyzed by Paoletti [83], the factory worker (the caller) explains that the accident appears to be a fainting fit, yet urgent since the patient is unconscious. The operators reach out to the ambulance station asking to dispatch an ambulance, specifying the emergency code as 'fainting fit' indicating the urgency. When the paramedics arrive at the factory, they call the operators. The paramedics report that the patient is under an engine and "seemed not to be alive" [83], thus it is a work accident and not a 'fainting fit'. Determining the appropriate action, and not erasing the previous information provided by the original caller (the factory worker) who reported a less severe situation, they dispatch a helicopter with a doctor on board. When the doctor arrives, he confirms that the patient is dead. The doctor files a complaint about the operators' incorrect decision of dispatching a helicopter, as helicopters should only be dispatched when the patient is alive.

In this hybrid work situation, we have four geographical sites: The factory, the dispatch center, the ambulance center, and the helicopter center – however the main hybrid interaction takes place at two sites: The factory and the dispatch center. At the factory site the factory worker and then later two paramedics and the doctor arriving by helicopter are physically collocated. At the dispatch center, the two operators are collocated. What we see in this example is that the nature of a hybrid situation is malleable as the temporal development of the location change as time passes. Which actors are geographically dispersed and who are collocated is thus not a straightforward question to answer as it might change as the cooperative work situation develop over time. Answering the question of who are collocated is dependent upon '*when* we ask' during the cooperative activity. Further, we also see from this empirical example how the different professional disciplines matter for how the hybrid work task is accomplished. While the factory worker initially reporting the accident does not have medical expertise, the operators, the paramedics, and the doctor each have different types of medical skills and expertise. Communicating across the different types of medical expertise while working across disciplinary boundaries combined with the changes in geographical boundaries of the actors are all factors shaping the nature of the hybrid work situation, and, in this case, produce a communication breakdown.

The second empirical case of hybrid work arrives from Engström et al.'s [36] study of the live broadcasting of an Ice Hockey Game. In this case, the actors include camera operators, commentators, and visual image providers. All actors involved are divided into sub-groups, each with clearly defined roles and activities. The three camera operators cooperate to produce audio-visual material from different perspectives, e.g., overview shots and close-up shots. The vision mixer cooperates closely with the replay operator to decide on what to broadcast. The visual mixer decides *what* to broadcast, while the replay operator managed the work related to *editing* the sequences to be replayed, involving the producer, the script operator, and the graphic operator. The camera operators record the images selected for broadcasting by the vision mixer. The commentators make the audio speech. During this process, the replay operator simultaneously selects and organizes recordings for replays of the game. The replay operator scrolls through recordings and selects moments that are valuable to replay for the audience. The empirical case on the broadcasting of an ice hockey game provides insights into how closely coupled work tasks organized in tight coordination activities across three geographical sites take place. The geographical locations include the bus, the arena, and the studio, and the hybrid team includes 16 actors working in four different sub-groups.

The third empirical case arrives from a study of offshore oil production by Bayerl and Lauche [11]. The study of Offshore Oil Production consists of actors who continuously coordinate interdependent tasks required in the production and maintenance of the oil platform. The overall distribution of actors is divided between the onshore and offshore personnel containing sub-groups of actors. Onshore includes support engineers, team leaders, technical authorities, and field operators. Offshore includes technicians, petroleum engineers, team leaders, operations engineers, and installation managers. Bayerl and Lauche [11] identify three main areas of recurrent coordination activities between onshore and offshore. These activities include 1) the well and plant configuration for optimized production, 2) planned and unplanned maintenance of the offshore installation, and 3) reactions to unexpected events. All three types of activities are related to planning, executing, reporting, and negotiating across the geographical sites and sub-groups with different professional backgrounds [11]. Coordination across the actors is guided and managed by the actors located onshore, while execution and monitoring activities are performed offshore (at the oil platform). For example, the specialized onshore engineers ensure that materials are available for the personnel on the rig in due time. The control room at the oil platform has access to data on the valves, pumps, flow rates, fire alarm systems, fluid pressures and temperatures in the plant. The main responsibility of monitoring and controlling the data is with the offshore personnel, only sharing the data upon request. The Offshore Oil production case is thus a hybrid cooperative situation, where long-term coordination and division of tasks onshore/offshore impact the access to data. The empirical case shows how changing the access to data in a hybrid work arrangement impacts the cooperative work arrangement in important ways.

The last empirical case by Mark et al. [72] takes place in a hybrid office environment. This case involves actors that are closely aligned in their engineering disciplines yet with different professional expertise. The study focuses on a cooperative task of a space mission design, which took nine hours distributed over a week – three hours on three different days. The work activity is distributed over four different teams with 1, 9, 12, and 26 actors, whereas each team is placed in different geographical positions. The cooperative work aims to combine different specialized expertise across various areas of responsibility relevant for the shared cooperative task. All teams had different methodological engineering approaches, which were required to be aligned to achieve the joined task.

4.2 Cooperative Technologies

All the selected empirical cases describe work activities that require highly cooperative activities between the different actors working in different types of hybrid settings. These cooperative tasks are enabled by different technologies that support the individual's activity, as well as the coordination, and communication across individuals. Exploring the use of technologies in the selected cases allows us to explore and potentially identify the unique technological features embedded in hybrid cooperative settings as well as investigate how actors follow different strategies to bridge the hybrid setup.

In the Emergency Calls case, the technical setup is characterized by disconnections and unstable infrastructure. The technological setup includes telephones, computers, and radio communication. All the interaction is enabled by audio technologies (phone or radio). The operators communicate with the factory worker reporting the case using the phone, however, the factory worker ends up hanging up in frustration. The factory worker's frustration is grounded in misunderstandings and unclear information about whether an ambulance has been dispatched or not. The paramedics call the operator using a phone when they arrived at the factory. In this call, the paramedics and the dispatch center are interrupted technically and experience several disconnections in their use of both the radio and the cellular phone for interaction. The operator can

hear the paramedics, but the paramedics cannot hear the operator. The lack of a stable technical setup made it impossible to discuss questions and concerns, which then influenced their opportunities for developing common ground as part of the hybrid setup.

In the offshore Oil Production case, the technologies that the company implemented to support the cooperation between the onshore office and the offshore rig include videoconferencing, desktop-sharing, and real-time access to plant and process data – all in addition to technologies such as phone, email, and audio-conferencing. One core shared activity between onshore and offshore is the information exchange of data between the sub-groups. The onshore team offices have large, shared screens installed where real-time data about the oil platform is visualized. This allows the onshore engineers to follow the status of the plant from afar limiting the need to request information from the offshore personnel. However, the introduction of new technology also changed the collocated activities as the projection of data on the shared screens in the room "provoke a conversation" [11]. With the data visually available for everyone to see (both onshore and offshore), the onshore sub-group had immediate reactions to the data and was able to effectively start investigations of sudden changes. Moreover, the offshore control room had video-connections implemented, allowing the onshore personnel to visually follow the activities. Implementing live-feed video provided new ways for doing information exchange temporally, compared to the previous use of sending emails with images. With the videoconferencing, geographically distributed actors showed the relevant information directly during the call. The technologies in the Oil Production case enable cooperation by increasing the distribution of data and providing (almost) synchronous access to information for both collocated and distributed team actors.

Differently, the technologies used to facilitate interaction in the Ice Hockey case did not increase access to information, instead, the technology setup was structured to limit the actors' access to information. Let us take a close look. In the Ice Hockey case, actors use several different technologies. The producer, script operator, and graphic operator each have different screens however they all display and provide access to the same information. Some of the other actors, e.g., the vision mixer and the replay operator, has different technological setup providing different visual streams to be available. The replay operator is collocated with other actors but has a split-screen display of all four live camera feeds combined with two monitors which are used to record and manipulate video footage for replay. As such, the replay operator can react immediately when situations arise in the match stipulating the need for replay – and then use the technical setup to scroll back in time for any of the four camera feeds. The cooperation between the actors is enabled by radio communication, however, not all actors have radio access. The vision mixer and replay operator do not have radio access and can instead overhear the interaction by listing to the commentators from the loudspeakers. The vision mixer has direct audible contact with the commentators (due to physical proximity), while the replay operator is only able to contact the commentators by pressing a button to create an audio-stream. The technical setup shapes the access to information and access across sub-groups, professional expertise, and geographical sites, and thus creates the shared hybrid workspace for all actors.

In the Office Work case, the collaboration between the four teams is enabled by a video conferencing service that displays the video stream from the site that is most vocally active. The sites have different large displays matching the size of the local contexts; Site 1 has three public displays of 12 x 6 feet, Site 2 has two displays of 6 x 5 feet, and site 3 has a display of 6 x 5 feet. Additionally, they use a shared application linking spreadsheets and graphics, which enabled the actors to publish relevant specifications and parameters. The collaboration across the different teams is mediated by video teleconferencing, which is available for all actors, and as part of subgroup conversation which is only available for selected actors either locally or across the four sites. Finally, the actors use telephones and voice conferencing technology.

In all four selected cases, the hybrid setup includes multiple technological systems that together formed the technical infrastructure required to accomplish the work. While the technical setups were different across the four empirical cases, they all confirm that the implementation and use of technologies shape the basic nature for which type of cooperative engagement can take place [51] is also relevant in a hybrid work setting.

4.3 Breakdowns in Communication and Creating Common Ground

Collaboration between different actors requires a shared understanding of coordination and communication. The selected cases exemplified both breakdowns and successes in creating common ground, which in hybrid arrangements is not only required for the geographically distributed actors but also the collocated sub-groups.

The selected cases represent work where different professions and expertise is present, and that potential communication breakdowns can emerge due to the interdisciplinary nature of the work and the lack of common vocabulary. Unpacking the communication breakdown in the emergency call case, we find that the call operator and the factory worker reporting the accident lacked a shared understanding of the situation at the factory. The operator misunderstood the factory worker reporting the accident [83]. Developing common ground in the distributed situation was challenged by the actors' (in)access to information. The operator strictly follows protocol, but the factory worker does not understand *why* he must provide the information requested and gets provoked by the assumed lack of action: "[the caller] see the questioning as an unreasonable way of postponing the delivery of help" [83:236–237]. In this case, the factory worker utters profanity and then hangs up, with no attempt to close the call. That the call operator has already requested an ambulance while starting the questionnaire with the factory worker was not visibly available for the factory worker. Thus, using the protocol for questions became a provocation for the factory worker who then expressed anger. After hanging-up the phone, the connection between the factory worker and the call operator was re-established (new call) but continued in the same unproductive tone. In the control room at the dispatch center, the computer monitors enabled the operators to see that an ambulance *is* on its way. However, the factory worker does not have access to this information and complaints about the lack of action by the operator. To establish common ground concerning the actions that

have been taken, the operators need to convey such information to the factory worker, and in the situation this did not happen.

The inaccurate information provided by the factory worker, further complicated due to stress and anxiety, makes the call operator misinterpret the accident as a fainting accident, rather than as a severe work accident. Despite the frustration in the communication between the two, the operator sticks to the information first provided and registers the emergency as a 'fainting fit' and dispatches an ambulance. It then turned out that two different people had reported the accident - the first factory worker reports a fainting fit and is unable to explain what has happened but can only report a colleague is on the ground unconscious; the second factory worker reporting the accident also mentions the fainting fit but also reports that his colleague is breathing but unable to talk. The operator presumed that *all collocated actors* (first and second factory workers) have equal access to the same information. The operator presumes that the local actors must have access to the same and correct information since they are collocated. When the paramedics report that the patient is dead, the operator does not "erase" the information previously provided by the two factory workers and decides to dispatch a helicopter with a doctor on board. Currently, we have three collocated actors (two factory workers and a paramedic) and the operator continues to assume that all collocated actors share the same information. It turned out that the patient was dead already when the paramedics arrived, also verified by the doctor when they arrive at the factory. What this empirical case demonstrates is that we cannot assume that actors involved in hybrid work have access to the same information and share common ground despite being collocated.

In contrast, the case of broadcasting an ice hockey game [36] demonstrates how the communication across disciplinary boundaries was successful despite the hybrid setup, because of the important effort of all actors in establishing common ground. Let us explore the concrete situation. A gaming incident where a penalty is committed takes place in the hockey game. When a gaming incident occurs, the footage must be replayed for the audience. The replay operator searches the video bank and produces the relevant replay footage. Another penalty is committed in the game, while the replay operator is searching for replay footage of the first penalty. The new incident needs to be replayed directly after the first incident. However, the replay operator does not look at the live footage while searching the video bank for the first incident, thus they do not know who did the second penalty and the commentators' reactions (audio) are temporally out-of-synch with the game event. To reestablish common ground, the replay operator needs information from other actors. The replay operator requests additional information by asking openly, which makes their request for information audibly available to all collocated actors involved. The vision mixer hears the request and since he has access to different visual streams, he can identify the person involved in the second penalty and provide the number of the player to the replay operator. Further, to give the replay operator more time, the vision mixer asks the camera operators to swift their tasks. All this coordination work is enabled by audio communication and all actors have a shared understanding of all actors' actions in the cooperative activities. Engström et al. write that "It is the availability of several media, visual and auditory, that makes this split of attention possible." [36:1499]. The hybrid cooperative work therefore only succeeded because of the technology-enabled communication of the actors related to their activity and not related to their physical location. The vision mixer and replay operator act as distributed actors, so while all actors are geographically close to each other during the hockey game, not all are collocated. Yet, each specifically defined work activity is accomplished only due to the seamless interaction solving the interdependence of the other actors' access to information. The replay operator is dependent on the commentator and vision mixer's information as they do not have visual access to this themselves.

In the Oil Production case, the geographical distance between sites in the hybrid setup is several kilometers, yet the technological setup made the distributed actors achieve an experience of copresence. As the study is conducted under the process of implementing new information and communication technologies in the oil production setup, the paper provides empirical data that display the change in technology and how such changes shape the condition for common ground in hybrid work. The core technological change is two-folded: 1) providing direct access to the data onshore and 2) a continuous video link across the two sites. While some of the actors prefer using emails to document the coordinative decisions, the video links replaced a significant amount of phone calls and emails. One of the video connections is placed in the control room on the rig, which by the offshore personnel is perceived as intrusive and adds pressure from the onshore. Bayerl and Lauche document in their finding: "[. . .] '*I just don't like it. I mean, maybe it's a bit of added pressure if somebody is watching you*'. Especially in the early stages after the implementation of video-links, offshore technicians reacted by placing coffee cups and hardhats on cameras or by pointing the cameras to ceilings or corner." [11:151]. Thus, despite the technologies enabling synchronous collaboration improving the conditions for common ground, the technological setup also introduces new challenges to the hybrid setup such as the relations between surveillance and privacy. Over time it facilitates new opportunities for hybrid collaboration and some actors experience a social connection between the onshore and offshore engineers, a social connection they had not previously had: "some of the guys that I've hardly ever spoken to before I'm now chatting away like we're best of friends" [11:152]. In this way, the continuous synchronous connection over time supports the shared meaning context across sub-groups in the hybrid setup. While the video link impacts the hybrid work, the new data-sharing setup across onshore and offshore also transforms the cooperation. After the implementation of the new technology setup, data are shared automatically between onshore and offshore. This allows onshore personnel to monitor the plant from afar, yet it also blurs the boundaries between specific roles and responsibilities across sites. The actors involved in the hybrid setup on the platform can be divided into the generalists and specialists, whereas the specialists are placed onshore to plan and guide the tasks, while the generalists organize the everyday work on the platform. It is the generalists' job to analyze the day-to-day data, but the new setup of real-time sharing of data transforms the work. "[W]ith the availability of real-time data and the easier access to the control room, onshore engineers were now drawn closer into the day-to-day issues on the platform with the danger of losing their longer-term, strategic focus" [11:159]. Thus, the data sharing

invites onshore specialists to act upon the daily tasks, which blurs the roles between the actors. Consequently, this transformation in work adds additional work to the specialists, while erasing the job functions of the generalists. The Oil Production case reminds us that when designing technology setups, it is important to find ways to facilitate the establishment of common ground, but we must be aware of the potential consequences our efforts might also produce, which might be counter to our initial purpose.

In the Office Work case, creating common ground was challenged by the different sub-groups. Mark et al. [72] explain how all teams entered the collaborative work with their own culture and practices, which complicate their ability to create shared language and terminology to solve the specific space design activity. For example, the largest of the collocated teams (26 local actors) had worked together for several years. Therefore, they had shared experiences supporting the development of common ground. In such group-to-group collaboration, the actors know about the methodology used by their collocated group, but the practices and processes of the groups are not visible between different groups. Technology can be used to enable a shared understanding between the different groups; however, it can also extend the misalignment between the actors - what Mark et al. [72] define as the "space between" the subgroups. During the articulation work that supports the cooperative work, the actors achieved to create hybrid solutions to create common ground, yet the subgroups were challenged in adopting the new language created, as they still hold on to their subgroup's methodologies and processes. In this way, the Office Case shows an example of hybrid work that succeeds in the creation of common ground between the distributed teams, however, this does not necessarily mean that the subgroups adapt to the new understanding created across the teams, as the collocated practices risk taking precedence.

5 DISCUSSION

We have explored the characteristics of hybrid cooperative work in diverse cases from previously published papers. Our selected empirical cases allowed us to scrutinize the nuances in hybrid work situations as an analytical frame for depicting the subtle differences between distributed work and hybrid work. The subtle differences become pertinent for design decisions for hybrid work and rest on the fundamental similarity between distributed and hybrid work in that they both are cases where the accomplishment of the cooperative task produces interdependence across actors requiring them to engage in articulation work despite geographical dislocation. As such, we view hybrid work as a subset of distributed work. This allowed us to consider hybrid work as a special entity and area of interest for CSCW design while utilizing the existing theoretical contributions emerging from literature on distributed work as a steppingstone.

5.1 Hybrid Work as a subset of Distributed Work and Cooperative Work: Collocated Distance

Across all the selected empirical cases, we identified an interesting design challenge: The design of cooperative technologies tends to focus on the problem of creating common ground *across geographical sites*, yet another equally important design challenge emerging from our analyses is the challenge of supporting the development of common ground *in the collocated part of the hybrid setup* – however this design challenge tends to be completely neglected in hybrid technologies. In the Emergency Call case [83] the challenge became pertinent when the data revealed that the two collocated participants in the factory who were assumed to have common ground, clearly had divergent perspectives on the situation (as described in section 4.3). Or in the case of the Ice Hockey Game [36] where the participants who were collocated turned out to have very different access to information and thus did not have the otherwise assumed common ground which arrived with collocation. Across all our cases, *collocation without common ground* emerged as an interesting and surprising design challenge that is uniquely shaped in hybrid work situations, and we suggest labeling this challenge, the design challenge of *collocated distance* in hybrid work.

Collocated distance refers to the challenge in hybrid work where collocated actors do not share common ground despite their immediate shared context. In this way, collocated distance can be considered as depicting a boundary that entails a 'distance' within the collocated actors. Across all four cases, we saw that the hybrid work setup produced different types of sub-groups. The sub-groups emerged and were enforced by the technology setup where people who were geographically distributed emerged as sub-groups. However, sub-groups also emerged between people who were collocated in all our cases. For example, in the Emergency Call case, the call center sub-group assumed that the factory sub-group was collocated and thus had access to the same information and were interacting with each other. Similarly, in the Hockey Game, the control room sub-group and the camera sub-group had assumptions about the other sub-groups as well as who had access to the same information. However, in both cases, the actors in the collocated sub-groups were not interacting and thus did not share information, nor had access to the same information which created a situation of miscommunication. Miscommunication has been a core challenge within cooperative work for decades, and we therefore explore this issue further.

In previous literature on common ground, the focus has been on the boundaries created by the geographical distance jeopardizing the establishment and maintenance of common ground. As such, prior research tends to focus on miscommunications between geographical dispersion, and not within the collocated context. Distributed work has similar challenges as collocated cooperative work, but the introduction of geographical distance transformed some of the conditions for how actors could engage. When we explore hybrid work within prior conceptual understanding of space and place [38, 51], our analysis shows how the opportunities for interactions in hybrid work technologies tend to focus on the remote situations – the digital 'space' providing the opportunity for interaction despite dispersed participation. The design challenge in current research tends to focus on 'creating a space' for interaction when no resources exist without the technology. We expand this argument by emphasizing that – yes – we do need to consider how hybrid technologies can produce opportunities for interaction between distributed actors – however in this attempt we must not

forget that the space for interaction in hybrid work *also exists between collocated actors.* Based upon our analysis, we argue that the design challenge for hybrid technologies cannot take the 'space for cooperation' (the opportunity for interaction) in the collocated context for granted when designing hybrid technologies. Instead, the design of hybrid technologies must simultaneously find ways to shape the *remote* as well as *collocated space* for interaction - if we are to produce a hybrid space for collaboration where placed-based activities can take place.

Considering geography at a dimensional scale [62, 103] mixing collocation with remote participation introduces potential challenges of different life worlds, time zones, assumptions, and languages into the mix of distributed work [18]. In all our selected empirical cases, the geographical distribution did shape the kind of collaboration that could take place. The geographical distance between some but not all participants produced sub-groups as pertinent for the hybrid setup. However, we identified that an essential 'distance' that jeopardized the establishment of common ground was not between remote participants but instead between the collocated sub-groups. The distinction between geographical distance and perceived geographical distance matters [23]; however, in our selected cases it was not the perceived geographical distance or geographical distance which mattered the most. Instead, it was the non-geographical distance created *within* the collocated setup, shaped by access/lack of access to information combined with different types of professional expertise.

We found that hybrid work situations *inherit all the challenges* and aspects from both collocated cooperative work and distributed work, including the challenges of creating common ground, identifying the appropriate coordination strategies, supporting mutual awareness, and balancing the geography dimension to find ways to navigate multiple lifeworlds, assumptions, languages, etc. Further, we found that professional expertise, hierarchy, and information access matter for how the hybrid work situations produce certain conditions for establishing and maintaining common ground. All these factors can potentially also emerge in collocated cooperative work and distributed work. However, we would argue that these factors have increased complexity in hybrid work settings. Why? Firstly, in all the selected cases we found that when introducing collocated sub-groups into the mix of geographically distributed actors introduced misalignment and asymmetry by default. When we have a cooperative situation where actors do not have equal access to the same information, to other actors, or to monitor others' activities and act accordantly, additional boundaries emerge. Sub-group dynamics can be essential to all types of collocated and distributed work – however *sub-groups based upon some participants being collocated and others not, are always part* of hybrid work situations. The geographically collocated sub-groups consequentially increase the difficulties of establishing and maintaining common ground [81]. Not because common ground is only difficult in hybrid work (it is always difficult), but because the condition for grounding activities is constrained due to unequal access. Further, we found that the additional boundary of collocated distance was pertinent impacting the potential for creating common ground.

This means that when we design technologies for hybrid work, we can not only focus on the boundaries across geographical distances but must remember the potential boundaries which can be pertinent for the whole hybrid setup which is emergent within *one* geographical location. We propose collocated distance as a way to remind ourselves not to forget the collocated interaction when we design cooperative technologies for hybrid work and to pay attention to sub-groups that are collocated yet exist due to e.g., professional expertise, hierarchy, and differences in information accessibility despite the collocation. Collocated distance complements previous distance conceptualizations such as geographical distance as a scale [62] and perceived distance [23], by nuancing our vocabulary and thus our design focus when developing hybrid technologies. Collocated distance teaches us that we must not forget the potential challenges that can arise in collocated work even though our design 'entity' includes geographical distance. If we are to design technologies that support hybrid work, we need to consider the dispersed nature of knowledge involved in cooperative work – in Hutchins's words the distributed cognition [56] – since all cooperation is immediate social by nature and thus the knowledge and activities are distributed across actors (also between collocated actors). We must pay equal attention to the interaction *across* geographical sites and the interaction *within* geographical sites. Finally, we must remember that hybridity in a cooperative setup might change over time, thus we should consider the spatial-temporal aspects of hybrid work in future design.

5.2 Design Challenges for Hybrid Work Technologies: Professional Disciplines, Hierarchy, and Information Accessibility

As we have emphasized throughout the paper, the core challenges in hybrid work circle around the difficulties in establishing and maintaining common ground. The tools and technologies enacted in cooperative engagements shape the conditions for common ground, and many CSCW researchers have explored different technological design strategies to improve the conditions for common ground in distributed work, such as feed-through [49], articulation spaces [22], and interaction walls [60]. However, most of these solutions are based upon a situation where either all participants are geographically dispersed, or all participants are collocated, with only a few exceptions [37].

Where current design approaches for cooperative technologies tend to simplify the situation to be able to address the challenge of common ground [9, 17, 50]. Instead, we tried to follow the complexities in the cases to see if they would allow us to create a nuanced understanding of the challenge. Following the complexities in developing common ground in the selected cases, we identified *two important dimensions* which shape the characteristics of hybrid work, *namely relations between hierarchy and professional expertise*, and the relations between *information access and the diverse technological contexts.* Let us look at each in turn.

Across the cases, the conditions for establishing common ground were impacted by which actors are involved (who) and how these actors are 'sorted' *hierarchically* within the organizational setup. The actors involved each have their own *disciplinary background* including domain-specific language, procedures, and practices. Professional backgrounds impact participants' expectations of the cooperation. In this way, each actor brings with them to the interaction in the hybrid work their own social context including professional

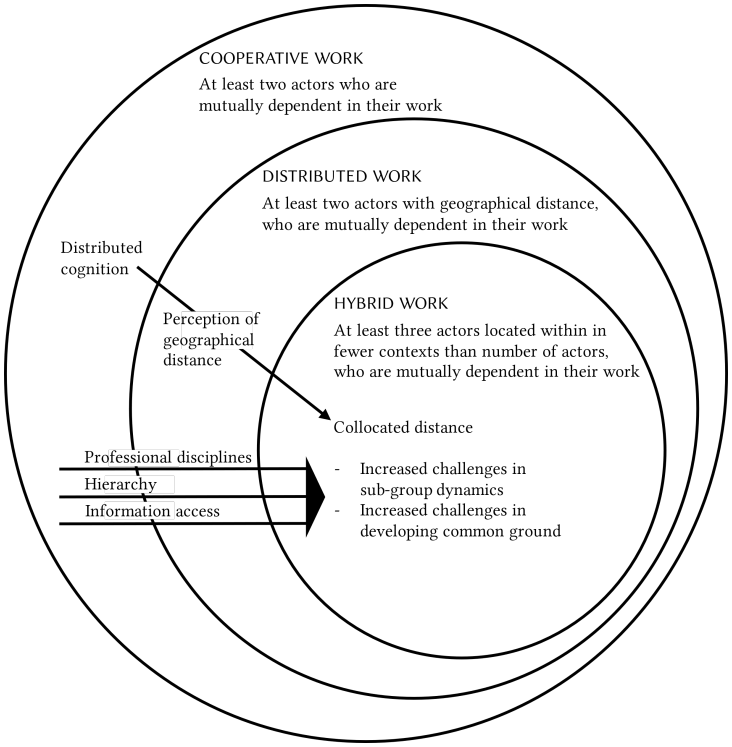

Figure 2: Visualizing Hybrid work as a subset of Distributed work and Cooperative work

language and assumptions [18], which are challenged when interacting with others with different professional disciplinary backgrounds. For example, this was the situation in the Office Work paper [72] where the different groups brought their individual and professional practices into the mix, challenging the development of a shared understanding across all participants. When various actors interact, each bringing their own background assumptions and social contexts into the mix, they negotiate the common field of work by engaging in grounding activities [29]. However, the geographical dispersion of the actors and the constellation of who is collocated and who is dislocated impact the conditions for creating common ground *across professional boundaries*. In the Oil Production case, the actors making the long-term planning were placed onshore while the actors the activities were placed offshore. Thus, the professional disciplinary boundaries aligned with the geographical boundaries. Not only did the different professional expertise complicate the establishment of common ground in the Oil case, but the *hierarchical positioning of the actors* also impacted the hybrid situation. Professional background and hierarchy are often linked together, as different professional disciplines often are situated in a hierarchical order. When dividing shared tasks into subtasks through segregation the purpose is to reduce the complexity of solving the task through coordination [40], in such a way that everyone does not need the complete overview of the shared task but only focuses on specific assigned tasks. Decisions on who then should do which subtasks are then decided upon based on professional expertise as well as hierarchy – thus simpler tasks are distributed to people with less expertise, allowing for people with high expertise to focus on the more complex part of the work and solve complicated problems and breakdowns. Such setup often means that the details of the work become invisible by distance [98], and thus the detailed information of certain tasks slides into the background.

Interestingly, the Oil Production case showed that providing *information access* to all actors, risks moving the tasks and responsibilities across actors and in this way erases job functions. In contrast, the actors in the Ice Hockey game case are limited to only accessing the information relevant to their own individual activity. In this way, the *hierarchy defined by expertise and the hierarchy across members* in the collaboration was shifted by the changes in setup and information accessibility in the Oil case. From the early days of groupware research, we know that cooperative technologies can disrupt social processes [48]. For example, email can disrupt the hierarchy in an organization by allowing low-level organizational members to have direct access to top management by sending them an email. The Oil Production case does not refer to email, but what emerged in the case was that the *accessibility to information was transformed* because of a re-arrangement of the technological setup which again disrupted existing professional expertise division of the tasks, impacting the actors' conditions for establishing common ground.

Professional expertise and hierarchy thus shaped and were shaped by the technological context stipulating specific conditions for information accessibility. Further, we also saw that specific subgroup dynamics [35] emerged within the hybrid setup – and in the cases where the demarcation of the sub-groups was overlapping

with both professional discipline and hierarchy – and the impact of 'distance' was increased and can consequentially develop fault lines within the cooperation [35]. This means that if the sub-groups shaped by geographical distance also overlap with differences in professional disciplines and hierarchy it *increased the impact of distance and challenged* the conditions for creating common ground.

Considering our analytical findings in a design context for hybrid work technologies, we propose that hybrid technologies should not simply focus on supporting the remoteness embedded within the arrangement. We argue that by only focusing on the remote boundaries, we risk neglecting the important collocated boundaries. Further, we argue that in this attention to collocated distance, we must consider the professional disciplines, the hierarchy, and the organization of information accessibility. So how does this extend the design space? Referring to one concrete hybrid technology namely the Sidebar technology [37], we see an example of how the designers focused on facilitating the connections between distributed actors placed in hybrid meetings. However, we also discover that their design is based upon the assumption that the collocated participants in the hybrid meetings do not experience any boundaries for interaction requiring technology support.

We argue that designers of hybrid technologies cannot assume that collocated actors share the same information and have the opportunities for seamless interaction simply because they are collocated. Thus, our work extends the design challenge for hybrid work technologies such as Sidebar [37] to include additional design considerations for supporting or reducing the risk of collocated distance jeopardizing the development of common ground.

6 CONCLUSION

We sat out to investigate the characteristics of hybrid cooperative work to determine how hybrid work situations introduce unique design challenges for hybrid technologies. Through cross-case analysis of existing empirical cases from literature, we categorized hybrid work into four categories: Hybrid work in healthcare, Hybrid work in performance, Hybrid work in the office, and Hybrid work in non-office work. Selecting one paper from each category each providing rich empirical details allowed us to unpack the characteristics of hybrid work as a subset of distributed work with related design challenges. We propose *collocated distance*, an oxymoron, which makes visible an overlooked challenge reminding us not only to focus on the geographical boundaries but also to pay attention to the collocated boundaries which are produced in hybrid setups when we design hybrid technologies. Hybrid work arrangements take many different formats – and our conceptualization proposes hybrid work as a continuum of different work setups. We know that we have not unpacked all the variety within hybrid work in this paper, and we will encourage future research to further nuance the details embedded within hybrid work, for us to start classifying and developing different categories of hybrid work technologies. Finally, we hope that our categorization and visualization of hybrid work can help others to continue the work of understanding the special characteristic of hybrid work with the aim of designing hybrid technologies.

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REFERENCES

[1] Anne P. Massey, Mitzi M. Montoya-Weiss, and Yu-Ting Hung. 2003. Because Time Matters: Temporal Coordination in Global Virtual Project Teams. *J. Manag. Inf. Syst.* 19, 4 (April 2003), 129–155. DOI:https://doi.org/10.1080/07421222.2003.11045742

[2] Hilary Arksey and Lisa O'Malley. 2005. Scoping studies: Towards a methodological framework. *Int. J. Soc. Res. Methodol. Theory Pract.* 8, 1 (2005), 19–32. DOI:https://doi.org/10.1080/1364557032000119616

[3] Gabriela Avram, Liam Bannon, John Bowers, Anne Sheehan, and Daniel K. Sullivan. 2009. Bridging, Patching and Keeping the Work Flowing: Defect Resolution in Distributed Software Development. *Comput. Support. Coop. Work CSCW* 18, 5–6 (December 2009), 477–507. DOI:https://doi.org/10.1007/s10606-009-9099-6

[4] Gagandeep Singh Bachhal and Amanjot Kaur Sandhu. 2013. Remote Patient Health Alert System. In *Proceedings of the 11th Asia Pacific Conference on Computer Human Interaction* (APCHI '13), Association for Computing Machinery, New York, NY, USA, 167–173. DOI:https://doi.org/10.1145/2525194.2525282

[5] Ellen Baker, John Geirland, Tom Fisher, and Annmarie Chandler. 1999. Media Production: Towards Creative Collaboration Using Communication Networks. *Comput. Support. Coop. Work CSCW* 8, 4 (December 1999), 303–332. DOI:https://doi.org/10.1023/A:1008616002814

[6] Lyndsey L. Bakewell, Konstantina Vasileiou, Kiel S. Long, Mark Atkinson, Helen Rice, Manuela Barreto, Julie Barnett, Michael Wilson, Shaun Lawson, and John Vines. 2018. Everything We Do, Everything We Press: Data-Driven Remote Performance Management in a Mobile Workplace. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), Association for Computing Machinery, New York, NY, USA, 1–14. DOI:https://doi.org/10.1145/3173574.3173945

[7] Aruna D. Balakrishnan, Susan R. Fussell, and Sara Kiesler. 2008. Do Visualizations Improve Synchronous Remote Collaboration? In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '08), Association for Computing Machinery, New York, NY, USA, 1227–1236. DOI:https://doi.org/10.1145/1357054.1357246

[8] Jakob E. Bardram and Claus Bossen. 2005. A web of coordinative artifacts: collaborative work at a hospital ward. In *Proceedings of the 2005 international ACM SIGGROUP conference on Supporting group work* (GROUP '05), Association for Computing Machinery, New York, NY, USA, 168–176. DOI:https://doi.org/10.1145/1099203.1099235

[9] Jakob E. Bardram, Thomas R. Hansen, and Mads Soegaard. 2006. AwareMedia: a shared interactive display supporting social, temporal, and spatial awareness in surgery. In *Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work* (CSCW '06), Association for Computing Machinery, New York, NY, USA, 109–118. DOI:https://doi.org/10.1145/1180875.1180892

[10] Louise Barkhuus and Chiara Rossitto. 2016. Acting with Technology: Rehearsing for Mixed-Media Live Performances. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, ACM, San Jose California USA, 864–875. DOI:https://doi.org/10.1145/2858036.2858344

[11] Petra Saskia Bayerl and Kristina Lauche. 2010. Technology Effects in Distributed Team Coordination—High-Interdependency Tasks in Offshore Oil Production. *Comput. Support. Coop. Work CSCW* 19, 2 (April 2010), 139–173. DOI:https://doi.org/10.1007/s10606-010-9107-x

[12] Gabrielle Benabdallah, Sam Bourgault, Nadya Peek, and Jennifer Jacobs. 2021. Remote Learners, Home Makers: How Digital Fabrication Was Taught Online During a Pandemic. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (CHI '21), Association for Computing Machinery, New York, NY, USA, 1–14. DOI:https://doi.org/10.1145/3411764.3445450

[13] Pernille Bjørn. 2003. Re-negotiating protocols: a way to integrate groupware in collaborative learning settings - researchr publication. *ECIS New Paradig. Organ. Mark. Soc. Proc. 11th Eur. Conf. Inf. Syst. Napoli* (2003). Retrieved September 11, 2022 from https://researchr.org/publication/Rasmussen03%3A1

[14] Pernille Bjørn. 2016. New fundamentals for CSCW research: from distance to politics. *Interactions* 23, 3 (April 2016), 50–53. DOI:https://doi.org/10.1145/2903753

[15] Pernille Bjørn. 2019. Dark Agile: Perceiving People As Assets, Not Humans. In *Rethinking Productivity in Software Engineering*, Caitlin Sadowski and Thomas Zimmermann (eds.). Apress, Berkeley, CA, 125–134. DOI:https://doi.org/10.1007/978-1-4842-4221-6_11

[16] Pernille Bjørn and Nina Boulus-Rødje. 2018. Infrastructural Inaccessibility: Tech Entrepreneurs in Occupied Palestine. *ACM Trans. Comput.-Hum. Interact.* 25, 5 (October 2018), 26:1-26:31. DOI:https://doi.org/10.1145/3219777

[17] Pernille Bjørn and Morten Hertzum. 2011. Artefactual Multiplicity: A Study of Emergency-Department Whiteboards. *Comput. Support. Coop. Work CSCW* 20, 1 (April 2011), 93–121. DOI:https://doi.org/10.1007/s10606-010-9126-7

[18] Pernille Bjørn and Ojelanki Ngwenyama. 2009. Virtual team collaboration: building shared meaning, resolving breakdowns and creating translucence. *Inf.*

Syst. J. 19, 3 (2009), 227–253. DOI:https://doi.org/10.1111/j.1365-2575.2007.00281.x

[19] Pernille Bjørn and Ojelanki Ngwenyama. 2010. Technology Alignment: A New Area in Virtual Team Research. *IEEE Trans. Prof. Commun.* 53, 4 (December 2010), 382–400. DOI:https://doi.org/10.1109/TPC.2009.2034926

[20] Pernille Bjorn, Ada Scupola, and Brian Fitzgerald. 2006. Expanding Technological Frames Towards Mediated Collaboration. 18, (2006), 41.

[21] Pernille Bjørn, Anne-Marie Søderberg, and S Krishna. 2019. Translocality in Global Software Development: the Dark Side of Global Agile. *Human–Computer Interact.* 34, 2 (March 2019), 174–203. DOI:https://doi.org/10.1080/07370024.2017.1398092

[22] Alexander Boden, Frank Rosswog, Gunnar Stevens, and Volker Wulf. 2014. Articulation spaces: bridging the gap between formal and informal coordination. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing* (CSCW '14), Association for Computing Machinery, New York, NY, USA, 1120–1130. DOI:https://doi.org/10.1145/2531602.2531621

[23] Erin Bradner and Gloria Mark. *Why Distance Matters: Effects on Cooperation, Persuasion and Deception!*

[24] Boyd Branch, Christos Efstratiou, Piotr Mirowski, Kory W. Mathewson, and Paul Allain. 2021. Tele-Immersive Improv: Effects of Immersive Visualisations on Rehearsing and Performing Theatre Online. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (CHI '21), Association for Computing Machinery, New York, NY, USA. DOI:https://doi.org/10.1145/3411764.3445310

[25] Carrie J Cai, Michelle Carney, Nida Zada, and Michael Terry. 2021. Breakdowns and Breakthroughs: Observing Musicians' Responses to the COVID-19 Pandemic. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (CHI '21), Association for Computing Machinery, New York, NY, USA. DOI:https://doi.org/10.1145/3411764.3445192

[26] Clara Caldeira, Cleidson R.B. de Souza, Letícia Machado, Marcelo Perin, and Pernille Bjørn. 2022. Crisis Readiness: Revisiting the Distance Framework During the COVID-19 Pandemic. *Comput. Support. Coop. Work CSCW* (April 2022). DOI:https://doi.org/10.1007/s10606-022-09427-6

[27] Stefania Castellani, Antonietta Grasso, Jacki O'Neill, and Frederic Roulland. 2009. Designing Technology as an Embedded Resource for Troubleshooting. *Comput. Support. Coop. Work CSCW* 18, 2–3 (June 2009), 199–227. DOI:https://doi.org/10.1007/s10606-008-9088-1

[28] Lars Rune Christensen, Rasmus Eskild Jensen, and Pernille Bjørn. 2014. Relation Work in Collocated and Distributed Collaboration. In *COOP 2014 - Proceedings of the 11th International Conference on the Design of Cooperative Systems, 27-30 May 2014, Nice (France)*. Springer International Publishing, 87–101. DOI:https://doi.org/10.1007/978-3-319-06498-7_6

[29] Herbert H. Clark and Susan E. Brennan. 1991. Grounding in communication. In *Perspectives on socially shared cognition.* American Psychological Association, Washington, DC, US, 127–149. DOI:https://doi.org/10.1037/10096-006

[30] Matthew Claudel, Emanuele Massaro, Paolo Santi, Fiona Murray, and Carlo Ratti. 2017. An exploration of collaborative scientific production at MIT through spatial organization and institutional affiliation. *PLOS ONE* 12, 6 (June 2017), e0179334. DOI:https://doi.org/10.1371/journal.pone.0179334

[31] Catherine Durnell Cramton. 2001. The Mutual Knowledge Problem and Its Consequences for Dispersed Collaboration. *Organ. Sci.* 12, 3 (June 2001), 346–371. DOI:https://doi.org/10.1287/orsc.12.3.346.10098

[32] Gavin Doherty, Nikiforos Karamanis, and Saturnino Luz. 2012. Collaboration in Translation: The Impact of Increased Reach on Cross-organisational Work. *Comput. Support. Coop. Work CSCW* 21, 6 (December 2012), 525–554. DOI:https://doi.org/10.1007/s10606-012-9175-1

[33] Paul Dourish and Victoria Bellotti. 1992. Awareness and coordination in shared workspaces. In *Proceedings of the 1992 ACM conference on Computer-supported cooperative work - CSCW '92*, ACM Press, Toronto, Ontario, Canada, 107–114. DOI:https://doi.org/10.1145/143457.143468

[34] Paul Dourish and Sara Bly. 1992. Portholes: supporting awareness in a distributed work group. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '92), Association for Computing Machinery, New York, NY, USA, 541–547. DOI:https://doi.org/10.1145/142750.142982

[35] Catherine Durnell Cramton and Pamela J. Hinds. 2004. SUBGROUP DYNAMICS IN INTERNATIONALLY DISTRIBUTED TEAMS: ETHNOCENTRISM OR CROSS-NATIONAL LEARNING? *Res. Organ. Behav.* 26, (January 2004), 231–263. DOI:https://doi.org/10.1016/S0191-3085(04)26006-3

[36] Arvid Engström, Oskar Juhlin, Mark Perry, and Mathias Broth. 2010. Temporal Hybridity: Mixing Live Video Footage with Instant Replay in Real Time. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '10), Association for Computing Machinery, New York, NY, USA, 1495–1504. DOI:https://doi.org/10.1145/1753326.1753550

[37] Morten Esbensen, Paolo Tell, and Jakob E. Bardram. 2014. SideBar: Videoconferencing system supporting social engagement. In *10th IEEE International Conference on Collaborative Computing: Networking, Applications and Worksharing*, 358–367. DOI:https://doi.org/10.4108/icst.collaboratecom.2014.257335

[38] G. Fitzpatrick. 2003. *The Locales Framework: Understanding and Designing for Wicked Problems.* Springer Science & Business Media.

[39] Yumei Gan, Christian Greiffenhagen, and Stuart Reeves. 2020. Connecting Distributed Families: Camera Work for Three-party Mobile Video Calls. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20), Association for Computing Machinery, New York, NY, USA, 1–12. DOI:https://doi.org/10.1145/3313831.3376704

[40] Elihu M. Gerson. 2008. Reach, Bracket, and the Limits of Rationalized Coordination: Some Challenges for CSCW. In *Resources, Co-Evolution and Artifacts.* Springer London, London, 193–220. DOI:https://doi.org/10.1007/978-1-84628-901-9_8

[41] Elihu M. Gerson and Susan Leigh Star. 1986. Analyzing due process in the workplace. *ACM Trans. Inf. Syst.* 4, 3 (July 1986), 257–270. DOI:https://doi.org/10.1145/214427.214431

[42] Christina B. Gibson and Jennifer A. Manuel. 2003. Building trust: effective multicultural communication processes in virtual teams. *Virtual Teams Work Creat. Cond. Virtual Team Eff.* (2003).

[43] Nitesh Goyal, Gilly Leshed, Dan Cosley, and Susan R. Fussell. 2014. Effects of Implicit Sharing in Collaborative Analysis. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14), Association for Computing Machinery, New York, NY, USA, 129–138. DOI:https://doi.org/10.1145/2556288.2557229

[44] Irene Greif. 2019. How we started CSCW. *Nat. Electron.* 2, 3 (March 2019), 132–132. DOI:https://doi.org/10.1038/s41928-019-0229-y

[45] Rebecca E. Grinter. 1996. Supporting articulation work using software configuration management systems. *Comput. Support. Coop. Work CSCW* 5, 4 (December 1996), 447–465. DOI:https://doi.org/10.1007/BF00136714

[46] Jens Emil Grønbæk, Banu Saatçi, Carla F. Griggio, and Clemens Nylandsted Klokmose. 2021. MirrorBlender: Supporting Hybrid Meetings with a Malleable Video-Conferencing System. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (CHI '21), Association for Computing Machinery, New York, NY, USA. DOI:https://doi.org/10.1145/3411764.3445698

[47] Tom Gross. 2013. Supporting Effortless Coordination: 25 Years of Awareness Research. *Comput. Support. Coop. Work CSCW* 22, 4–6 (August 2013), 425–474. DOI:https://doi.org/10.1007/s10606-013-9190-x

[48] Jonathan Grudin. 1994. Groupware and social dynamics: eight challenges for developers. *Commun. ACM* 37, 1 (January 1994), 92–105. DOI:https://doi.org/10.1145/175222.175230

[49] Carl Gutwin and Saul Greenberg. 2002. A Descriptive Framework of Workspace Awareness for Real-Time Groupware. *Comput. Support. Coop. Work CSCW* 11, 3 (September 2002), 411–446. DOI:https://doi.org/10.1023/A:1021271517844

[50] Carl Gutwin, Reagan Penner, and Kevin Schneider. 2004. Group awareness in distributed software development. In *Proceedings of the 2004 ACM conference on Computer supported cooperative work* (CSCW '04), Association for Computing Machinery, New York, NY, USA, 72–81. DOI:https://doi.org/10.1145/1031607.1031621

[51] Steve Harrison and Paul Dourish. 1996. Re-place-ing space: the roles of place and space in collaborative systems. In *Proceedings of the 1996 ACM conference on Computer supported cooperative work* (CSCW '96), Association for Computing Machinery, New York, NY, USA, 67–76. DOI:https://doi.org/10.1145/240080.240193

[52] Christian Heath and Paul Luff. 1992. Collaboration and controlCrisis management and multimedia technology in London Underground Line Control Rooms. *Comput. Support. Coop. Work CSCW* 1, 1–2 (March 1992), 69–94. DOI:https://doi.org/10.1007/BF00752451

[53] Christian Heath and Paul Luff. 1996. Documents and professional practice: "bad" organisational reasons for "good" clinical records. In *Proceedings of the 1996 ACM conference on Computer supported cooperative work* (CSCW '96), Association for Computing Machinery, New York, NY, USA, 354–363. DOI:https://doi.org/10.1145/240080.240342

[54] J.D. Herbsleb, A. Mockus, T.A. Finholt, and R.E. Grinter. 2001. An empirical study of global software development: distance and speed. In *Proceedings of the 23rd International Conference on Software Engineering. ICSE 2001*, 81–90. DOI:https://doi.org/10.1109/ICSE.2001.919083

[55] Erzhen Hu, Md Aashikur Rahman Azim, and Seongkook Heo. 2022. FluidMeet: Enabling Frictionless Transitions Between In-Group, Between-Group, and Private Conversations During Virtual Breakout Meetings. In *CHI Conference on Human Factors in Computing Systems*, ACM, New Orleans LA USA, 1–17. DOI:https://doi.org/10.1145/3491102.3517558

[56] Edwin Hutchins. 1995. *Cognition in the Wild.* MIT Press.

[57] Marleen Huysman, Charles Steinfield, Chyng-Yang Jang, Kenneth David, Mirjam Huis In 't Veld, Jan Poot, and Ingrid Mulder. 2003. Virtual Teams and the Appropriation of Communication Technology: Exploring the Concept of Media Stickiness. *Comput. Support. Coop. Work* 12, (2003), 411–436.

[58] Timothy Kayworth and Dorothy Leidner. 2000. The global virtual manager: a prescription for success. *Eur. Manag. J.* 18, 2 (April 2000), 183–194. DOI:https://doi.org/10.1016/S0263-2373(99)00090-0

[59] Alexander Kipp, Lutz Schubert, Matthias Assel, and Terrence Fernando. 2008. Dynamism and Data Management in Distributed, Collaborative Working Environments. (2008). Retrieved September 13, 2022 from https://dl.eusset.eu/handle/20.500.12015/2810

[60] Scott R. Klemmer, Katherine M. Everitt, and James A. Landay. 2008. Integrating Physical and Digital Interactions on Walls for Fluid Design Collaboration. *Human–Computer Interact.* 23, 2 (May 2008), 138–213. DOI:https://doi.org/10.1080/07370020802016399

[61] Grete Helena Kütt, Kevin Lee, Ethan Hardacre, and Alexandra Papoutsaki. 2019. Eye-Write: Gaze Sharing for Collaborative Writing. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), Association for Computing Machinery, New York, NY, USA, 1–12. DOI:https://doi.org/10.1145/3290605.3300727

[62] Charlotte P. Lee and Drew Paine. 2015. From the matrix to a model of coordinated action (MoCA): A conceptual framework of and for CSCW. In *CSCW 2015 - Proceedings of the 2015 ACM International Conference on Computer-Supported Cooperative Work and Social Computing*, Association for Computing Machinery, Inc, 179–194. DOI:https://doi.org/10.1145/2675133.2675161

[63] Min Kyung Lee and Leila Takayama. 2011. "Now, i Have a Body": Uses and Social Norms for Mobile Remote Presence in the Workplace. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11), Association for Computing Machinery, New York, NY, USA, 33–42. DOI:https://doi.org/10.1145/1978942.1978950

[64] Minha Lee, Wonyoung Park, Sunok Lee, and Sangsu Lee. 2022. Distracting Moments in Videoconferencing: A Look Back at the Pandemic Period. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (CHI '22), Association for Computing Machinery, New York, NY, USA. DOI:https://doi.org/10.1145/3491102.3517545

[65] Thomas Ludwig, Oliver Stickel, Peter Tolmie, and Malte Sellmer. 2021. shARe-IT: Ad hoc Remote Troubleshooting through Augmented Reality. *Comput. Support. Coop. Work CSCW* 30, 1 (February 2021), 119–167. DOI:https://doi.org/10.1007/s10606-021-09393-5

[66] Jandy Luik, Jenna Ng, and Jonathan Hook. 2019. Virtual Hubs: Understanding Relational Aspects and Remediating Incubation. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19), Association for Computing Machinery, New York, NY, USA, 1–12. DOI:https://doi.org/10.1145/3290605.3300471

[67] Rowena Luk, Melissa Ho, and Paul M. Aoki. 2008. Asynchronous Remote Medical Consultation for Ghana. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '08), Association for Computing Machinery, New York, NY, USA, 743–752. DOI:https://doi.org/10.1145/1357054.1357173

[68] Stephan Lukosch, Heide Lukosch, Dragoş Datcu, and Marina Cidota. 2015. Providing Information on the Spot: Using Augmented Reality for Situational Awareness in the Security Domain. *Comput. Support. Coop. Work CSCW* 24, 6 (December 2015), 613–664. DOI:https://doi.org/10.1007/s10606-015-9235-4

[69] Shiran Magrisso, Moran Mizrahi, and Amit Zoran. 2018. Digital Joinery For Hybrid Carpentry. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), Association for Computing Machinery, New York, NY, USA, 1–11. DOI:https://doi.org/10.1145/3173574.3173741

[70] Ann Majchrzak, Ronald E. Rice, Arvind Malhotra, Nelson King, and Sulin Ba. 2000. Technology Adaptation: The Case of a Computer-Supported Inter-Organizational Virtual Team. *MIS Q.* 24, 4 (2000), 569–600. DOI:https://doi.org/10.2307/3250948

[71] Arvind Malhotra and Ann Majchrzak. 2004. Enabling knowledge creation in far-flung teams: best practices for IT support and knowledge sharing. *J. Knowl. Manag.* 8, 4 (January 2004), 75–88. DOI:https://doi.org/10.1108/13673270410548496

[72] Gloria Mark, Steve Abrams, and Nayla Nassif. 2003. Group-to-Group Distance Collaboration: Examining the "Space Between." In *ECSCW 2003*, Kari Kuutti, Eija Helena Karsten, Geraldine Fitzpatrick, Paul Dourish and Kjeld Schmidt (eds.). Springer Netherlands, Dordrecht, 99–118. DOI:https://doi.org/10.1007/978-94-010-0068-0_6

[73] Gloria Mark, Jonathan Grudin, and Steven E. Poltrock. 1999. Meeting at the Desktop: An Empirical Study of Virtually Collocated Teams. (1999), 12–16.

[74] Stina Matthiesen and Pernille Bjørn. 2016. Let's Look Outside the Office: Analytical Lens Unpacking Collaborative Relationships in Global Work. In *COOP 2016: Proceedings of the 12th International Conference on the Design of Cooperative Systems, 23-27 May 2016, Trento, Italy*, Springer International Publishing, Cham, 107–122. DOI:https://doi.org/10.1007/978-3-319-33464-6_7

[75] Stina Matthiesen and Pernille Bjørn. 2017. When Distribution of Tasks and Skills are Fundamentally Problematic: A Failure Story from Global Software Outsourcing. *Proc. ACM Hum.-Comput. Interact.* 1, CSCW (December 2017), 74:1-74:16. DOI:https://doi.org/10.1145/3139336

[76] Stina Matthiesen, Pernille Bjørn, and Claus Trillingsgaard. Implicit bias and negative stereotyping in global software development and why it is time to move on! *J. Softw. Evol. Process* n/a, n/a , e2435. DOI:https://doi.org/10.1002/smr.2435

[77] Moira McGregor, Nicola J. Bidwell, Vidya Sarangapani, Jonathan Appavoo, and Jacki O'Neill. 2019. Talking about Chat at Work in the Global South: An Ethnographic Study of Chat Use in India and Kenya. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, ACM, Glasgow Scotland Uk, 1–14. DOI:https://doi.org/10.1145/3290605.3300463

[78] Helena M. Mentis, Yuanyuan Feng, Azin Semsar, and Todd A. Ponsky. 2020. Remotely Shaping the View in Surgical Telementoring. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 1–14. Retrieved from https://doi.org/10.1145/3313831.3376622

[79] Kana Misawa and Jun Rekimoto. 2015. ChameleonMask: Embodied Physical and Social Telepresence Using Human Surrogates. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '15), Association for Computing Machinery, New York, NY, USA, 401–411. DOI:https://doi.org/10.1145/2702613.2732506

[80] Bonnie A. Nardi, Allan Kuchinsky, Steve Whittaker, Robert Leichner, and Heinrich Schwarz. 1994. Video-as-data: Technical and social aspects of a collaborative multimedia application. *Comput. Support. Coop. Work CSCW* 4, 1 (1994), 73–100. DOI:https://doi.org/10.1007/BF00823364

[81] Gary M. Olson and Judith S. Olson. 2000. Distance matters. *Hum.-Comput. Interact.* 15, 2–3 (2000), 139–178. DOI:https://doi.org/10.1207/S15327051HCI1523_4

[82] Judith S. Olson and Gary M. Olson. 2013. Working Together Apart: Collaboration over the Internet. *Synth. Lect. Hum.-Centered Inform.* 6, 5 (November 2013), 1–151. DOI:https://doi.org/10.2200/S00542ED1V01Y201310HCI020

[83] Isabella Paoletti. 2009. Communication and Diagnostic Work in Medical Emergency Calls in Italy. *Comput. Support. Coop. Work CSCW* 18, 2–3 (June 2009), 229–250. DOI:https://doi.org/10.1007/s10606-009-9091-1

[84] Thammathip Piumsomboon, Gun A. Lee, Jonathon D. Hart, Barrett Ens, Robert W. Lindeman, Bruce H. Thomas, and Mark Billinghurst. 2018. Mini-Me: An Adaptive Avatar for Mixed Reality Remote Collaboration. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), Association for Computing Machinery, New York, NY, USA, 1–13. DOI:https://doi.org/10.1145/3173574.3173620

[85] Irene Rae and Carman Neustaedter. 2017. Robotic Telepresence at Scale. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17), Association for Computing Machinery, New York, NY, USA, 313–324. DOI:https://doi.org/10.1145/3025453.3025855

[86] Poster Winifred Rebecca. 2007. Saying 'Good Morning' in the Night: The Reversal of Work Time in Global ICT Service Work. In *Workplace Temporalities*, Beth A. Rubin (ed.). Emerald Group Publishing Limited, 55–112. DOI:https://doi.org/10.1016/S0277-2833(07)17003-5

[87] Mike Robinson. 1991. Double-level languages and co-operative working. *AI Soc.* 5, 1 (January 1991), 34–60. DOI:https://doi.org/10.1007/BF01891356

[88] Karen Ruhleder and Brigitte Jordan. 1999. Meaning-Making Across Remote Sites: How Delays in Transmission Affect Interaction. (1999), 12–16.

[89] Karen Ruhleder and Brigitte Jordan. 2001. Co-Constructing Non-Mutual Realities: Delay-Generated Trouble in Distributed Interaction. *Comput. Support. Coop. Work CSCW* 10, 1 (March 2001), 113–138. DOI:https://doi.org/10.1023/A:1011243905593

[90] Banu Saatçi, Kaya Akyüz, Sean Rintel, and Clemens Nylandsted Klokmose. 2020. (Re)Configuring Hybrid Meetings: Moving from User-Centered Design to Meeting-Centered Design. *Comput. Support. Coop. Work CSCW* 29, 6 (December 2020), 769–794. DOI:https://doi.org/10.1007/s10606-020-09385-x

[91] Kjeld Schmidt. 1999. Of maps and scripts: The status of formal constructs in cooperative work [1999].*Inf. Amp Softw. Technol.* (January 1999). Retrieved September 11, 2022 from https://www.academia.edu/1760985/Of_maps_and_scripts_The_status_of_formal_constructs_in_cooperative_work_1999_

[92] Kjeld Schmidt. 2002. The Problem with 'Awareness': Introductory Remarks on 'Awareness in CSCW'. *Comput. Support. Coop. Work CSCW* 11, 3 (September 2002), 285–298. DOI:https://doi.org/10.1023/A:1021272909573

[93] Kjeld Schmidt, Liam Bannon, Mike Robinson, and Lucy Suchman. 1992. Taking CSCW Seriously Supporting Articulation Work. *Comput. Support. Coop. Work CSCW* 1, (1992), 7–40.

[94] Kjeld Schmidt and Ina Wagner. 2002. Coordinative artifacts in architectural practice. In *In*.

[95] S. A. R. Scrivener, S. M. Clark, and N. Keen. 1993. The LookingGlass distributed shared workspace. *Comput. Support. Coop. Work CSCW* 2, 3 (September 1993), 137–157. DOI:https://doi.org/10.1007/BF00749012

[96] Anne-Marie Søderberg, S. Krishna, and Pernille Bjørn. 2013. Global Software Development: Commitment, Trust and Cultural Sensitivity in Strategic Partnerships. *J. Int. Manag.* 19, 4 (December 2013), 347–361. DOI:https://doi.org/10.1016/j.intman.2013.04.004

[97] Anselm Strauss. 1988. The Articulation of Project Work: An Organizational Process. *Sociol. Q.* 29, 2 (1988), 163–178. DOI:https://doi.org/10.1111/j.1533-8525.1988.tb01249.x

[98] Lucy Suchman. 1995. Making work visible. *Commun. ACM* 38, 9 (September 1995), 56–64. DOI:https://doi.org/10.1145/223248.223263

[99] Lucy A. Suchman. 1983. Office procedure as practical action: models of work and system design. *ACM Trans. Inf. Syst.* 1, 4 (October 1983), 320–328. DOI:https://doi.org/10.1145/357442.357445

[100] John C. Tang and Ellen Isaacs. 1992. Why do users like video?: Studies of multimedia-supported collaboration. *Comput. Support. Coop. Work CSCW* 1, 3 (September 1992), 163–196. DOI:https://doi.org/10.1007/BF00752437

[101] Dylan Tutt, Jon Hindmarsh, Muneeb Shaukat, and Mike Fraser. 2007. The distributed work of local action: Interaction amongst virtually collocated research teams. In *ECSCW 2007*, Liam J. Bannon, Ina Wagner, Carl Gutwin, Richard H. R. Harper and Kjeld Schmidt (eds.). Springer London, London, 199–218. DOI:https://doi.org/10.1007/978-1-84800-031-5_11

[102] Gina Venolia, John Tang, Ruy Cervantes, Sara Bly, George Robertson, Bongshin Lee, and Kori Inkpen. 2010. Embodied Social Proxy: Mediating Interpersonal Connection in Hub-and-Satellite Teams. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '10), Association for Computing Machinery, New York, NY, USA, 1049–1058. DOI:https://doi.org/10.1145/1753326.1753482

[103] Mary Watson-Manheim, Katherine Chudoba, and Kevin Crowston. 2002. Discontinuities and Continuities: A New Way to Understand Virtual Work. *IT People* 15, (September 2002), 191–209. DOI:https://doi.org/10.1108/09593840210444746

[104] Naomi Yamashita, Hideaki Kuzuoka, Keiji Hirata, Shigemi Aoyagi, and Yoshinari Shirai. 2011. Supporting Fluid Tabletop Collaboration across Distances. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11), Association for Computing Machinery, New York, NY, USA, 2827–2836. DOI:https://doi.org/10.1145/1978942.1979362

[105] Longqi Yang, David Holtz, Sonia Jaffe, Siddharth Suri, Shilpi Sinha, Jeffrey Weston, Connor Joyce, Neha Shah, Kevin Sherman, Brent Hecht, and Jaime Teevan. 2022. The effects of remote work on collaboration among information workers. *Nat. Hum. Behav.* 6, 1 (January 2022), 43–54. DOI:https://doi.org/10.1038/s41562-021-01196-4

[106] Svetlana Yarosh and Gregory D. Abowd. 2011. Mediated parent-child contact in work-separated families. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11), Association for Computing Machinery, New York, NY, USA, 1185–1194. DOI:https://doi.org/10.1145/1978942.1979120

[107] Pernille Bjørn and Lars Rune Christensen. 2011. Relation work: Creating socio-technical connections in global engineering. ECSCW 2011 Proc. 12th Eur. Conf. Comput. Support. Coop. Work 24-28 Sept. 2011 Aarhus Den. (2011), 133–152.

[108] Melanie Duckert, Eve Hoggan, Louise Barkhuus, Pernille Bjørn, Nina Boulus-Rodje, Susanne Bødker, Naja Holten Møller, and Irina Shklovski. 2022. Work of the Future. In Adjunct Proceedings of the 2022 Nordic Human-Computer Interaction Conference (NordiCHI '22), Association for Computing Machinery, New York, NY, USA, 1–4. DOI:https://doi.org/10.1145/3547522.3547707

[109] Mehrdad Farzandipour, Ehsan Nabovati, and Reihane Sharif. 2023. The effectiveness of tele-triage during the COVID-19 pandemic: A systematic review and narrative synthesis. J. Telemed. Telecare (January 2023), 1357633X2211502. DOI:https://doi.org/10.1177/1357633X221150278

[110] Vidar Hepsøand Elena Parmiggiani. 2022. From Integrated to Remote Operations: Digital Transformation in the Energy Industry as Infrastructuring. In Digital Transformation in Norwegian Enterprises, Patrick Mikalef and Elena Parmiggiani (eds.). Springer International Publishing, Cham, 21–41. DOI:https://doi.org/10.1007/978-3-031-05276-7_3

[111] Rasmus Eskild Jensen and Pernille Bjørn. 2012. Divergence and Convergence in Global Software Development: Cultural Complexities as Social Worlds. (2012). Retrieved February 13, 2023 from https://dl.eusset.eu/handle/20.500.12015/2759

[112] Junjie H. Xu, Yu Nakano, Lingrong Kong, and Kojiro Iizuka. 2023. CS-lol: a Dataset of Viewer Comment with Scene in E-sports Live-streaming. DOI:https://doi.org/10.1145/3576840.3578334

PAPER II

Melanie Duckert and Pernille Bjørn.

2025

Location Multiplicity:
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Location Multiplicity: Lost Space in the Hybrid Office

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Navigating the complexities of shared hybrid workspaces presents significant challenges, with a risk of producing problematic spatial dynamics. Drawing on an ethnographic study, we scrutinize how office workers produce and negotiate hybrid spatial arrangements and identify *location multiplicity* as a core challenge for reintroducing physical elements into hybrid office workspaces after the COVID-19 pandemic. From a temporal perspective, hybrid work represents multiple locations, separated across several 'homes' and office spaces. Location multiplicity emphasizes the mobility of individuals, introducing instability and unpredictability into cooperative work. To navigate the temporal nature of constellation change, our findings reveal workers rely on the stability of the digital space, while consequently disconnecting from the malleable physical space. Thus, the physical space risks becoming a lost opportunity for the collocated subgroup - a 'lost space' in hybrid work. We suggest that a CSCW design challenge for hybrid work is designing hybrid infrastructures that facilitate an experience of stability and predictability across temporal and spatial dimensions, with embedded affordances for integrating both physical and digital elements across multiple locations.

CCS Concepts: • **Human-centered computing** → **Empirical studies in collaborative and social computing**; **Computer supported cooperative work**.

Additional Key Words and Phrases: Hybrid work, Workspace, Office work

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1 Introduction

The COVID-19 pandemic has significantly influenced work and careers, and its long-term impact is still unfolding [44]. Few professions remain unaffected by the pandemic, yet they face distinct challenges, depending on their reliance on physical proximity. Occupations such as health and social care, which are heavily dependent on collocation, experienced significant disruptions [62], while other types of work transitioned more easily to online formats. One type of work that successfully went remote during the pandemic was computer-based office work, which a priori is computer-supported, thus producing fewer challenges when transitioning from physical offices to remote work at people's homes compared to other occupations [21, 35, 48, 62, 86]. Despite an initial decrease in productivity caused by disruptions such as technology issues, family responsibilities, and collaboration difficulties [20], computer-based office work managed to avoid a long-term decline in productivity during the pandemic [86]. However, the period of remote work has significantly influenced people's preference for work in the post-pandemic era, with a continuing wish for remote work [1, 78]. After the pandemic lockdown, remote work was initially presented as an option by companies [57], though challenges in encouraging employees to return to the office have caused some companies to modify policies that instead mandate physical office presence [59, 84]. This is

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further complicated by the pandemic-induced 'great resignation' phenomenon with employees leaving positions that enforce in-office work for job opportunities offering remote flexibility [25, 81]. The changing perspectives on work impact employees' relationships with the workplace [45, 46]. Companies struggle with finding the balance between remote and collocated work to allow their workers to thrive and be productive without sacrificing opportunities for innovations for the future good of the organization. As a result, many organizations dedicate time and resources to finding the most effective ways to shape a future workplace.

To combine the flexibility of remote work with in-office interactions, companies are adopting hybrid work models that allow employees to work from home a few days per week [18, 31, 77]. These hybrid arrangements connect employees across collocated and distributed configurations through digital technologies that many companies relied on during the pandemic [64, 72, 85]. While hybrid work shares characteristics with distributed work, the inherent partial collocation introduces new design requirements for cooperative technology [30], making it relevant to understand how hybrid scenarios unfold in practice, across organizational, digital, and physical spaces [39]. This paper explores *the spatial challenges of producing and negotiating a shared workspace in hybrid office work arrangements.* Through an ethnographic study of an IT organization working hybridly across six office spaces in two countries, we consider the temporal nature of hybrid office work and identify a core challenge in reintroducing the physical space in post-pandemic office work.

We find that individuals engaged in hybrid work continuously change their locations due to remote work options, resulting in an inherent condition of *location multiplicity*. In hybrid configurations, we never know who will work from where the next day, and consequently, who will be collocated. This mobility of hybrid workers requires continuous reconfiguration of the spatial practices [17], making it complicated to plan for collocated subgroup interaction. In our case, the flexibility in locations led organizational office workers to develop strategies that rely on the stability embedded into the digital options to in this way reduce the effort required for leveraging collocation and physical elements. Integrating both physical and digital components required continuous re-spatialization, consequently making office workers standardize their practices independently of the physical space. The approach of always structuring the work as if all participants are geographically distributed, despite some being collocated, evens out asymmetries and creates stability in the work. However, the "always remote" strategy also risks missing important opportunities for collocation facilitated by hybrid settings. Thus, we suggest that a design challenge for CSCW technologies supporting hybrid work is to facilitate seamless interaction in situations of location multiplicity with shifting constellations of people, locations, and digital applications. We must recognize the dynamic nature of hybrid interactions as they are produced differently on a day-to-day basis. Hybrid workspaces must include an experience of stability in *both the physical and digital space*, despite the mobility of individuals involved in the work who navigate location multiplicity.

2 Theoretical Framework: Hybrid Space

Our work concerns how a *shared workspace is produced and negotiated in hybrid office work arrangements*; thus, we need to unpack the nature of a 'hybrid workspace'. Hybrid work is characterized by cooperative engagements where at least three people are mutually dependent upon each other in a common field of work while being geographically distributed across fewer sites than the number of people, meaning that some are collocated while others are distributed [30]. Physical space in hybrid work is thus the 'sum' of the different geographical locations where people are situating their bodies. Hybrid work is enabled by digital technologies extending hybrid workspaces to the digital space, further constrained by organizational conditions [39, 69]. The concept of space has been a core interest for CSCW since the early 1990s and researchers explore, discuss, and continuously interrogate what space entails still. The abundance of literature on space demonstrates from various

perspectives that space is an important concern. However, it is difficult to constrain into one 'thing', instead, it produces multiple intertwined conceptual understandings, which are all relevant when people engage in a common field of work.

The conceptual work distinguishing 'space' from 'place' put forward the idea that 'space' is an architectural opportunity where place-based activities (produced through social engagements) can happen [40]. Later discussions point to that all spaces are immediately socially constructed, and thus the distinctions between space and place might be less simple [26]. The discussions on '*space' for CSCW design* circle two main interests, namely how physical space for cooperative work shapes activities in certain ways. For example, how the physical surroundings in hospitals create different technical requirements on hospital information systems [2] and how space metaphorically can produce relevant design requirements for cooperative work [3, 23]. This design interest further sprouts into three long-standing interests. First, *(1) the design of cooperative virtual environments* (CVE) including blended spaces [6], and immersive Cooperative Work Environments (CWE) [11]. This stream of research is dedicated to exploring how virtual reality, augmented reality, and extended reality technologies can be utilized to create 'digital spaces' for cooperative engagements [6, 56, 76]. Second, *(2) the design of media spaces (sometimes referred to as virtual spaces)* which fundamentally entails research on technology-mediated synchronous interaction across cooperative actors working together focusing on awareness and communication [19, 29]. Third and finally *(3) the design of common information spaces*, which fundamentally is about knowledge production and interpretation of information used within cooperative coordinative tasks [4, 5]. While all the above streams of research have focused on the cooperative activities shaping the collaboration, they simultaneously consider how the digital or physical environments matter conditioning how cooperative activities unfold. Our interest focuses on establishing a shared space for collaboration in hybrid work as it is produced in our empirical study of hybrid office work, and since our case does not entail any kind of virtual reality or extended reality features, we situate our theoretical CSCW concerns for *hybrid space as media spaces* and *hybrid space as common information spaces*.

Hybrid space as media space guides us to dedicate our empirical concerns to exploring how hybrid space allows for engagements and enactments in communication and awareness activities across geographically distributed participants. The seminally work on media space arrived from the research conducted at Xerox PARC in the 1980s and 90s. Already back then, researchers had access to digital systems which allowed them to have digitally mediated interaction with video across locations as well as within the actual office [28, 36]. This meant that the research early on had access to long-term use of these types of technologies, which today are commonplace. One of the interesting findings back then was that the technology did not only impact the people using it but also extended beyond the individual using the technology and impacted the wider social grouping of use [27, 68]. Physical surroundings matter for where work can take place, and while spatial properties can be mimicked in the design of digital systems, they can also transcend and extend the affordances of the physical space thus extending the environments in new ways [19, 55]. Geyer et al. develop a matrix between work-related, meeting-related, and people-related interaction patterns and then combine this with individual mode, meeting mode, and social mode [37]. In their design, they consider articulation work, awareness, and communications in all the boxes in the matrix – demonstrating the focus on the virtual space is to design for reducing the effort of articulation work connected with communication and awareness. Further Healey et al. show how textual interaction and communication online produce communication beyond just 'being there' because the textual interaction allows participants to engage in multiple, overlapping, concurrent conversations across partially overlapping groups [41, p. 189].

Most research on media spaces and communication includes audio-visual feedback and here research has demonstrated how it takes more time and effort to build social relations in remote

situations [7]. In the early studies it was even argued that if people did not already know each other prior to online engagements, their collaboration rarely led to new forms of social interaction [54]. Moreover, design challenges such as the lack of peripheral awareness caused by the limitations of the camera feed were detected, and design agendas for multi-camera setup were explored [42]. Exploring the use of audio-visual interaction in the design of cooperative technologies developed into multiple different types of digital systems including but not limited to ClearBoard [49], t-Room [43], and Perspectives [83]. Multiple audio-visual technologies have been taken up by organizations, including full-immersive meeting setups like Polycom, as well as desktop/laptop/mobile device applications that are particularly widespread in global software development setups [14, 50, 66], and even more widespread during the pandemic such as Zoom, MS Teams, and Skype [20]. Whether organizations choose to create dedicated offices for technology-mediated interaction [8, 22] or the interaction is done using only laptops, phones, and screen sharing [9, 33] the challenges of creating social relations mediated solo by technology – engaging in relation work [7] – continue to be reported as a challenge. Information sharing and communication are important for cooperation [58].

Hybrid space as common information space research is dedicated to understanding and designing for knowledge production and coordination across cooperative practices. Well-designed common information spaces (CIS) allow participants to share information in such a way that interpretation allows for meaningful interaction [3]. A CIS does not just exist but requires participants to socially engage using the space (digital or physical) in meaningful ways. Common information spaces require that both the producer of information and the receiver consciously try to understand each other's context [3] and thus through engagement create a common context, which supports their interaction concerning information. Common information spaces are dialectic in nature, meaning that they are both malleable allowing participants to adapt technological structures and content to their purpose; while being intact, stable, and immutable allowing participants to negotiate and make sense of their common information space over time. In this way, common information spaces can appear as boundary objects in some situations allowing for interaction and interpretation across different contexts [80], while being flexible and configurable at other times. Common information spaces do not need to be online, in many cases the physical environment and available artifacts are part of what makes the common information space. For example in the War Room meetings, where engineers are collaborating between Copenhagen and Chennai, the physical paper posters and post-it notes placed in duplicate in the two geographically dispersed offices together created a common information space [8]. Similarly, Mark et al. demonstrate the physical space impact on the interpretation of cooperative practices, by arguing the 'space between' hybrid teams to increase the risk of errors in common products [65]. While literature on common information spaces often concerns organizational practice, new research studies have explored common information spaces outside work, but still related to concerns about work [67]. Møller et al. found an online platform that supported healthcare workers to discuss the implementation challenges of a healthcare platform, and in this way emerged as a worker-driven CIS [67]. Finally, research on co-working spaces demonstrates how the physical space can be important for workers, even if they do not collaborate. Self-employed workers would choose to go to co-working spaces to do work, supporting social interactions, even if the physical environment also produces certain constraints and tensions [82].

3 Method

To investigate the challenges of producing shared hybrid workspaces, we conducted an ethnographic workplace study at an IT company in the Spring of 2023 [13, 71]. Representatives from the company had engaged in workshops and discussions over 12 months before we initiated the ethnographic fieldwork. Along with 12 other organizations they shared their perspectives, experiences, and

challenges in their ongoing efforts to establish a modern hybrid workplace in the post-COVID-19 era. These workshops were part of a larger research project exploring the challenges of hybrid work (reference excluded for anonymity). During the events, the organizational representatives described a desire to embrace a hybrid work model but faced difficulties in organizational and spatial conditions, such as empty office spaces with employees working in silos at their desks. To explore the challenges of producing hybrid workspaces in greater detail, we chose one of the companies for ethnographic data collection, which is the focus of this paper. The chosen company, which we in this paper pseudo-name InterFin to protect their anonymity, had been remodeling their offices post-pandemic to welcome back their employees after almost 2 years of remote work. However, they were surprised with how the employees reacted and management was concerned with the low percentage of physical presence in the office by employees. InterFin was therefore an interesting case for empirical data collection to explore how the challenges of producing and negotiating hybrid workspaces unfold in real-world settings.

InterFin is organized as computer-based office work, allowing us to gain access to an empirical case where work transformed digitally to enable remote work during the pandemic, and thus is an excellent case to explore the conditions for new hybrid work arrangements. Hybrid work involves multiple physical locations in combination with digitally mediated collaboration [8, 32] and groups of physical and digital artifacts [53, 63]. When we studied the role of the physical space, it was clear that all hybrid activities were always digitally shaped, and thus we cannot understand the physical space without including the digital space. Thus, rather than only observing the physical office space, our ethnographic strategy was to follow organizational members and study the kind of activities they produced when engaging in hybrid work. Observing their work practices allowed us to comprehend the importance of technologies for collaboration, how these technologies were utilized, and to explore physical surroundings, architectural design, and movement within the office space – factors that all shape the hybrid workspace. Our goal was to capture organizational members' interaction and negotiation of a shared workspace when engaging in hybrid work through informal conversations, observations, and document analysis [13, 73], employing sociomaterial-design approaches [10]. Our sociomaterial reflections were therefore not limited to *what* to observe but also *how* we observed it [75], including the contextual circumstances of connections between artifacts, between artifacts and locations, and between artifacts and mobility [12]. The analytical work began within the field, prompting us to continually seek relations and connections between practices, artifacts, spaces, and organizational members' movements.

Ethnographic explorations of hybrid situations provide distinct methodological challenges due to work being spread across several physical and digital spaces, involving both analog and digital artifacts [52, 71, 73]. We were not able to observe employees at their home office, however, collecting ethnographic data at the office (i.e. excluding remote home offices) was aligned with our focus on the role of the organizational office space that hosts collocated subgroups in the hybrid setups. We talked with employees about their home offices, they explained how their work practices differentiated when working from their home, and we included our limited 'access' to observe the home offices during observations of synchronous technology-mediated activities (as could be seen in the video feed). While we fully acknowledge that hybrid work includes various challenges, such as geographical locations [16], personal preferences [34], and remote workspaces at home [23], our study is situated in the role of the 'hybrid workspace', with a particular interest in the partially collocated subgroup. Understanding the role of the physical office space in hybrid work is critically important, as the design and use of office environments have demonstrated significant value for companies [1, 59, 79, 84], and the collocated environment remains crucial for hybrid office work in general [30].

3.1 Empirical Case: InterFin

InterFin is an IT company with 1700 employees designing, implementing, and maintaining IT infrastructure for the financial industry. The company was established as a Danish company but expanded to Poland in 2018. Currently, InterFin has employees in two countries spanning multiple office buildings – five offices in Denmark (three different cities), and two offices in Poland (two different cities). Before the pandemic, less than 10 % of the employees were in Poland, however during the pandemic the office in Poland grew to approximately 50 %. Under the COVID-19 lockdown, all employees worked from home. The pandemic restriction in Denmark took place between March 2020 and January 2022; while in Poland the restriction took place between March 2020 to March 2022.

Post-pandemic company policy combined with the increased recruitment in Poland meant that all teams included employees from both Denmark and Poland. Thus, teams are never fully collocated even when all team members are working from the company office since they are located in different buildings. InterFin remodeled the physical office space and hired an architecture company to help re-think the office layout as well as the office colors, etc. The first part of the renovations finished in 2023 in both Denmark and Poland and are currently continuing. The renovation of the office allowed us to also observe discussions between employees and the architects about their experiences of the new office spaces during our ethnographic study.

Our ethnographic study took place in one department, following two teams working on respectively delivering (Team-1) and planning (Team-2) both for the development and implementation of agile work processes in the organization. The work is hands-on implementation in close collaboration with other departments in the company, covering activities such as coaching team managers, teaching tools and work processes, and other tasks to support agile work processes. Members of both Team-1 and Team-2 are therefore daily in touch internally within the teams, as well as with multiple departments across the company placed in both Denmark and Poland. Both teams had ten team members distributed across four office locations – one in Poland and three in Denmark.

While our study focused on two specific teams, it provides insights into the reasoning behind hybrid practices that are applicable in other office contexts. The research emphasized a temporal understanding of how office workers navigate and produce hybrid workspaces, allowing us to uncover nuanced understandings of organizational practices. Despite the limited number of teams, their diverse interactions across multiple departments and locations provide insights into the important challenges of continuous reconfigurations in hybrid workspaces.

3.2 Data Collection

The data collection focused on how the two teams established a shared workspace when arranged in hybrid arrangements. This included data on cooperative activities, the technologies used, and the organization of work. An important distinction between distributed and hybrid work is that hybrid work includes partially collocated participants, therefore, our observations focused on the shared organizational office spaces and the collocated practices in the hybrid arrangements.

Initially, the authors interviewed the head of facility management, who showed us around the office and explained the architectural changes implemented. This tour outlined actions taken to create an attractive workplace for employees, making the commute to work more relevant. Additionally, we interviewed the department manager, who provided access for empirical observation, and one employee from the relevant department to understand their interest and perceived challenges with hybrid work. These interviews covered department organization, regulations for working, and challenges in adapting hybrid work.

Table 1. Data Sources

Source	Frequency	Comments
Observation	55	hours
Informal interviews	8	people
Preliminary meetings with management	2	hours
Participation in meetings (passive observation by being present in physical/online meeting room)	22 (2/20)	meetings
People observed (physical office)	35-40	people
Internal documents	3	documents

Following these managerial and organizational perspectives, we initiated the ethnographic fieldwork. The data collection included observation, in-situ questions, informal interviews, and document analysis [51]. The fieldwork was conducted by the first author, with continuous discussion of impressions, insights, and methodological adjustments among all authors to ensure alignment between the method and findings given the constraints.

The observation took place at the office in Denmark where the selected department teams, Team-1 and Team-2, were located. We focused on how the team members navigated the office building and managed the hybrid setups. Due to GDPR (as the company handles personal and financial data) and geographical limitations, we only had access to one building. However, we were informed by the head of facility management that all office buildings in both Denmark and Poland mirrored the one we observed. The observation covered both synchronous and asynchronous activities related to cooperative work internally within the team, across departments, and with external stakeholders. Most synchronous work was planned as meetings, so to observe these activities, we participated in different types of interactions among various groups of participants. We ensured our observations included hybrid work within the two teams, across the two teams, and between teams and participants from external departments and stakeholders.

We applied different observation strategies [73] to gain insight into hybrid work activities from different perspectives, such as being at the office, in a meeting room, or remotely. When meetings were held online, we observed the interaction by participating digitally through a company laptop and a guest login while being physically located in the office space. To observe all local office events, the first author joined the local team members and quickly noted that nearly all activities were conducted online. Collaborative activities in both Team-1 and Team-2 were structured as calendar invites with MS Teams links to online meetings. Observing the details of the complex interaction of online activities was challenging due to the simultaneous occurrence of several activities and the noise in the office space. Therefore, we complemented in-office observations with remote observations of online activities and reviewed archived data of these activities, such as text messaging and backchannel communication during meetings.

To study asynchronous work, we identified workers who allowed observation of their daily activities. The first author sat next to these employees on different days to observe all activities throughout the day, with opportunities to ask elaborative questions either at the moment, during breaks, or in follow-up interviews later. These questions clarified the nature of different activities and the reasoning behind specific practices. This approach provided insights into the different work tasks, sub-groups the person engaged in, and which technologies were used for different activities. When allowed, we documented the work with pictures and screenshots. Otherwise, all observations were written down in detail in a notebook. Afterward, all observations were written up into rich

descriptions ready for analysis. Due to GDPR, we were not allowed to record the employees' voices, so we made sure to write memos and thoroughly document all observations in written format.

The observation started in March 2023. Each observation activity was structured between 4 and 7 hours for one day observation allowing for time to write up notes afterwards. In total, the first author spent 55 hours observing the two teams. Observations were conducted on different weekdays allowing us to notice specific temporal patterns. Further, we knew from preliminary meetings that some employees work from home on different days of the week. Despite focusing on one specific department, the open office space allowed peripheral observations of employees from other departments as well. The total period of empirical data collected at InterFin spanned five months, from the first interview in December 2022 to the last observation day in Ultimo April 2023.

3.3 Data Analysis

All data, including internal documents and policies, pictures, screenshots, and observation notes, were imported into Nvivo. We carefully reviewed the data to analyze how workers navigate and negotiate the physical office space as part of their hybrid engagements. The iterative analysis was conducted concurrently with the data collection, as the empirical work revealed insights that refined the focus on the ethnography. Early in the observation process, we noticed that workers strategically minimized their use of the physical space by either avoiding the office, choosing not to use meeting rooms, and in other ways *not utilizing* the collocated space while collaborating with others in hybrid settings. While our initial study broadly aimed to explore how hybrid work unfolds in a real-world office case, our analysis specifically focused on understanding why collocated organizational members do not fully incorporate the available space when collaborating in hybrid settings.

During the observations at the office, we found that all asynchronous work was conducted digitally at the individual's desk using laptops. Surprisingly, almost all synchronous collaborative work was scheduled and performed as online meetings, also facilitated by personal laptops at desks, regardless of whether collaborators were geographically located at the same site. The employees did not utilize the physical space despite these being newly renovated for supporting various work events. Therefore, we decided to delve into the digital workspace in greater detail to explore the broader challenges of producing *shared hybrid workspaces* utilizing both the physical and digital space. We strategically mapped out the work activities performed in the digital space to conduct an inductive thematic analysis [15].

Firstly, we identified the online tools and communication channels supporting the work (e.g., Microsoft Office, Jira), and then analyzed which tools were used for different types of activities. Subsequently, we linked these tools to collaborative activities among different employees, mapping out cooperative groups and subgroups along with their geographical locations to explore how the employees' location affected their work practices. This analysis allowed us to understand how team members created a digital space to support their work, comparing it to their actions in the physical space.

Using NVivo, we identified various events and collaborative activities (e.g., social events, planning, evaluation) and correlated them with insights from the interviews (e.g., noise from colleagues, uncomfortable headphones) and observations of how the office space was utilized (e.g., location changes, artefact use). By mapping out the entire ecosystem of artifacts and applications, as well as the work activities and cooperative groups in which organizational workers engage, we uncovered that all cooperative work activities are facilitated by digital technologies that support hybrid work among organizational members, while also being constrained by shared physical elements within the office space. In this analysis, we point to three main categories essential for understanding why workers choose to disconnect from the physical environment and work digitally regardless of

their geographical location and cooperative engagements: 1) the *organizational policies* regulating workers' condition for teamwork, 2) the affordance of *artifacts in the physical environment*, and 3) the affordance of the *artifacts in the digital environment*. In our results, we delve into these three categories to understand the consequential choice of not fully utilizing the physical space but, instead, creating a stable digital workspace and engaging in *collocated digital work*.

4 Results

As hybrid workspaces are shaped by physical, digital, and organizational conditions, we divide our result section into these three perspectives. First, we elaborate on InterFin's organizational approach to adopting a hybrid work model with a focus on their organizational policies and architectural spaces. Hereafter, we present findings on the contradictions between the nature of the work and the organizational interventions for adopting hybrid work. Thirdly, we elaborate on the digital space enabling distributed collaboration, yet, adding complexities for integrating physical components when engaging in hybrid arrangements.

4.1 Re-Organizing from Remote Office to Hybrid Office

Since the COVID-19 pandemic, InterFin reformulated their organizational policies and implemented architectural renovations to enforce conditions for hybrid office work. Our findings indicate the management's impact on workers' engagement in hybrid work, therefore we initiate the results with the organizational practices that were shaped and re-shaped post and during the ethnographic work.

4.1.1 Organizational Policies. During the COVID-19 pandemic, InterFin adhered to governmental policies demanding remote work, transitioning all activities online. As regulations eased, the top management faced the decision of how to reintroduce physical office presence. In the summer of 2021, just before the regulations were lifted, the company updated its policies to reflect a desire for a modern, collaborating, and flexible workplace. The policies allowed remote work one or two days per week, to meet the wishes for work-life flexibility from the employees yet emphasized performance expectations equivalent to office work. A year later, in the summer of 2022, the policies were revised due to low on-site attendance of around 35 %, while the ambition of allowing remote work was to have 70 % of employees regularly working on-site. Management expressed concerns about a lack of sense of belonging, decreased engagement, and increased feelings of loneliness among employees working remotely. During the observation, we noticed fluctuations in-office presence. While the average number of on-site workers aligned with InterFin's estimate, day-to-day variations were substantial. One day only one person worked on-site, while the next day, more people were present than available desks.

The company policy links the office presence to challenges such as increased employee turnover and a sense of loneliness. Management's shift from encouraging employees back to the office to *mandating* physical presence is noteworthy. Despite acknowledging sustained effectiveness and productivity, they expressed concerns about stagnation in innovation and employees perceive the company as less attractive. This was expressed during our interviews with the department manager, who explained that remote work had not decreased the department's productivity, instead they experienced an impact on innovations and new ideas that otherwise would come from physical collocation. The department manager described a vision for "a vibrant office", which seemed elusive with empty spaces. Further, he presented the contradicting challenges, that employees left the company due to not feeling a sense of belonging, while they still demanded the option of working remotely from home. Differently, the strategy of pushing employees back with regulations was perceived as controlling from some employee's perspectives.

Fig. 1. Image of workstation layout at the company office site

> "I've been in the company for 7 years, and my relationships date back to before the pandemic. Most of the team members I work with today I've never met – and I never will. It doesn't make sense to demand rules on physical attendance at the office [...] often, I feel more lonely when I'm at the office than when I work from home." (Informant from Team-2).

The quote illustrates how employees felt that managers deciding their location on specific days created a less welcoming atmosphere, resembling micromanagement that hindered engagement rather than fostering it. An organizational member additionally expressed feeling lonely at the office but not when remotely, questioning the need for commuting to the office.

4.1.2 Organizational Office Space. During our interviews, the facility manager explained that InterFin had invested significantly in renovating the office building following the COVID-19 pandemic. Their goal was to establish an appealing office space that encouraged physical presence in a hybrid environment. The renovation aimed to create a vibrant workplace supporting flexibility, diverse work arrangements, remote participation, and an inspiring atmosphere. However, the organization's perspective on architectural measures promoting a modern hybrid office was not aligned with the employees' utilization.

The redesigned physical space featured an open office space with only a few closed rooms. Workstations were arranged in groups of four desks, each equipped with two monitors. Various sub-areas were designated for different types of work activities, including lounge areas for informal discussions, rooms with two individual monitors for focused work, meeting rooms of varying sizes (2 to 8 people), and silent boxes for private phone calls. All meeting rooms were equipped with a table and chair(s), and the larger rooms included a shared screen. Reservations of the rooms operate on a first-come, first-served basis. See Figure 1 for the workstation layout at the office site.

InterFin adhered to a free seating policy, requiring employees to clear their desks when leaving the office. Most employees complied with this rule, ensuring tables were clean and available for everyone. Lockers were placed around the office for employees to store items such as laptops, computer accessories (mouse, keyboard), and small belongings (e.g., headphones, pens, paper, wires). Employees would retrieve their belongings from the locker in the morning and select an available seat. At the end of the day, they either left their belongings in the locker or took them home.

The architectural design and free seating policy aimed to facilitate flexible work, allowing employees to move freely within the office space and choose suitable areas for specific tasks. However, there was a misalignment between the management's vision, organizational and technological conditions, and the actual cooperative setups. Despite the intention for an open and dynamic office environment, we observed instances where the actual use of the office posed challenges to work rather than supporting it.

4.2 Collocated Digital Work

When exploring hybrid office workers' navigation of the office space, we were surprised about the tendency to disconnect from the physical environment in their cooperative work rather than taking advantage of the collocation. During the observation, we participated in 22 synchronous events: 2 in collocated settings, 20 in hybrid settings (involving both collocated and remote participants), and 2 in fully distributed settings. Despite the presence of collocated participants in nearly all synchronous work, *the activities were approached as if they were in a fully distributed setup.* The majority of work, synchronous and asynchronous, took place individually at desktops using laptops, and we observed no instances of individuals utilizing any physical artefacts in the office space (e.g., whiteboards, etc.), instead, all physical whiteboards were empty and clean. See Figure 2. Informants from both Team-1 and Team-2 described that they had never used any of the whiteboards, and rarely saw other employees using them. Focusing on synchronous work activities, the choice to disconnect from the office space becomes particularly pertinent. Synchronous activities were consistently performed in the same manner as distributed activities regardless of the geographical distribution of the participants or the content of the activity.

The two teams engage in different configurations in their work. While each team followed the agile work approach with daily check-in meetings, they also collaborated in subgroups within the team, and across the teams and departments. A typical day for team members may involve a series of back-to-back meetings lasting from 15 to 60 minutes, with only brief intervals between sessions. On other days, the team is immersed in a single digital meeting for the entire day, such as during extended teaching activities.

To illustrate our findings, we present three empirical scenarios: 1) a hybrid meeting performed as a distributed meeting, 2) a hybrid meeting indicating the added challenges of the hybrid work mode, and 3) a collocated meeting showing the reliance on digital tools even in collocated settings.

4.2.1 Collocated Digital Work Event. The first empirical example is with participation of both teams to present updates and receive feedback from external clients. The meeting took place online using the MS Teams application to accommodate remote participation. There were 12 participants: six located at the office, whereas three of the team members were only a few meters apart, one was ten meters away, and the remaining two were placed down the hallway. To indicate the proximity of the team members, the researcher observing the situation experienced an echo effect from the collocated participants' voices in both the physical office and MS Teams call, despite using noise-cancelling headphones. The remaining participants were distributed across various locations, all joining individually from their laptops with cameras on. When the participants at the office joined the meeting, they put on their headphones (if not already wearing them), turned on their cameras, and connected through MS Teams. All participants at the office stayed at their desks.

The proximity required the participants to mute their microphones when not speaking and use noise-cancelling headphones to manage ambient sound. During the meeting, other employees in the department (not joining the meeting) were in the office space next to people speaking on other calls. Noise-cancelling headphones were used by all employees independent of being involved in meetings or not.

Fig. 2. Images from the field site showcasing various office areas, including meeting areas in the open office setting, whiteboards, and lounge areas.

The meeting followed a remote format, with the facilitator sharing slides to outline the agenda, and participants taking turns presenting their input. This approach characterized almost all work activities in our observation, where out of the 20 hybridly distributed meetings, 19 followed the described scenario. This includes the regular meetings internally in the departments, and therefore not including external clients. Figure 3 illustrates the geographical distribution of one of the internal events, that regularly took place between the organizational members.

The visualization illustrates the proximity of the collaborative participants and is an example of a "collocated digital" event. While our observation focused on the specific department, peripheral observations on the other floors and departments revealed similar scenarios. The majority of workers at the office consistently stayed at their desks throughout the day for various cooperative work activities, acting more like remote workers than utilizing physical office space and artifacts.

4.2.2 Hybrid Work Event. The sole event observed during the fieldwork where participants utilized the physical space to create a hybrid setup with both collocated and remote members, involved an internal team meeting in Team-1 to plan their upcoming activities. This meeting included eight participants, with five team members present at the office and three joining remotely. Before the meeting commenced, the five collocated participants moved to an available meeting room. Since rooms cannot be booked in advance, they roamed the office to find a suitable space. After settling down, the team manager connected the laptop to the shared screen in the meeting room. However, technical issues with connecting the laptop to the shared monitor and audio caused a delay. After

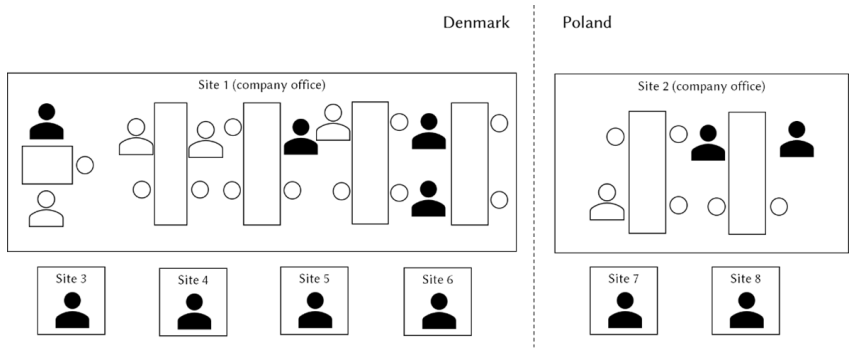

Fig. 3. Visualization of a hybrid setup of a synchronously collaborating team distributed across eight sites in two countries. Stick figures represent employees physically present at the office, whereas the colored figures indicate participants involved in the shared digital meeting.

resolving the issues with cables and wiring, they set up the screens to display the MS Teams meeting. In the MS Teams call, the three remote participants and a shared Jira board are visible. Jira is a project managing tool, where all tasks can be illustrated, assigned to team members, simultaneously updated, and interlinked to different visual boards and canvases. All team members have access to the Jira board on their laptops, which some team members during the meeting had open, while others had calendars and notes on their laptops. During the meeting, challenges emerged including collocated team members discussing in their native language, making it challenging for remote participants to follow. Moreover, sound issues and a lack of visual representation for the remote participants occurred when collocated team members pointed to their local screens. This scenario highlights some of the challenges that arise when participants leverage the physical environment and the additional effort required to establish a shared cooperative setup when the same attendees are remote. Later in the same day, the team had another meeting but chose to remain at their desks, participating 'remotely,' even though the same team members were still collocated in the office. This means that five participants engaged in the same MS Teams meeting, seated at a shared office and therefore only a few meters apart, necessitating the use of noise-cancelling headphones, and simulating geographical distribution.

4.2.3 Collocated Work Event . We observed a collocated work event involving two workers, John from Team-1 and Patrick from Team-2. To present their interaction and reasoning, we have assigned pseudonames to these individuals making it easier to understand. They intentionally scheduled the meeting on a day when both were physically present at the office. The purpose was to update a task in the Jira board. Both members brought their laptops, along with notebooks and pens, to the meeting room. John connected his laptop to the shared monitor, displaying the Jira board, while Patrick closed his laptop and referred to the shared monitor. John suggested using the physical whiteboard instead of the screen monitor to "disconnect from the laptop" now that they were both collocated. However, after a quick search for a pen, they returned to the laptop. They opened the Jira board, discussed the task, and considered what to write on the digital Board.

Interestingly, they explained afterward that moving to a meeting room in the office further complicated their work instead of making the work easier. John mentioned they planned the meeting on this day because they were both at the office; he even postponed it from the original plan when he chose not to commute to the office that day. As the work was produced in the online application Jira, they argued it might have been easier to use individual laptops, allowing both to

edit simultaneously. Although they initially considered using the whiteboard to discuss the task, the physical board would have necessitated duplicating their work to implement it into the digital Jira board afterward. Moving to a meeting room meant that they had to disconnect from their laptops at the desk, and only one person could control the actions executed in the IT application. While not a hybrid setup, this scenario illustrates how synchronous cooperative work in our empirical case is further complicated when articulated in collocated settings – even when all participants are at the same site.

The empirical scenarios indicate the complexity of producing a shared workspace in hybrid settings, as opting for digital options allows for equal participation across hybrid setups. Moreover, the observed attempts to utilize the physical space show how it does not efficiently support the work, instead, it adds challenges. While the office's architectural design aims to encourage flexible work activities, practical work scenarios do not always align with office availability. The physical space not only invites flexible conditions but also *requires flexibility from the workers*. Whenever organizational workers utilize the office space, they must disconnect from their desk setups to find appropriate spaces in the office, available at that moment. The added work makes the employees stay at their desks, though, the open office layout contributed to sound issues, particularly when the workspace was crowded. Employees commonly cited sound problems as a significant challenge when working from the office, which was also seen in the extensive use of noise-cancelling headphones. The value of commuting to the office diminished on days of sparse attendance or excessive crowding, which impacted the overall experience for employees, as commuting to the office could risk being perceived as a waste of time.

4.3 Navigating the Technology Complexities in Hybrid Work

Examining the role of the office space revealed hybrid collaboration to always be digitally mediated even when participants were fully collocated. To support the varying nature of the work activities, the digital space represents a complex interconnected infrastructure of applications supporting various work activities. InterFin primarily relies on eight IT applications, accessible via laptop with data securely stored in the cloud. Key software tools include Microsoft Office (Teams, Outlook, PowerPoint, Word, Excel), internal and external team sites, as well as Jira and Confluence. These IT applications are employed in diverse constellations, for various activities, and over different durations.

As agile mentors, the teams focused on educating others in agile work methods. They utilized various applications and tools for distinct purposes, such as Excel for data management, Word for text production, PowerPoint for education, Confluence for brainstorming, and Jira for process management. Internal and external sources, like the Intranet, were used to gather organizational information, while MS Teams were particularly crucial for supporting communication, information sharing, and knowledge exchange within and across work groups. MS features such as chat, sub-groups, and organized sub-folders, for tasks, and documents were essential in this process.

The software tools were used in different configurations depending on the context. Their interconnected nature allowed, for example, the daily meetings in MS Teams involved sharing a Kanban board in Jira to display task overviews, and PowerPoint was shared for presentations or sometimes in edit mode for collaborative content discussions.

The overlapping features of communication and coordination in, for example, MS Teams and Jira raised challenges in inconsistency and disagreements on where this work should take place. We for example observed situations where coordination and communication on a task was articulated both in the Jira application's comment feature and in the MS Teams sub-group, leading to miscommunication and misunderstands.

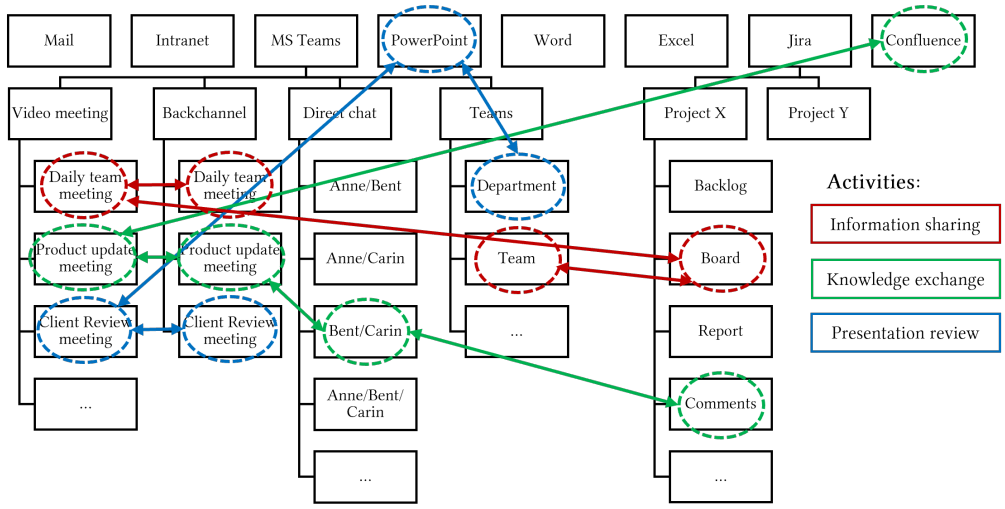

Fig. 4. Illustration of digital applications used by the individual worker. The red lines indicate applications used for information sharing, such as the morning updates held by both teams. The green lines represent applications that support knowledge exchange, such as collaboration on updating a digital board used to educate in agile work methods. The blue lines exemplify a meeting with external clients where new products were reviewed.

A detailed exploration of the connectedness between applications reveals complex interactions across sub-groups and platforms. Office workers continuously create new sub-groups, and each MS Teams meeting is automatically accompanied by a backchannel in the Chat section. This backchannel supported synchronous communication during meetings and asynchronous interaction both before and after them. For example, Team-1 occasionally posted updates within this backchannel chat, even though they had a designated group page in the MS Teams. The automatic creation of chat groups resulted in numerous channels within the MS Teams, sometimes overlapping sub-groups, as individual workers participated in multiple meetings across various departments and teams. To illustrate the interconnected nature of the digital workspace, Figure 4 shows the software applications and examples of how they are connected in different configurations depending on specific activities.

When asked about the complexity of the digital space, the team members explained that using the multi-connected applications was less complex, as they got familiar with the systems during the pandemic that required abrupt transition and intense adoption. One of the team members from Team-2 described:

> "We were used to going out [before the pandemic lockdown] to educate [the organizational teams in agile work methods], but during COVID, we had to transform it to online. We were actually pretty good at this transition. Today, we're no longer dependent on the physical; we can accomplish [the work] completely online, which we also have to do since we're distributed. I had to adapt to not using the whiteboards. I do miss that, but it's just easier to do it digitally." (Informant from Team-2)

The digital space was facilitated by different devices, such as laptops and several monitors. A member from Team-2 described the simultaneous use of various software applications to require a

Table 2. Example of an office worker's sequential order of various planned cooperative activities performed in different digital configurations throughout one day.

Length	Activity	Participants	Technology	Distribution
15 min	Information sharing	9 team members	MS Teams, Jira, Notes	Cross-country
30 min	Knowledge exchange	2 team members	MS Teams, Confluence	Local office
60 min	Presentation and feedback	12 internal and external members	MS Teams, PowerPoint	Cross-country
15 min	Coaching	2 cross-departmental members	MS Teams	Cross-office sites
30 min	Knowledge exchange	4 team members	MS Teams, Excel	Cross-country
15 min	Knowledge exchange	2 team members	MS Teams, Jira	Cross-office sites
30 min	Coaching	2 cross-departmental members	MS Teams	Cross-office sites

carefully structured setup to appropriately create a 'workspace' both at her desk in the office and at her desk at home:

> "In the beginning, I did spend a lot of time figuring out how to manage the screens and applications, and which application should appear on which monitor to create a setup that supports the work most efficiently. I've found a good setup [of the applications] now, but I still struggle with how to handle the noise at the office." (Informant from Team-2).

During the observation, she further experimented with different headphones to manage the noise at the office, as almost all work was conducted from the desktop and required participation in online meetings, leading to discomfort from wearing headphones for prolonged hours each day.

Since the team members are geographically dispersed, they must schedule all collaborative activities. All synchronous activities, irrespective of their nature, are uniformly scheduled in the MS Teams application. The term "meeting" was broadly used by employees to refer to synchronous work, be it planning, teaching, brainstorming, or socializing. Though all these activities are facilitated by the MS Teams application, the use of additional digital application(s) and tool(s) was also included in the online meeting.

In table 2, we have exemplified the planned synchronous cooperative work of an individual worker through one day. The table shows how diverse planned and structured activities are supported by a complex setup of various digital applications in different cooperative arrangements. Workers must navigate the digital workspace while simultaneously managing the sequential changes in various cooperative work arrangements.

As illustrated, office workers collaborate across the organization in various configurations during the day. However, the workers are not only participating in *planned synchronous* activities, There are numerous unplanned activities, such as direct calls and digital messaging requiring immediate access to specific individuals and digital applications. These emerging interactions were facilitated by existing MS Teams chat channels or through newly created channels to include additional participants in sub-discussions. In our empirical data, we observed several situations where communication in one channel was linked to interactions in other channels simultaneously, involving

both text-based exchanges and online meetings. For example, we observed an unplanned MS Teams meeting being interrupted by a scheduled meeting involving some of the same participants. In this case, three people had to leave their ongoing digital meeting to join a different online meeting, to which a fourth person was also invited. Thus, the same individuals moved from one digital meeting room to another.

While some cooperative activities involved workers associated with the shared office site, remote work options made it difficult to predict cooperative setups and plan for collocated activities. For scheduled meetings, this was managed by making all meetings online, meanwhile, the MS Teams 'availability status' feature was extensively used for ad-hoc interactions. To check a colleague's availability, workers would rely on the availability status in MS Teams, regardless of whether the relevant person was at the office or working remotely. Scanning the office would not provide insights about availability, as most employees wore headphones for noise management, even when not participating in meetings.

In summary, team members utilize multiple IT applications and platforms for their work, serving diverse purposes in different constellations. Digital interlinks facilitate and support complex collaboration despite the distributed nature of the cooperative setup. Team members seamlessly transition between virtual meetings, applications, and contexts, interacting online for most of the day. This pattern persists even after the return to the office, with observations indicating that employees in the two teams predominantly function as online workers, even when physically present at the office. All organizational members produced a digital space that supports their work and enables access and communication for cooperative engagements – *independent of their physical location*. The challenges in hybrid practices are linked to the confidence and stability in remote practices and the unpredictability of the hybrid setup.

5 Discussion

We explored how organizational workers produce and negotiate a shared workspace in hybrid office arrangements through an ethnographic study at an IT company embracing a hybrid work model. The post-pandemic era has introduced the challenge of organizing hybrid environments that leverage in-person interaction at the office while still delivering the flexibility of remote work. Here, we discuss the challenges of re-introducing physical elements into shared hybrid workspaces that integrate digital and physical work practices. Our findings indicate that treating locations in hybrid office work as a binary (home and office) does not align with how hybrid office work is enacted in practice. We suggest the concept of *location multiplicity*, which refers to the inherent condition in hybrid office work that encompasses several physical spaces at the office as well as numerous remote sites outside the office. We discuss how location multiplicity requires a temporal perspective on hybrid work to understand the unique requirements for technologies that provide an experience of stability and predictability across continuously reconfiguring cooperative work settings, supporting individuals in navigating location multiplicity.

5.1 Location as a Multiplicity

Our findings showed that team members engaging in hybrid collaboration relied on the digital space even when working collocated in the same office space. The workers in our case seemed to specifically disconnect from the physical space to manage their hybrid work conditions, though also producing a digital workspace more than a hybrid workspace, utilizing the partial collocation of the physical environment in hybrid work.

The teams did not have a single platform, but rather a group of collaborative, interrelated applications that together created a coherent space for their work. The group of collaborative applications together formed their cooperative infrastructure – or rather their collaborative platform,

within a pertinent ecology of artefacts [7, 53, 63] fundamental to their engagements. The ecology of artifacts enacted within the team collaboration was the backbone of the engagements between all team members and served as one large digital *common information space* [3]. Common information spaces are specifically designed to support and enable knowledge production across participants. In our findings, we see that the common information space included *all the applications and their interrelated connections* as the foundational ground by which participants could collaborate. A collaboration that sometimes involved only geographically distributed participants and sometimes collocated participants – and often in between.

The digital common information space also produced and made available awareness information among participants [28]. Awareness as a feature of cooperative work is essential and allows participants to make visible their activities in such ways that other team members can monitor activities and act accordingly. We saw in our findings that, for example, MS Team indicates the availability of the team members, whereas Jira is used to coordinate activities by visually assigning tasks. Interestingly all the awareness information was only available digitally, and even when people were collocated, team members would still monitor the digital track to gain awareness information as gazing the office would not produce information about availability, since people would wear headphones all the time. Collocated team members continued to rely on MS Teams and Jira to communicate, coordinate, and update, despite being physically collocated.

Communication was embedded in their use of the ecology of artefacts creating the digital common information space. Here we saw how multiple intertwined communication channels were used synchronously as well as asynchronously. Past communication was stored while supporting future directions for the teams, while new communication threads were connected to share documents. Though, the digital space supported communication outside information exchange such as social interactions [68], the digital common information space comprised the multiple connected cooperative applications supporting knowledge coordination, storing of information, communication, and awareness. In this way, the digital ecology of artifacts as 'one platform' emerged as one complete common information space supporting awareness and communication [3, 29].

Moving our lens from the digital towards the physical environment, we witness how team members were working in constantly changing environment configurations, depending on, and impacted by how the team members are located at different times. Interestingly, we notice that organizational members and managers often referred to 'location' as a binary distinction between 'home' and 'office'. In our results, this is for example seen in the organizational policy on hybrid work, as well as the informants' presentation of their work practices. However, 'location' was far from a binary distinction between two entities. Instead, location concretely took the form of complex multiplicities, where different locations 'entered' or 'left' the cooperative hybrid engagement over time. The 'office' could mean five different buildings in two countries. Further, all buildings consist of several different types of spaces, and with 'the floating chairs policy' employees are not assigned to a specific seat. The conceptual understanding of 'office' can therefore not be reduced to one specific location, but instead includes multiple locations.

Similarly, the conceptual understanding of 'home' in the hybrid work arrangement does *not* refer to one geographical location, but instead always and immediately includes several different locations, as there exist as many 'homes' as there are employees in the company. This is not the same as the 'third place' identified in co-workspaces for nomadic workers [60], but instead includes considerations for temporal constellations where participants as individuals and together create hybrid workspaces, which are location independent. Due to the cross-team and -department work, there are multiple sub-groups within the organization, and all sub-groups comprise people who span multiple 'office' spaces and numerous 'homes.' Sub-groups are therefore not simply one team but include multiple intertwined constellations across locations. These constellations change

depending on the contextual nature of the work and based on the required competencies and qualifications for the work task. Adding in that the participants also continuously change location over time – team members might work from the office or home across days and even in different concrete locations in the office on the same day. Hybrid workers therefore meet similar challenges as individual and mobile workers in configuring space and technology [17, 47, 61, 70], despite the person in our case *is* connected to a company office. The sociomaterial circumstances of the team shaping the boundaries for team engagement are thus malleable over time [10] and thus need to be considered when we try to understand the hybrid constellations.

Comparing our empirical findings with prior research on hybrid work, a case study from 2010 explores engineers working in hybrid teams across Denmark and India, and in this case, the workers managed to include and take advantage of the physical artefacts and circumstances in their hybrid arrangements [8]. Teams of 10–15 people divided across two locations conducted 'war room meetings' across sub-teams engineering a cement factory. The war room meetings were weekly stand-up meetings produced to visualize the dependencies across teams and were conducted as short 15-minute meetings in batch order twice a week. For structuring the meetings, large brown-paper posters with post-it notes, and printed diagrams and tables were critical to the execution [8]. The digital tools for connection comprised low-level video camera and audio links (long before Zoom and MS Teams), however, participants managed to connect the physical post-its, war room posters, and documents across the hybrid setup, why the common information space in the war room meetings included both digital and physical artefacts. So, the question becomes how the engineers succeeded in including physical artefacts into their hybrid work arrangement with 'bad digital connections' in 2010 when the IT workers in our empirical case in 2023 were not able to take advantage of the physical space. The main difference between the cases are that in our empirical case, it is only the infrastructures of the digital common information space that remain constant despite people moving around. The situation makes the physical work environments outside the digital common information space an added complexity. Additionally, the workers in our case transitioned all their tasks to the digital space during the pandemic lockdown. In this period, they exclusively engaged in digital cooperative work, creating familiarity and confidence in the use of the systems. They had established a functional digital workspace. After the pandemic and reopening of the office, the digital collaborative applications remained the same. What makes team members able to work in the inconsistency of locations is that digital common information space makes the work independent of who is placed where and when since a team's collaboration always takes place online. Differently in the 'war room' setup, the two locations in Denmark and India always remained the same in all meetings across all projects [8]. While participants entered and left the physical 'war rooms' locally, the space and artefacts (posters, post-its, and printed diagrams) remained in the location. A fundamental difference in the two cases of hybrid setups is that in the 'war room case' the hybrid space is binary (*only two* dedicated rooms in two specific office buildings in Denmark and India) and this location binary served as the foundation for the hybrid collaboration between the engineers. The binary understanding of location does not exist in our case. Instead, we have a case of location multiplicity.

With *location multiplicity*, the 'digital space' is the only 'space' that remains stable and reliable across collaborative constellations. Keeping the digital cooperative environment consisting of the same digital artifacts, applications, folder structures, communication treads, etc., allows the workers to navigate the hybrid setup by disconnecting from the physical space and in this way reduce the effort of articulation work [24, 74]. By not taking advantage of the physical space and only including digital artifacts, the hybrid team members standardize the technology setup enabled by their digital common information space by continuing to use the artifacts that are available independent of time and space – and therefore also the next day when they might work in a different configuration.

5.2 Stability and Predictability across Spatial and Temporal Dimensions

The remote option of hybrid work provides individuals with flexibility while challenging the cooperative team's production of a hybrid workspace utilizing the shared physical space. Duckert et al. [30] argue that hybrid arrangements are determined by *collocated distance*, which future technology should try to bridge. The concept of location multiplicity extends this argument. The challenge in hybrid work is not only to create and maintain connections across and within collocated subgroups but includes the fact that individuals engaging in the work *leave* and *enter* multiple locations in the cooperative setup on a day-by-day basis. Hybrid workspaces lack stability and predictability, as office workers cannot foresee which colleagues will be located where and when.

The extra work required for producing a hybrid setup always lies with the individuals located in the space with collocation – the dominant space. To navigate location multiplicity in hybrid work in our case relied on the stability of the digital space. A stability built upon a confidence developed during the pandemic lockdown. Leveraging the opportunities of the shared collocated space increased the required effort of articulation work, as the opportunities for interaction in the physical and the digital space were not connected. The hybrid workers lack access to the hybrid infrastructure where the *physical components* are stable, consequently making the office a 'lost space' that brings no advantages to the execution of work.

To support hybrid workspaces, it is not enough to deliver space as an architectural opportunity [40], as this does not necessarily link the office to the multiple locations, digital spaces, and artefacts existing in hybrid office work. The instability of the hybrid workspace is further seen in the missed opportunity for letting these traces of the work exist beyond the singular event. The lack of 'permanence' in traces digitally when using a whiteboard increases the work effort when added to hybrid events. This is in contrast to the distributed team in for example the war room meetings where the physical spaces were a stable factor [8]. Since hybrid work constellations are *always immediately* malleable, changeable, and flexible, the locations will not be the same the next day. Thus, we extend existing research on hybrid work beyond the insurmountable gaps of asymmetry [7] to include a *temporal nature of constellation change*.

Due to the location multiplicity in hybrid work, technologies must be embedded and aligned with the physical spaces allowing hybrid participants to create and maintain connections across the physical and digital circumstances when they change locations to provide the opportunity for cooperative actors in creating a *hybrid common information space*. Including physical artefacts directly into their cooperative space requires the option to create and maintain connections between the physical and digital environment without adding further efforts of articulation work. Previous research on technologies for hybrid work already presents design solutions supporting collaboration between collocated and remote participants [49, 55], and solutions aiming to align symmetry across collocated and distributed participants [43, 83]. However, these solutions do not introduce physical elements of the local space without requiring the increased effort of articulation work from the collocated subgroup, for example, by requiring the collocated participants to move to a meeting room and produce an appropriate technology setup. Differently, we suggest that technologies for hybrid work should consider the inherent location multiplicity of hybrid work, which sets different requirements for producing a hybrid workspace that continues to exist across temporal and spatial dimensions. Engaging in spatial practices always requires additional effort [38, 47, 61], and hybrid workers' need for continuous configuration is similar to mobile workers [17]. Though, in our case, the hybrid workers make the space workable by exclusively relying on the digital space, whereas the physical space adds increased requirements for the effort of articulation work without contributing to an experienced added value in the work. We suggest that future design research on technologies for hybrid work should further explore ways to produce shared workspaces that

support individuals in navigating location multiplicity by embedding affordances for connecting physical and digital practices across multiple sites.

6 Conclusion

We investigated the challenges of creating shared hybrid workspaces connecting both digital and physical spaces in hybrid office work. We propose *location multiplicity* as an inherent characteristic of hybrid work. Understanding physical space in hybrid work through a 'location binary' perspective between the home and office provides a problematic and limited comprehension of navigating the complexity of re-introducing physical elements in hybrid arrangements. Alternatively, we suggest approaching the challenge of navigating the physical locations in hybrid work as a negotiation of 'location multiplicity'. The location multiplicity approach further invites new design challenges for CSCW technologies supporting hybrid work, as producing shared workspaces in hybrid work is constrained by the malleability and unpredictability of location multiplicity. We suggest that future work on developing technologies for hybrid work should explore ways to create sociomaterial connections linking digital and physical elements to produce hybrid infrastructures in which both digital and physical components remain stable across spatial and temporal configurations.

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References

[1] Rianne Appel-Meulenbroek, Astrid Kemperman, Amke Water, Minou Weijs-Perrée, and Jan Verhaegh. 2022. How to attract employees back to the office? A stated choice study on hybrid working preferences. *Journal of Environmental Psychology* 81 (March 2022), 101784. https://doi.org/10.1016/j.jenvp.2022.101784

[2] Ellen Balka, Pernille Bjørn, and Ina Wagner. 2008. Steps Toward a Typology for Health Informatics. SIGCHI, Association for Computing Machinery, 732–732.

[3] Liam Bannon and Susanne Bødker. 1997. *Constructing Common Information Spaces.* Kluwer Academic Publishers, Dordrecht, The Netherlands.

[4] Liam Bannon and Kari Kuutti. 1996. Shifting Perspectives on Organizational Memory: From Storage to Active Remembering. In *Proceedings of HICSS-29: 29th Hawaii International Conference on System Sciences*, Vol. 3. 156–167 vol.3. https://doi.org/10.1109/HICSS.1996.493187

[5] Liam J Bannon. 2000. Understanding Common Information Spaces in CSCW. *Position paper for Workshop on Common Information Spaces* (2000).

[6] David Benyon and Oli Mival. 2015. Blended Spaces for Collaboration. *Computer Supported Cooperative Work (CSCW)* 24, 2-3 (June 2015), 223–249. https://doi.org/10.1007/s10606-015-9223-8

[7] Pernille Bjørn, Juliane Busboom, Melanie Duckert, Susanne Bødker, Irina Shklovski, Eve Hoggan, Kellie Dunn, Qianqian Mu, Louise Barkhuus, and Nina Boulus-Rødje. 2024. Achieving Symmetry in Synchronous Interaction in Hybrid Work Is Impossible. *Transaction on Computer-human Interaction (TOCHI)* Forthcoming (2024).

[8] Pernille Bjørn and Lars Rune Christensen. 2011. Relation Work: Creating Socio-Technical Connections in Global Engineering. In *ECSCW 2011: Proceedings of the 12th European Conference on Computer Supported Cooperative Work, 24-28 September 2011, Aarhus Denmark*, Susanne Bødker, Niels Olof Bouvin, Volker Wulf, Luigina Ciolfi, and Wayne Lutters (Eds.). Springer London, London, 133–152. https://doi.org/10.1007/978-0-85729-913-0_8

[9] Pernille Bjørn, Morten Esbensen, Rasmus Eskild Jensen, and Stina Matthiesen. 2014. Does Distance Still Matter? Revisiting the CSCW Fundamentals on Distributed Collaboration. *ACM Transactions on Computer-Human Interaction* 21, 5 (2014), 26–26. https://doi.org/10.1145/2670534

[10] Pernille Bjørn and Carsten Østerlund. 2014. *Sociomaterial-Design.* Springer International Publishing, Cham. https://doi.org/10.1007/978-3-319-12607-4

[11] Pernille Bjørn, Mark Wulff, Mathias Schmidt Petræus, and Naja Holten Møller. 2021. Immersive Cooperative Work Environments (CWE): Designing Human-Building Interaction in Virtual Reality. *Computer Supported Cooperative Work (CSCW)* 30, 3 (June 2021), 351–391. https://doi.org/10.1007/s10606-021-09395-3

[12] volume = 24 langid = english Bjørn, Pernille, year = 2012. [n. d.]. Bounding Practice: How People Act in Sociomaterial Practices. ([n. d.]).
[13] Jeanette Blomberg and Helena Karasti. 2013. Reflections on 25 Years of Ethnography in CSCW. *Computer Supported Cooperative Work (CSCW)* 22, 4-6 (Aug. 2013), 373–423. https://doi.org/10.1007/s10606-012-9183-1
[14] Alexander Boden, Gabriela Avram, Liam J. Bannon, and Volker Wulf. 2009. Knowledge Management in Distributed Software Development Teams - Does Culture Matter? (July 2009), 18–27. https://doi.org/10.1109/icgse.2009.10
[15] Virginia Braun, Victoria Clarke, Nikki Hayfield, and Gareth Terry. 2019. Thematic Analysis. In *Handbook of Research Methods in Health Social Sciences*, Pranee Liamputtong (Ed.). Springer, Singapore, 843–860. https://doi.org/10.1007/978-981-10-5251-4_103
[16] Thomas Breideband, Robert Glenn Moulder, Gonzalo J. Martinez, Megan Caruso, Gloria Mark, Aaron D. Striegel, and Sidney D'Mello. 2023. 'Location, Location, Location': An Exploration of Different Workplace Contexts in Remote Teamwork during the COVID-19 Pandemic. *Proceedings of the ACM on Human-Computer Interaction* 7, CSCW1 (April 2023), 71:1–71:22. https://doi.org/10.1145/3579504
[17] Barry Brown and Kenton O'Hara. 2003. Place as a Practical Concern of Mobile Workers. *Environment and Planning A: Economy and Space* 35, 9 (Sept. 2003), 1565–1587. https://doi.org/10.1068/a34231 Publisher: SAGE Publications Ltd.
[18] Juliane Busboom and Nina Boulus-Rødje. 2023. Planning for hybrid cooperation - a design driven exploration. (2023). https://dl.eusset.eu/handle/20.500.12015/4680 Publisher: European Society for Socially Embedded Technologies (EUSSET).
[19] Monika Büscher, Preben Mogensen, and Dan Shapiro. 2002. Spaces of Practice. In *ECSCW 2001*, Wolfgang Prinz, Matthias Jarke, Yvonne Rogers, Kjeld Schmidt, and Volker Wulf (Eds.). Kluwer Academic Publishers, Dordrecht, 139–158. https://doi.org/10.1007/0-306-48019-0_8
[20] Clara Caldeira, Cleidson R.B. de Souza, Letícia Machado, Marcelo Perin, and Pernille Bjørn. 2022. Crisis Readiness: Revisiting the Distance Framework During the COVID-19 Pandemic. *Computer Supported Cooperative Work (CSCW)* (April 2022). https://doi.org/10.1007/s10606-022-09427-6
[21] Hancheng Cao, Chia-Jung Lee, Shamsi Iqbal, Mary Czerwinski, Priscilla N Y Wong, Sean Rintel, Brent Hecht, Jaime Teevan, and Longqi Yang. 2021. Large Scale Analysis of Multitasking Behavior During Remote Meetings. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–13. https://doi.org/10.1145/3411764.3445243
[22] Lars Rune Christensen, Rasmus Eskild Jensen, and Pernille Bjørn. 2014. Relation Work in Collocated and Distributed Collaboration. (Jan. 2014), 87–101. https://doi.org/10.1007/978-3-319-06498-7_6
[23] Luigina Ciolfi, Breda Gray, and Pinatti de Carvalho, Aparecido Fabiano. 2020. Making Home Work Places. (2020). https://doi.org/10.18420/ECSCW2020_EP10
[24] Luigina Ciolfi, Myriam Lewkowicz, and Kjeld Schmidt. 2023. Computer-Supported Cooperative Work. In *Handbook of Human Computer Interaction*, Jean Vanderdonckt, Philippe Palanque, and Marco Winckler (Eds.). Springer International Publishing, Cham, 1–26. https://doi.org/10.1007/978-3-319-27648-9_30-1
[25] Ian Cook. 2021. Who Is Driving the Great Resignation? *Harvard Business Review* (Sept. 2021).
[26] Paul Dourish. 2006. Re-Space-Ing Place: "Place" and "Space" Ten Years On. In *Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work (CSCW '06)*. Association for Computing Machinery, New York, NY, USA, 299–308. https://doi.org/10.1145/1180875.1180921
[27] Paul Dourish, Annette Adler, Victoria Bellotti, and Austin Henderson. 1996. Your Place or Mine? Learning from Long-Term Use of Audio-Video Communication. *Computer Supported Cooperative Work* 5 (Jan. 1996), 33–62. https://doi.org/10.1007/BF00141935
[28] Paul Dourish and Victoria Bellotti. 1992. Awareness and Coordination in Shared Workspaces. In *Proceedings of the 1992 ACM Conference on Computer-supported Cooperative Work - CSCW '92*. ACM Press, Toronto, Ontario, Canada, 107–114. https://doi.org/10.1145/143457.143468
[29] Paul Dourish and Sara Bly. 1992. Portholes: Supporting Awareness in a Distributed Work Group. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '92)*. Association for Computing Machinery, New York, NY, USA, 541–547. https://doi.org/10.1145/142750.142982
[30] Melanie Duckert, Louise Barkhuus, and Pernille Bjørn. 2023. Collocated Distance: A Fundamental Challenge for the Design of Hybrid Work Technologies. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, 1–16. https://doi.org/10.1145/3544548.3580899
[31] Melanie Duckert, Eve Hoggan, Louise Barkhuus, Pernille Bjørn, Nina Boulus-Rodje, Susanne Bødker, Naja Holten Møller, and Irina Shklovski. 2022. Work of the Future. In *Adjunct Proceedings of the 2022 Nordic Human-Computer Interaction Conference (NordiCHI '22)*. Association for Computing Machinery, New York, NY, USA, 1–4. https://doi.org/10.1145/3547522.3547707
[32] Catherine Durnell Cramton and Pamela J. Hinds. 2004. Subgroup Dynamics in Internationally Distributed Teams: Ethnocentrism or Cross-National Leaning? *Research in Organizational Behavior* 26 (Jan. 2004), 231–263. https:

//doi.org/10.1016/S0191-3085(04)26006-3
[33] Morten Esbensen and Pernille Bjørn. 2014. Routine and Standardization in Global Software Development. In *Proceedings of the 2014 ACM International Conference on Supporting Group Work (GROUP '14)*. Association for Computing Machinery, New York, NY, USA, 12–23. https://doi.org/10.1145/2660398.2660413
[34] Rafael Ferreira, Ruben Pereira, Isaías Scalabrin Bianchi, and Miguel Mira da Silva. 2021. Decision Factors for Remote Work Adoption: Advantages, Disadvantages, Driving Forces and Challenges. *Journal of Open Innovation: Technology, Market, and Complexity* 7, 1 (Feb. 2021), 70. https://doi.org/10.3390/joitmc7010070
[35] Asbjørn Ammitzbøll Flügge and Naja Holten Møller. 2023. The Role of Physical Cues in Co-located and Remote Casework. *Computer Supported Cooperative Work (CSCW)* 32, 2 (June 2023), 275–312. https://doi.org/10.1007/s10606-022-09449-0
[36] William W. Gaver. 1992. The Affordances of Media Spaces for Collaboration. In *Proceedings of the 1992 ACM Conference on Computer-supported Cooperative Work (CSCW '92)*. Association for Computing Machinery, New York, NY, USA, 17–24. https://doi.org/10.1145/143457.371596
[37] Werner Geyer, Heather Richter, Ludwin Fuchs, Tom Frauenhofer, Shahrokh Daijavad, and Steven Poltrock. 2001. A Team Collaboration Space Supporting Capture and Access of Virtual Meetings. In *Proceedings of the 2001 ACM International Conference on Supporting Group Work (GROUP '01)*. Association for Computing Machinery, New York, NY, USA, 188–196. https://doi.org/10.1145/500286.500315
[38] Breda Gray, Luigina Ciolfi, and Aparecido de Carvalho. 2020. *Made to Work: Mobilising Contemporary Worklives*. https://doi.org/10.4324/9780429023958
[39] Susan Halford. 2005. Hybrid workspace: re-spatialisations of work, organisation and management. *New Technology, Work and Employment* 20, 1 (2005), 19–33. https://doi.org/10.1111/j.1468-005X.2005.00141.x _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1468-005X.2005.00141.x.
[40] Steve Harrison and Paul Dourish. 1996. Re-Place-Ing Space: The Roles of Place and Space in Collaborative Systems. In *Proceedings of the 1996 ACM Conference on Computer Supported Cooperative Work (CSCW '96)*. Association for Computing Machinery, New York, NY, USA, 67–76. https://doi.org/10.1145/240080.240193
[41] Patrick G. T. Healey, Graham White, Arash Eshghi, Ahmad J. Reeves, and Ann Light. 2008. Communication Spaces. *Computer Supported Cooperative Work (CSCW)* 17, 2-3 (April 2008), 169–193. https://doi.org/10.1007/s10606-007-9061-4
[42] Christian Heath, Paul Luff, and Abigail Sellen. 1995. Reconsidering the Virtual Workplace: Flexible Support for Collaborative Activity. In *Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work ECSCW '95*, Hans Marmolin, Yngve Sundblad, and Kjeld Schmidt (Eds.). Springer Netherlands, Dordrecht, 83–99. https://doi.org/10.1007/978-94-011-0349-7_6
[43] Keiji Hirata, Yasunori Harada, Toshihiro Takada, Shigemi Aoyagi, Yoshinari Shirai, Naomi Yamashita, Katsuhiko Kaji, Junji Yamato, and Kenji Nakazawa. 2008. T-Room: Next Generation Video Communication System. In *IEEE GLOBECOM 2008 - 2008 IEEE Global Telecommunications Conference*. 1–4. https://doi.org/10.1109/GLOCOM.2008.ECP.1058
[44] Linda M. Hite and Kimberly S. McDonald. 2020. Careers after COVID-19: Challenges and Changes. *Human Resource Development International* 23, 4 (Aug. 2020), 427–437. https://doi.org/10.1080/13678868.2020.1779576
[45] Julie Hui, Justin Cranshaw, Yasmine Kotturi, and Chinmay Kulkarni. 2019. The Future of Work(Places): Creating a Sense of Place for On-demand Work. In *Conference Companion Publication of the 2019 on Computer Supported Cooperative Work and Social Computing (CSCW '19)*. Association for Computing Machinery, New York, NY, USA, 487–491. https://doi.org/10.1145/3311957.3359432
[46] Julie Hui, Elizabeth M. Gerber, Lynn Dombrowski, Mary L. Gray, Adam Marcus, and Niloufar Salehi. 2018. Computer-Supported Career Development in The Future of Work. In *Companion of the 2018 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '18)*. Association for Computing Machinery, New York, NY, USA, 133–136. https://doi.org/10.1145/3272973.3274545
[47] Justine Humphry. 2014. Officing: Mediating Time and the Professional Self in the Support of Nomadic Work. *Computer Supported Cooperative Work (CSCW)* 23 (April 2014). https://doi.org/10.1007/s10606-013-9197-3
[48] Shamsi T. Iqbal, Jina Suh, M. Czerwinski, G. Mark, and J. Teevan. 2020. Remote Work and Well-being.
[49] Hiroshi Ishii and Minoru Kobayashi. 1992. ClearBoard: A Seamless Medium for Shared Drawing and Conversation with Eye Contact. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '92)*. Association for Computing Machinery, New York, NY, USA, 525–532. https://doi.org/10.1145/142750.142977
[50] Rasmus Eskild Jensen and Pernille Bjørn. 2012. Divergence and Convergence in Global Software Development: Cultural Complexities as Social Worlds. (2012).
[51] Brigitte Jordan. 1996. Chapter 3 Ethnographic Workplace Studies and CSCW. In *Human Factors in Information Technology*, Dan Shapiro, Michael Tauber, and Roland Traunmüller (Eds.). The Design of Computer Supported Cooperative Work and Groupware Systems, Vol. 12. North-Holland, 17–42. https://doi.org/10.1016/S0923-8433(96)80005-0
[52] Brigitte Jordan. 2009. Blurring Boundaries: The "Real" and the "Virtual" in Hybrid Spaces. *Human Organization* 68, 2 (2009), 181–193. jstor:44148549

[53] Heekyoung Jung, Erik Stolterman, Will Ryan, Tonya Thompson, and Marty Siegel. 2008. Toward a Framework for Ecologies of Artifacts: How Are Digital Artifacts Interconnected within a Personal Life?. In *Proceedings of the 5th Nordic Conference on Human-computer Interaction: Building Bridges (NordiCHI '08)*. Association for Computing Machinery, New York, NY, USA, 201–210. https://doi.org/10.1145/1463160.1463182

[54] C. Kent Kantarjiev and R. Harper. 1994. *Portable Porthole Pads: An Investigation into the Use of a Ubicomp Device to Support the Sociality of Work.* Technical Report. Rank Xerox Research Centre.

[55] Scott R. Klemmer, Katherine M. Everitt, and James A. Landay. 2008. Integrating Physical and Digital Interactions on Walls for Fluid Design Collaboration. *Human–Computer Interaction* 23, 2 (May 2008), 138–213. https://doi.org/10.1080/07370020802016399

[56] Boriana Koleva, Steve Benford, and Chris Greenhalgh. 1999. The Properties of Mixed Boundaries. (1999).

[57] KPMG. 2023. From Remote to Hybrid Work - KPMG Belgium. https://kpmg.com/be/en/home/insights/2021/06/aud-from-remote-to-hybrid-work.html.

[58] R. Kraut, R. S. Fish, R. W. Root, B. L. Chalfonte, I. S. Oskamp, and S. Spacapan. 1990. Informal Communication in Organizations: Form, Function, and Technology.

[59] Shana Lebowitz. 2023. Here's a List of Major Companies Requiring Employees to Return to the Office. https://www.businessinsider.com/companies-making-workers-employees-return-to-office-rto-wfh-hybrid-2023-1.

[60] Ahreum Lee, Austin Toombs, Ingrid Erickson, David Nemer, Yu-shen Ho, Eunkyung Jo, and Zhuang Guo. 2019. The Social Infrastructure of Co-spaces: Home, Work, and Sociable Places for Digital Nomads. *Proceedings of the ACM on Human-Computer Interaction* 3 (Nov. 2019), 1–23. https://doi.org/10.1145/3359244

[61] Michael Liegl. 2014. Nomadicity and the Care of Place—on the Aesthetic and Affective Organization of Space in Freelance Creative Work. *Computer Supported Cooperative Work (CSCW)* 23, 2 (April 2014), 163–183. https://doi.org/10.1007/s10606-014-9198-x

[62] Susan Lund, Anu Madgavkar, James Manyika, and Sven Smit. 2020. What's next for Remote Work: An Analysis of 2,000 Tasks, 800 Jobs, and Nine Countries. (Nov. 2020).

[63] Peter Lyle, Henrik Korsgaard, and Susanne Bødker. 2020. What's in an Ecology? A Review of Artifact, Communicative, Device and Information Ecologies. In *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society (NordiCHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3419249.3420185

[64] Sabine Madsen, Christian Ravn Haslan, and Jeppe Agger Nielsen. 2020. Accelerated Digital Transformation: The Case of The Online University Caused By Covid-19. (2020), 16.

[65] Gloria Mark, Steve Abrams, and Nayla Nassif. 2003. Group-to-Group Distance Collaboration: Examining the "Space Between". In *ECSCW 2003*, Kari Kuutti, Eija Helena Karsten, Geraldine Fitzpatrick, Paul Dourish, and Kjeld Schmidt (Eds.). Springer Netherlands, Dordrecht, 99–118. https://doi.org/10.1007/978-94-010-0068-0_6

[66] Stina Matthiesen and Pernille Bjørn. 2017. When Distribution of Tasks and Skills Are Fundamentally Problematic: A Failure Story from Global Software Outsourcing. *Proceedings of the ACM on Human-Computer Interaction* 1, CSCW (Dec. 2017), 74:1–74:16. https://doi.org/10.1145/3139336

[67] Naja Holten Møller, Maren Gausdal Eriksen, and Claus Bossen. 2020. A Worker-Driven Common Information Space: Interventions into a Digital Future. *Computer Supported Cooperative Work (CSCW)* 29, 5 (Oct. 2020), 497–531. https://doi.org/10.1007/s10606-020-09379-9

[68] Bonnie A. Nardi, Steve Whittaker, and Erin Bradner. 2000. Interaction and outeraction: instant messaging in action. In *Proceedings of the 2000 ACM conference on Computer supported cooperative work (CSCW '00)*. Association for Computing Machinery, New York, NY, USA, 79–88. https://doi.org/10.1145/358916.358975

[69] Judith S. Olson and Gary M. Olson. 2014. Working Together Apart: Collaboration over the Internet. *Synthesis lectures on human-centered informatics* 6, 5 (Nov. 2014), 1–151. https://doi.org/10.2200/s00542ed1v01y201310hci020

[70] Gianpiero Petriglieri, Susan J. Ashford, and Amy Wrzesniewski. 2019. Agony and Ecstasy in the Gig Economy: Cultivating Holding Environments for Precarious and Personalized Work Identities. *Administrative Science Quarterly* 64, 1 (March 2019), 124–170. https://doi.org/10.1177/0001839218759646 Publisher: SAGE Publications Inc.

[71] Dave Randall, Richard Harper, and Mark Rouncefield. 2007. *Fieldwork for Design.* Springer London, London. https://doi.org/10.1007/978-1-84628-768-8

[72] Anna Rudnicka, Joseph W Newbold, Dave Cook, Marta E Cecchinato, and Anna L Cox. 2020. Eworklife: developing effective strategies for remote working during the COVID-19 pandemic. *The New Future of Work Symposium* (2020), 13.

[73] Karen Ruhleder. 2000. The Virtual Ethnographer: Fieldwork in Distributed Electronic Environments. *Field Methods* 12, 1 (Feb. 2000), 3–17. https://doi.org/10.1177/1525822X0001200101

[74] Kjeld Schmidt and Liam Bannon. 1992. Taking CSCW seriously: Supporting articulation work. *Computer Supported Cooperative Work (CSCW)* 1 (1992), 7–40.

[75] Ulrike Schultze, Gijs van den Heuvel, and Marko Niemimaa. 2020. Enacting Accountability in IS Research after the Sociomaterial Turn(Ing). *Journal of the Association for Information Systems* 21 (July 2020), 811–835. https://doi.org/10.17705/1jais.00620

[76] Hitesh Nidhi Sharma, Sultan A. Alharthi, Igor Dolgov, and Zachary O. Toups. 2017. A Framework Supporting Selecting Space to Make Place in Spatial Mixed Reality Play. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*. ACM, Amsterdam The Netherlands, 83–100. https://doi.org/10.1145/3116595.3116612

[77] Darja Smite, Emily Christensen, Paolo Tell, and Daniel Russo. 2023. The Future Workplace: Characterizing the Spectrum of Hybrid Work Arrangements for Software Teams. *IEEE Software* 40 (2023), 34–41. https://doi.org/10.1109/MS.2022.3230289

[78] Darja Smite, Nils Moe, Eriks Klotins, and Javier Gonzalez-Huerta. 2022. From forced Working-From-Home to voluntary working-from-anywhere: Two revolutions in telework. *Journal of Systems and Software* 195 (Sept. 2022), 111509. https://doi.org/10.1016/j.jss.2022.111509

[79] Darja Smite, Nils Brede Moe, Anastasiia Tkalich, Geir Kjetil Hanssen, Kristina Nydal, Jenny Nøkleberg Sandbæk, Hedda Wasskog Aamo, Ada Olsdatter Hagaseth, Scott Aleksander Bekke, and Malin Holte. 2022. Half-Empty Offices in Flexible Work Arrangements: Why are Employees Not Returning? https://doi.org/10.48550/arXiv.2208.12797 arXiv:2208.12797 [cs].

[80] Susan Leigh Star and James R. Griesemer. 1989. Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science* 19, 3 (Aug. 1989), 387–420. https://doi.org/10.1177/030631289019003001

[81] Donald Sull, Charles Sull, and Ben Zweig. 2022. Toxic Culture Is Driving the Great Resignation. *MIT SLOAN MANAGEMENT REVIEW* (2022).

[82] Casey Swezey and Janet Vertesi. 2019. Working Apart, Together: The Challenges of Co-Work. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (Nov. 2019), 204:1–204:22. https://doi.org/10.1145/3359306

[83] John C. Tang, Kori Inkpen, Sasa Junuzovic, Keri Mallari, Andrew D. Wilson, Sean Rintel, Shiraz Cupala, Tony Carbary, Abigail Sellen, and William A.S. Buxton. 2023. Perspectives: Creating Inclusive and Equitable Hybrid Meeting Experiences. *Proceedings of the ACM on Human-Computer Interaction* 7, CSCW2 (Oct. 2023), 351:1–351:25. https://doi.org/10.1145/3610200

[84] Jordan Valinsky. 2023. Even Zoom Is Making Its Staff Return to the Office | CNN Business. https://www.cnn.com/2023/08/07/business/zoom-return-to-office/index.html.

[85] Yun Wang, Ying Liu, Weiwei Cui, John Tang, Haidong Zhang, Doug Walston, and Dongmei Zhang. 2021. Returning to the Office During the COVID-19 Pandemic Recovery: Early Indicators from China. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–6. https://doi.org/10.1145/3411763.3451685

[86] Longqi Yang, David Holtz, Sonia Jaffe, Siddharth Suri, Shilpi Sinha, Jeffrey Weston, Connor Joyce, Neha Shah, Kevin Sherman, Brent Hecht, and Jaime Teevan. 2022. The Effects of Remote Work on Collaboration among Information Workers. *Nature Human Behaviour* 6, 1 (Jan. 2022), 43–54. https://doi.org/10.1038/s41562-021-01196-4

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PAPER III

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RESEARCH

The Ripple Effect of Information Infrastructures

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Abstract. This paper explores how the nature of work is impacted by the information infrastructure within the work exists. Drawing on an empirical case of a global organization replacing the local area network (LAN), we examine the work required for (re)designing, implementing, maintaining, and managing the sociotechnical aspects of the LAN. We identify breakdowns related to cooperative, technical, and organizational work, revealing faultlines in boundary-crossing activities. By exploring the characteristics of these faultlines, our study highlights how work and infrastructure co-evolve. Work may appear to take place within a local context, yet in practice, it transforms the global infrastructure, with interdependent entities located elsewhere in the infrastructural setup, such as people, artifacts, and policies that only have peripheral (or invisible) relations to the work. This interplay impacts not only the characteristics of the work itself but also the inherent characteristics and legacy of multiple work contexts beyond immediate boundaries. We argue that viewing work from an infrastructural perspective is crucial for identifying who and what is needed to accomplish work tasks. The ripple effect of information infrastructures impacts local work contexts in unanticipated ways, extending beyond visible work practices. Transforming infrastructures thus requires an extended peripheral perception in shaping and scoping the work at multiple scales.

Keywords: Work, Information infrastructure, Collaboration, Internet

1 Introduction

The expanding interconnectivity of the world has led to an increasing reliance on the Internet to facilitate communication, coordination, and collaboration among various CSCW systems (Bly and Anderson 1996; Olson and Olson 2000). As technology advances, the Internet is indispensable for shaping the landscape of future work environments, giving rise to the development of expansive and intricate infrastructures (Khodeir and Nabawy 2019). The COVID-19 pandemic prompted the emergence of hybrid workplaces, further heightening the imperative for robust information systems to support cooperative work across office sites and private homes, positioning information infrastructures as the cornerstone of modern work environments (Busboom and Boulus-Rødje 2023; Duckert et al. 2022; Duckert and Bjørn 2024). These infrastructures are both technological and

deeply embedded in social and organizational contexts, influencing how work is situated and performed (Suchman 2006). Understanding the connectedness between work and information infrastructures is essential to understanding how local work tasks are shaped by the characteristics of global infrastructures.

To identify particular ways in which the context and content of work and infrastructure co-evolve, we examine an empirical case within a globally networked organization composed of multiple sub-organizations. The organization is replacing the local area network (LAN) across 30 sites in 12 countries. Although the organization operates as a holding company in diverse work domains unrelated to network provision, all workers share the reliance on intra- and Internet access, which is considered a default integration across all sites. The LAN replacement involves a comprehensive redesign and reconfiguration of the network, referred to in this paper as the Network Project. The Network Project is a response to organizational growth, post-pandemic work practices, such as remote work, and general advancements in information technologies, setting new requirements for the LAN architecture to bolster security and support contemporary work practices.

The Network Project is an interesting case for exploring the relationship between work and infrastructure, as while the network's integration often appears seamless, the infrastructure supporting it is complex, and the work to maintain its functionality often goes unnoticed (Star and Ruhleder 1996). The network infrastructure is both material and digital, with the 'digital cloud' being very much physical (Dourish 2017), requiring various people's work to function (Bowers 1994, 1995). Understanding the work within the Network Project thus requires us to explore the work on maintaining and managing the sociotechnical aspects of the global information infrastructure. Our research explores *how the information infrastructure impacts the nature of work as it emerged in the Network Project.* Specifically, we examine the characteristics of the work and the necessary articulation work required to manage and navigate the interdependencies within the common field of work (Schmidt and Bannon 1992), which are further dependent on actions not directly linked to the task at hand (Lee and Paine 2015). Throughout the project's execution, we observed different breakdowns in the cooperative, technical, and organizational work, forcing the project to expand beyond its borders continually. Rather than being a mere redesign of the LAN, the Network Project transformed the information infrastructure, exerting a reciprocal impact across the entire organization.

Information infrastructures are always invariably embedded into policies, relationships, and technologies (Star and Ruhleder 1996), rendering transformation a complex challenge (Hanseth, Monteiro, and Hatling 1996). While prior research has advocated a shift in perspective from 'artifacts to infrastructures' (Monteiro et al. 2013), *our study suggests that the interrelation between work and infrastructures requires CSCW examinations of work practices to adopt an*

infrastructural perspective to understand how the characteristics of the global information infrastructure are shaping and scoping local work contexts at multiple scales.

We propose that adopting an infrastructural perspective when examining work can contribute to identifying the people, technological artifacts, and organizational policies crucial for successful infrastructural transformations. Work activities cannot be isolated from the infrastructural context in which they occur, as *the ripple effect of information infrastructures impacts local work contexts in unexpected ways*, *extending beyond visible work practices*. Confirming previous research (Ciolfi, Lewkowicz, and Schmidt 2023; Schmidt and Bannon 1992; Suchman 1996), we observe that characteristics of the information infrastructure are pivotal in defining the nature of work, meaning that the articulation work required for handling specific tasks is directly influenced and shaped by the cooperative task at hand. We extend this as our data demonstrate the relation between work and infrastructures are *scoping* local work contexts by detailing who and what is pertinent. Identifying these interdependencies may require excavation of the infrastructure (Matthiesen and Bjørn 2015), causing the scope to evolve dynamically and reveal hidden connections. Further, our data indicate that the nature of work inherits characteristics across various contexts. Local work contexts adopt the legacy embedded within the infrastructure, and the complexity of the work, along with potential breakdowns, can be attributed to different interrelated contexts – often extending beyond the immediate context where the work is performed, due to invisible people, artifacts, and policies, thereby impacting the required articulation and *scaling* work.

The rest of the paper is structured as follows: First, we present the theoretical background of CSCW and information infrastructure. Then, we present our methodological approach and the empirical case in greater detail. Hereafter, we demonstrate our results by presenting the challenges of identifying work activities as infrastructural transformations, implementing these transformations, and finally, breakdowns expanding the project's boundaries. Finally, we discuss how the ripple effect of information infrastructures impacts the nature of the work, particularly when the work transforms the infrastructure.

2 Working in information infrastructures

When people engage in complex cooperative work, they are not only engaging immediately in social relations (Bjørn and Christensen 2014; Christensen, Jensen, and Bjørn 2014) but also seek out ways to reduce the efforts of articulation work by creating and implementing protocols and structures for work, often embedded within various types of digital systems, physical artifacts, or professional choices (Bardram and Bossen 2005; Møller and Dourish 2010; Jensen 2014). Research into coordination in CSCW has led to a wide conceptual understanding

of coordination activities, such as the work of Schmidt and Simone (1996) on coordination mechanisms, the work of Schmidt and Wagner (2004) on ordering systems, and the work of Gerson (2008) on standardization, aggregation, and segregation. Across this work, CSCW researchers have been driven by an interest in conceptualizing the empirical ethnographic observations in the workplace to understand complexities while considering how the design of cooperative systems can address coordination activities within their design.

While the majority of CSCW research on coordination has emerged from workplace studies of specific professional practices such as architectural work, healthcare work, or software development work (Boden, Nett, and Wulf 2007; Christensen 2010; Grinter et al. 1999; Kobayashi et al. 2005), there has been a shift in research focus from coordination practices focusing within a collocated entity of work such as in emergency departments (Bjørn and Østerlund 2014) towards coordination as it occurs within large infrastructural distributed sites of interaction (Bjørn and Boulus-Rødje 2015; Blomberg and Karasti 2013). Cooperative work may depend on individuals at various levels within loose and tight structural integrations, with the work relying on all involved activities, practices, and technologies (Strauss 1988). This shift in the research perspective fundamentally involves scaling CSCW research endeavors from understanding practice to design artifacts to understanding practice to design infrastructures (Monteiro et al. 2013). In this shift from artifacts to infrastructures, it becomes evident that many existing theoretical framework, conceptual understandings, and design strategies developed for collocated cooperative entities are not applicable when considering CSCW at scale. Infrastructures are inherently invisible and relational simultaneously, yet they shape the action space for what is possible or not possible (Bjørn and Boulus-Rødje 2018; Bowker et al. 2010). Infrastructures are part of what shapes activities, technologies, and actions while setting the boundaries for what is possible by being embedded within standards, templates, policies, and technologies, and are very resistant to change (Jabbar and Bjørn 2018b; Matthiesen and Bjørn 2015; Star 1999). Infrastructures are mostly hidden and only become visible upon breakdowns; thus, studying infrastructures is challenging and requires different empirical strategies compared to studying artifacts (Randall et al. 2021).

The embeddedness of infrastructures means that the "design" never starts from nothing; instead, infrastructures are developed over time, continuously building on existing components with history and legacy (Cohn 2016; Fürstenau et al. 2019; Matthiesen and Bjørn 2015). Neither can it remain static, as it must adapt to changes such as emerging technologies (Jabbar and Bjørn 2018a; 2019) and organizations' evolution (Cramton and Hinds 2004; Hanseth, Monteiro, and Hatling 1996; Mark and Poltrock 2003; Sharma and Sawyer 2016). Design work on infrastructures is different from artifacts due to the embeddedness of ecologies and policies. When we design infrastructures, we must simultaneously consider

the inertia of the infrastructure shaped by history and legacy while considering what we want to do and where we want to go for the future. By wresting with the inertia of the infrastructure, we can push the infrastructure into a new direction, but this process is slow and requires dedication from all actors. Lee and Schmidt (2018) emphasize the need for conceptual clarity in defining 'infrastructure,' highlighting the complexities and ambiguities that arise from its varied interpretations over time.

Replacing infrastructures is never a quick fix but requires collaborative repair work to deal with the ambiguity in infrastructure projects. This means that "to infrastructure" work includes uncovering components hidden by the legacy of the infrastructure, identifying breakdowns, and engaging in repair work. Repair work of infrastructures can take different forms, including value-network repair, process repair, and participation repair (Mikalsen, Farshchian, and Dahl 2018). Repair work is a creative process extending the lifecycle of existing technologies (Henke 2017; Maestri and Wakkary 2011) to enhance sustainable societies (Graham and Thrift 2007) in collaborative processes (Ludwig et al. 2018). Such collaborative, participatory processes play out in the messy and complex interplay among people, organizations, and levels of political authority, providing a vocabulary for articulating the makeup and dynamics of these processes (Bødker, Dindler, and Iversen 2017). Consequentially, infrastructures do not break down; they continue to exist albeit in new forms and constellations - only individual components of infrastructures can break (Steinhardt 2016).

Studying integrations in infrastructures, Ellingsen et al. (2013) observed several unforeseen circumstances rooted in existing policies, systems, and practices, however, also incidents that could not be linked to a single concrete cause, as these were linked to several interlinked causes leading to an escalation of from small local issues transforming intro-large scale global issues. As argued by Latour (1993), the global and local relationship is interconnected and cannot be viewed as a simplified dichotomy. This underscores the complexity inherent in infrastructure integration, where multiple factors interact to influence outcomes. Further, considering the temporal nature of infrastructure work, the changing constellation of collaborating actors challenges cooperation, work synchronization, and work assemblage (Grisot and Vassilakopoulou 2015). The vision of infrastructures should, therefore, take long-term thinking concerning human and technological components, but also the interrelated social, organizational, and technical components or systems (Bowker et al. 2010; Karasti, Baker, and Millerand 2010; Ribes and Finholt 2009). Taking a longer view of infrastructural systems enables more detailed analyses and understandings of how the development and maintenance of particular system components requires ongoing negotiations among stakeholders and the continual reorganization of work in order to serve a variety of groups engaged with different problems (Neang et al. 2023).

Combining the study of infrastructures and the cooperative work of Paine and Lee (2020) on actions taken by coordinative entities stands out. In their work, they develop a conceptual landscape of how to analyze and make sense of complex organizations, which can help guide empirical investigations. *Coordinative entities* are groupings of actors ranging from dyads to sub-organizations that can connect, disconnect, and reconnect in different ways over time. Coordinative entities can be used by researchers (and others) to classify and illustrate messy and dynamic changes in the context and content of collaborations through empirical and analytical strategies of identifying, comparing, and tracing coordinative activities and practices across shifting organizational landscapes (Paine and Lee 2020) that act as multiple interlinked sites of design (Bjørn and Boulus-Rødje 2015). Ultimately, coordinative entities are analytical tools that allow us to identify what is centered or peripheral to coordinative practices in complex work arrangements at scale. In scaling the study of coordinative actions, seven dimensions have been identified as important: Synchronicity, physical distribution, scale, numbers of communities of practices, nascence, planned performance, and turnover (Lee and Paine 2015). Each of these dimensions has been proven to shape the potential of coordinative action in large infrastructural projects. Thus, they assist researchers in understanding the challenges or potentials for coordinative action that exist in an empirical field of research. Since large complex infrastructures, by definition, comprise multiple interlinked entities, the success or failure of such endeavors can often be characterized in terms of synergy (Bietz, Baumer, and Lee 2010) or by reverse synergy (Langhoff et al. 2018) within the coordinative actions which take place across entities.

When we explore work in our empirical case on network infrastructural change, we utilize the conceptual landscape of cooperative work as an analytical lens to unpack the otherwise invisible infrastructures that serve as the background in our complex organizational practice. The concepts guide the empirical investigation in terms of how and where we encounter and comprehend the breakdowns and how these breakdowns emerge in the project's everyday practices.

3 Method

Our research takes an empirical approach to explore the relationship between work and information infrastructure by examining the process of a global organization redesigning the local area network (LAN). We focus on a specific project, labeled the Network Project, tasked to replace a new LAN design across the organizational structure. This involved 30 sites spanning 12 countries, yet all managed from a single office location. This empirical case offers insights into how a work task evolves over time, starting from a client request and progressing through task assignment, design development, project establishment, and cross-disciplinary infrastructural modifications. We observed the project from when

the organization established the task as a 'project' until they defined it as 'completed'. This provides insights into the organizational challenges encountered during the project and how the progress was impacted by the nature of working across the global information infrastructure. Studying work within infrastructures is relevant for understanding how cooperative actions must take the (sometimes invisible) characteristics of the information infrastructure into account, given the necessity of collaborating across different departments, work professions, and geographical borders.

Information infrastructures are recognized as both relational and ecological (Star 1999; Star and Ruhleder 1996), presenting challenges in defining the "field site" when employing ethnographic methods to study large-scale infrastructures (Karasti and Blomberg 2013). Defining infrastructure's boundaries is blurred due to the interconnections and imbrications of infrastructural components (Star 2002), wherein one person's work may constitute another's infrastructure (Star and Ruhleder 1996). Methods to study such cases range from examining breakdowns to exploring the process from 'backstage' and 'in the making' (Bowker et al. 2010; Randall et al. 2021), whereas Garfinkel (1984) argues that breakdowns are a tool for making taking-for-granted aspects visible and analyzable. Our strategy was to study the Network Project's progress, which involved various tasks of (re)designing, implementation, and management. Throughout our observation, we encountered various breakdowns in the execution of the work that revealed the expanding borders of what the Network Project involved. As researchers, breakdowns in infrastructures allow us to gain insights into the 'engine room' of the infrastructure (Star 1999). We meticulously followed these breakdowns and the subsequent efforts required to resolve them by observing the people, technologies, and policies involved in this process. Exploring breakdowns as they coincided offered insights into working within information infrastructures, showing this embeddedness to make the Network Project emerge as a transformation of the information infrastructure. Observing this project enabled us to transcend the organization's perception of the work scope and utilize breakdowns as analytical tools to explore interdependent infrastructural elements, such as ownership, responsibility, space, devices, policies, and relationships – infrastructural interdependencies that are otherwise not immediately visible. In the following sections, we present the empirical case in greater detail, followed by our data collection and analysis method.

3.1 Empirical case

The chosen organization specializes in producing and distributing entertainment content for a diverse global audience. The collaboration with the company is solely for research purposes, and none of the authors contributed to the execution of the work; our role was limited to observing work activities. This agreement is based on a shared interest in the challenges of global work in large organizations

and involves no financial exchange, only the sharing of knowledge. To protect the anonymity of the company, we name them the pseudonym GlobalContent. To maintain confidentiality, specific details regarding the content domains produced by the organization and the organizational sites' geographical locations have been modified. Labeling domain content areas reflect the company's involvement in various work domains, and the fictional countries reflect the organization's global distribution while still protecting the organization's anonymity.

Being a 150-year-old organization, GlobalContent has undergone significant expansion since its early establishment. Consequently, the organization's information infrastructure has continuously evolved along with its history. Today, GlobalContent is a holding company comprising four main sub-organizations, identified in this paper as Book, Movie, Radio, and Game. Each of these four sub-organizations manages subsidiary companies within its organizational structures, representing 200 companies of varying sizes and ownership structures (including associate, joint venture, and subsidiary entities with diverse ownership percentages and individual contractual agreements). See Figure 1. The 200 companies related to GlobalContent are globally distributed across Asia, Australia, Europe, and the US. The geographical distribution across the subsidiary companies varies; while some operate across multiple countries, others are consolidated within a single office building.

Our empirical investigation centered on GlobalContent's IT department, which is responsible for parts of the IT infrastructure across the organizational setup. The IT department develops IT solutions for various companies within the organizational structure and maintains and provides appropriate equipment required for various work activities. Ownership and responsibility within the IT infrastructure are delineated by individual agreements with all subsidiary companies.

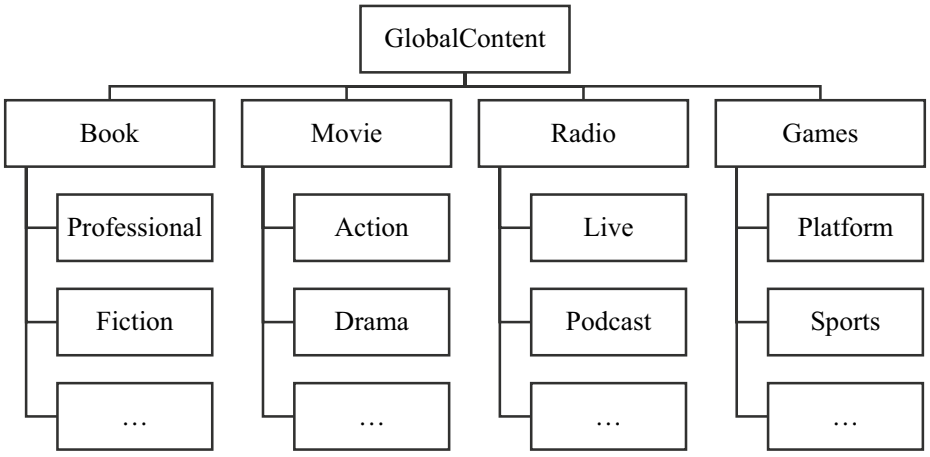

Figure 1. GlobalContent's organization structure.

For example, the IT department may oversee network maintenance and internet connectivity, while the ownership of local devices may rest elsewhere. The IT department is mainly centralized at one local site, with limited presence in other regions of the world. We focused on the IT department because of its integral role in the information infrastructure, leading to daily collaboration with multiple sub-companies dispersed throughout the organization and their work on ensuring internet access across the hybrid organizational structure. This work requires collaboration across organizational hierarchies, professional domains, and global borders. The IT department comprises approximately 55 employees, segmented into five sub-areas: data, security, devices, infrastructure, and business. This paper includes the holding company (GlobalContent), its IT department (IT), and the subsidiary main organizations (Book, Movie, Radio, and Game).

3.1.1 Organizational infrastructure

Work within information infrastructures span different organizational levels. The LAN must continuously be redesigned to meet the current organizational needs and technological advancements, including implementing and maintaining physical and digital components. The LAN work primarily involves two people employed in the internal IT department: a network architect responsible for overseeing and identifying relevant actions to be made and a supporting network engineer executing daily ad-hoc tasks. Maintenance is outsourced to an external agency that also occasionally is contracted for additional assistance in design and implementation tasks. Besides the hands-on work related to the LAN, managing positions from other levels of the organization are relevant for work related to negotiations of organizational agreements between different sub-organizations. As GlobalContent involves subsidiary companies, negotiations of contractual agreements defining ownership and responsibility of LAN components are an important. These agreements are continuously renegotiated and evolve alongside technical updates and organizational growth. For instance, the subsidiary company Movie had retained outdated components at one of its office sites prior to integrating into GlobalContent. Although Movie maintained ownership of the technical components, the IT department assumed the responsibility for their clean-up and upgrade following the integration. The complexity of these agreements often stems from the embedding nature of various infrastructure components. This is exemplified by the security locks on the LAN components at local sites, which depend on the IT department to select appropriate locks and handle their installation and maintenance, while Movie retains ownership of the locks and the associated financial expenditure. Consequently, the work related to the LAN is interconnected and depends on individuals across the organizational structure and geographical sites.

Various roles are essential for executing this work, each represented by different individuals. These roles change over time due to organizational restructuring

Table 1. Individuals related to the network project.

Subgroup	Individual	Work area
Network team	IT Conductor	Employed in the IT department at GlobalContent and responsible for managing network projects, including communication and coordination between different individuals and subgroups.
	IT Architect	Employed in the IT department at GlobalContent and responsible for infrastructure architecture and design of the new LAN architecture.
	IT Engineer	Employed in the IT department at GlobalContent and responsible for ongoing maintenance of LAN equipment.
Management	IT Director	Director of the IT department of GlobalContent.
	IT Manager	Manager at IT department responsible for the infrastructure in GlobalContent.
	Book Director	Director of the sub-organization Book working across various domains and multiple geographic locations.
	Movie Director	Director of the sub-organization Movie that works across various domains and multiple geographic locations.
Internal Resources	Device team	Includes a manager and 16 team members in the IT department at GlobalContent. They are responsible for the maintenance and service of user devices across the organization.
	Security team	Includes a manager and 5 team members at the IT department in GlobalContent, responsible for security across IT solutions.
External Resources	External A	Employed at an external agency and hired to assist infrastructure architecture in the design of the LAN.
	External B	Employed at an external agency and hired to manage the maintenance of the network across organizational entities.
	External C	Employed at an external agency and hired for technical aspects of LAN replacement.
	External D	Employed at an external agency and hired for technical aspects of LAN replacement.

and employee turnover, with individuals altering their work tasks and new people joining and leaving the organization. In this paper, we confine our empirical focus to include individuals employed at the organization during our data collection, regardless of any changes in their roles during our fieldwork. Table 1 enumerates the relevant individuals, their associations, and areas of work. We label them according to their roles in our empirical case, recognizing the evolving nature of their positions throughout our fieldwork.

3.1.2 Technical components

The LAN connects multiple groups of computer systems to share resources, Internet connection, applications, and devices (e.g., printers). It consists of both hardware and software components: the physical equipment includes network switches responsible for managing the network's configuration. These switches are housed in network racks, which provide secure and organized space for mounting and placing multiple switches, ventilation, and cable management. Each office site is equipped with at least one rack, based on their size. The software components of the network include management and surveillance tools to control user access, manage data storage, and ensure security protocols are in place.

As with any technological infrastructure, the LAN components may become outdated over time and require updates or modernized solutions. This can be necessitated by organizational changes or technological advancements. For example, if a company relocates to new office buildings or restructures its office site, the network rack may need to be relocated accordingly. Additionally, as the offices expand, the network may require extensions to ensure effective connectivity and new devices may need to be added to shared spaces such as receptions and meeting rooms.

Maintenance of the LAN involves activities such as handling LAN outages and ensuring all user clients have access, as well as updating and cleaning up old racks when new ones are implemented. Over time, as the LAN evolves and expands, new cables may be added, leading to disorganization and clutter on the racks that necessitate updates. Responsibility for LAN hardware maintenance at the subsidiary companies' local office sites varies depending on the organizational agreements and protocols.

3.1.3 Network project

We draw on the intricate details of the Network Project, which is managed by the IT department and aims to modernize the LAN architecture. The project was motivated by various internal and external factors. First, GlobalContent has shifted to cloud computing, migrating its IT infrastructure, data storage, software applications, and services from on-premises computing resources to cloud-based services hosted on the Internet. Secondly, remote work has become standard

following the COVID-19 pandemic, necessitating improved security for connecting to the LAN from different locations outside the office. Thirdly, office spaces have seen an increase in internet-dependent devices, following contemporary work practices supported by advanced meeting room equipment for hybrid setups with remote participants. Fourthly, GlobalContent has expanded organizationally, taking on responsibility for additional sub-companies with varying work domain characteristics. To reduce the need for unique solutions for these sub-companies, a standardized LAN design was preferred to facilitate effective implementation and maintenance in the future. Together, these factors imposed a new LAN infrastructure that securely and effectively facilitates employees' connections to internal resources, regardless of their locations, and dynamic cooperative work supported by various artifacts.

The redesigning of the LAN began in September 2022, albeit with several adjustments to the work approach, and concluded in October 2023. The first phases covered design work, while the plan for implementation across the 30 sites was initiated in the Spring of 2023. The LAN replacement occurred in two stages: first, the new LAN design was implemented, and subsequently, the old LAN was decommissioned. These two procedures were separated into different events, sometimes months apart. Consequently, two disruptive events were required at each site, amounting to 60 events in total. Before each event, the local devices must be identified to prepare for efficient reconfiguration. The technical work for replacing the LAN involves implementing new configurations for all network switch ports, a task managed by External C and D. Once replaced, the new network connections become operational. To verify the success of the replacement, the IT Architect and Engineer test the access and whether the local devices have successfully connected. During the procedure, the LAN is disabled, preventing Internet access at the local site. Since failures in connecting devices cannot always be handled remotely, a local person must be present at the office site for hands-on procedures such as replacing cables or testing the printers.

Given that the Network Project involved local replacements at 30 sites – resulting in 60 disruptive events where Internet access would be unavailable – scheduling activities required coordinating multiple individuals and adhering to a comprehensive timeline to complete the replacement phase within the four-month timeframe. The schedule was designed for replacement events on Mondays and Wednesdays, targeting one or two sites per day, starting at 3 PM to minimize work disruptions. Each replacement event must be completed on the same day to restore network access for local employees by the next morning Table 2.

3.2 Data collection

The data collection began with a broad focus on cooperative work activities within the IT department to obtain an overview of current projects. Two of the authors interviewed the IT Director, who provided insights into the organization's

Table 2. Locations and sub-organizations involved in the network project.

Pseudo Location	IT	Movie	Books	SUM
Avalora			1	**1**
Balunga	7		1	**7**
Cordonia		1	1	**2**
Drome			1	**1**
Elexor		1	2	**3**
Flerund		1	1	**1**
Goshal			1	**1**
Honspain		8		**8**
Idris			1	**1**
Jakovia			1	**1**
Kasnia			1	**1**
Lyrobia			1	**1**
SUM	**7**	**11**	**12**	**30**

structure and the roles and responsibilities of the IT department. During the data collection, we became familiar with the Network Project, which had been discussed in the company for years but had only recently been initiated as a project. We focused on this project due to its nature of being dependent on both digital and physical components and actions across the organization. Despite only three people being involved, it had a significant impact, particularly when it did not proceed as planned.

We studied the Network Project through observations combined with interviews, in-situ questions, and document analysis. The data collection was conducted by the first author, but strategy and focus were continuously discussed with fellow authors. Only one person worked full-time on the Network Project, the IT Conductor, and was the sole relevant employee who was associated with GlobalContent from the project's inception, thus becoming our main informant. The IT Conductor was interviewed in several iterations to understand the history of the project and the reasoning behind relevant activities that were later observed. Much of the work on the Network Project was often not immediately visible, so our strategy was to observe all work activities conducted by the IT Conductor, whose responsibility was to coordinate all actions related to the execution of the project. In this way, the IT Conductor also guided us to other relevant people, artifacts, and activities that ended up being relevant for accomplishing the work. Specifically, the first author observed the IT Conductor's activities, introducing us to new people who were relevant to the project. This included joining meetings and sitting next to the IT Conductor's desk, overseeing the screen to cover digital actions like texting, conversations, and information sharing. Since we discovered a misalignment between the scope of the Network Project as presented by GlobalContent and the relevant people and activities we observed while following the IT Conductor, this became our observation strategy

for "infiltrating" the project in practice, allowing us to map out the landscape of the infrastructural components that comprised the project.

Planned and unplanned interactions happened between various individuals, including internal meetings in the department, between managing positions internally and externally, individuals delivering either components or information to the project, the scheduling process, and the execution of the replacement. In this way, we were guided to relevant dependencies of the project, who then became a subject for our scrutiny to uncover their position, role, and tasks. Each time a person was introduced, we added this to our mapping of the infrastructure of the project work.

During the data collection, we observed various challenges and breakdowns in the work delivery. Realizing that these breakdowns happened weekly, though with varying impact, and sometimes easily solved, we observed that they were sometimes linked to actions not immediately a part of the work setting. As we were interested in how the work continuously expanded and showed to be dependent on more people than was first considered relevant, we used the breakdowns to uncover relevant individuals and components that are normally otherwise not visible (Randall et al. 2021; Star and Ruhleder 1996). When a breakdown happened, we observed the work conducted to solve the problem. Depending on the emergency of the breakdown, we asked elaborating questions either during the repair work or waited until an appropriate time later. In some cases, the incidents expanded more days, and we made sure to follow up on the situation later by interviewing the relevant individuals when possible. For example, we observed an incident of an external site reporting challenges in the newly implemented LAN, leaving local office users unable to connect to the network. Here, we observed the IT workers' communication and actions that transpired across the organization but always included representatives from the IT department's local office site. Concurrently with the IT workers' identification of the problem and their efforts to solve it, we documented observations on their scrutinizing work. We gained access to this through our observational presence at the office site, and at the end of the day, we asked the relevant individuals elaborating questions about the reasoning behind their actions and for additional information on the challenges encountered during the repair work for the specific breakdown.

Our data collection began in the Spring of 2023 and ended in the Fall of 2023. Since the planning of the LAN modernizations predates the actual project, interviews were conducted to document the history of the preparatory work. The first author carried out the observations and interviews during the ethnographic study, while the last author also interviewed the IT Director and other relevant management personnel. The ethnographic fieldwork entailed 75 h of observations, 16 field visits, and involved 55 people. To document the data, we took observation notes throughout all empirical work, supplemented with documents when available (i.e. screenshots of communication and policies in an anonymized

format). Since recording images and audio was prohibited, we relied on written notes taken during meetings and work activities. Upon completing fieldwork, we documented detailed descriptions daily. These accounts were used for subsequent analysis of the landscape of the infrastructure. Quotes from informants presented in the paper have been verified by those individuals, confirming the accuracy of their statements.

In collecting data, we recognize the limitations of conducting ethnographic research only at one of the office sites. Nevertheless, our objective was to examine the evolution of the work practices within the Network Project. Given that the project's management and execution were centralized at this office, it served as an ideal vantage point for gaining insights into the operation of information infrastructures. The significance of various individuals and subgroups, both internal and external, along with organizational policies and technical components not initially considered integral to the Network Project, became visible only through our observations at this site, which is why our methodological approach maintained this strategy throughout the data collection.

3.3 Data analysis

To analyze how the context and content of the work and information infrastructure co-evolve throughout the progress of the Network Project, we gathered all relevant data, including observation notes, interview transcripts, site pictures, screenshots, company documents, and other relevant material. When examining the work associated with the Network Project, multiple actions occur simultaneously that may or may not be organizationally connected. During the data collection, we realized that identifying relevant interdependencies across the infrastructure was a core challenge of performing the work – and for us as researchers to define our scope of research. The data analysis, therefore, began already during the data collection, allowing us to follow the complexities of the work. We mapped out individuals and activities relevant to accomplishing the work, as well as when they were only involved in a short time or minor activity of the project. Upon diving into the details of the project and the observed challenges in the execution, we realized that the work related to completing the task extended beyond the scope of the Network Project as it was presented by the organization. In particular, the observed breakdowns provided insights into relevant people, components, and policies that the work depended on despite not being within the scope of the project. This, for example, includes other projects in the IT department and companies that are not a part of GlobalContent's organization.

For our analysis, we included 12 breakdowns, all representing different characteristics, such as who was involved, the scale of the breakdowns' impact, and the geographical location of the breakdown and the involved individuals. We wrote detailed empirical descriptions of all the breakdowns to map out the technical cause of the breakdowns, the situation where the breakdown became visible, and who was

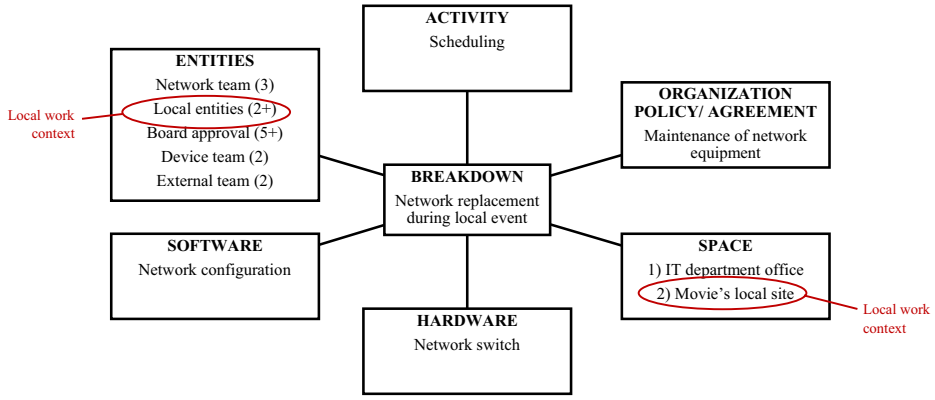

Figure 2. Example of affinity diagram of breakdown in work accomplishment.

involved in the repair work. Inspired by affinity diagramming (Lucero 2015), we mapped out the infrastructural details of each of the breakdowns to explore all contributing causes. For example, refer to Figure 2, which illustrates our analysis of a breakdown. Here, we map out the breakdown, the work required to solve it, the individuals participating in the work, the physical space where the work takes place, relevant organizational policies, and the software and hardware components involved. In this analysis, we also explored potential reasons for the breakdown (e.g., lacking knowledge, disagreements) and areas of manifestation (e.g., space, people, technology). The breakdown illustrated involved overlooking the local workspace beyond the directly involved collaborators, thereby encompassing additional work contexts and individuals placed outside the scope of awareness.

When comparing the characteristics of the different breakdowns, we group them into distinct categories based on the activity, the cooperative work, the technical components, and the responsibility and ownership of the infrastructure. In this analytical process, we found that while some breakdowns were more straightforward to map out and link to causing components, others had links to causing elements that were not immediately visible or solvable. The breakdowns revealed the LAN replacement to be a transformation of the information infrastructure. Failure to recognize this risked creating faultlines in the boundary-crossing activities among different 'work contexts' represented in the infrastructure. Based on the characteristics of the breakdowns we analyze the work on the Network Project from different analytical lenses, starting from the initial phases of the design work, leading to the final steps for accomplishing the project. Each breakdown expands the work's borders in different ways, providing insight into the implications of transforming information infrastructures.

4 Results

The perception of the Network Project changed throughout the execution of the work, initiating it as a design task and evolving it into a defined cross-organizational project. To present the actions, artifacts, and policies that contributed to the expanded borders of the work, our result section takes different viewpoints on the project. First (4.1), we focus on the design phase of LAN architecture and present the challenges that followed when the new LAN was to be implemented, relating to overlooked complexities in the nature of the work. Secondly (4.2), we demonstrate how the establishment of the Network Project altered the perception of the work, leading to a predefined workflow acknowledging the dependence of actions from people around the organization. However, our analysis of the breakdowns revealed faultlines between not only recognized dependencies within the project but also extending to invisible infrastructural components. The remainder of the result Sect. (4.3) presents breakdowns related to people, artifacts, and policies that occur within the recognized field of work, as well as boundary-crossing activities that are out of sight.

4.1 Identifying work as infrastructural transformations

Analyzing the process of the Network Project, the initial challenge was to comprehend that the project was an infrastructural transformation. The organization's perception of the work was shaped by the early stages of the project where the LAN reconfigurations were approached as a design task for outlying the architectural design when moving to cloud-based solutions. The redesign was motivated by a request from one of Book's sites in Lyrobia. The Lyrobia site relocated to a new office building, and the organizational agreement between GlobalContent and Book defines GlobalContent as responsible for delivering appropriate LAN infrastructure. Book requested a network solution that supported external access to the LAN, enabling guests to have Internet access. At that time, the LAN was supported by an old data center in the basement. Since then, the organization has moved to cloud-based solutions requiring a modern network architecture. In addition, after the COVID-19 pandemic, employees across the organization had normalized hybrid work models, where employees occasionally work remotely from home, which set new requirements for secure LAN access from locations outside the office. Furthermore, the type and number of devices have changed, and the work involves multiple devices at various locations; for instance, office spaces are equipped with monitors and speakers connected to the LAN that must be available for both internal employees and external guests, also setting a new requirement for the security of the network infrastructure. Finally, the organizational structure has changed over the past decades, resulting in GlobalContent consisting of several sub-companies with varying characteristics. The IT department is responsible for providing LAN infrastructure for some of these

sub-companies. Prompted by the specific request, the general status of the LAN led to the decision to create a new standardized design to be implemented organization-wide and meet the increasing demand for secure network infrastructure supporting modern work environments, such as working across multiple locations enabled by various artifacts.

Responsible for designing the new LAN, the IT Architect joined the IT department on September 1, 2022. Together with an external consultant, External A, they, with the use of pen and paper, brainstormed design solutions that could be implemented at all sites while accommodating different needs. When necessary, they collaborated with coworkers from the security team at the IT department to ensure the development of a secure solution. The design requirements included: (1) availability for external guests at the local office site and (2) enhanced security measures to accommodate the current work conditions with multiple devices requiring internet access and remote work from multiple locations.

When a design solution was developed, it was presented to the management team at the IT department, which included five managers across the IT department. As the solution was approved, the IT Architect and external consultant started prototyping and testing the solution. At the local IT office, they created a test setup including switches, access points, laptops, cell phones, and other relevant devices. Over a few weeks, they created a LAN design that was considered ready for being tested where Book's Lyrobia office site acted as a test place for proof-of-concept. In December, when Book moved into their new offices in Lyrobia, External A traveled to the site to set up all the required IT equipment for the new office space. This included the setup of racks, switches, access points, connecting cables, etc. After a week, External A returned to the local IT office, and together with the IT Architect, they spent a month solving emerging issues with the LAN solution. For example, challenges with connecting equipment in the meeting rooms. Throughout this month, final adjustments to the LAN design were implemented.

After the proof-of-concept, the Network Project was considered a completed design task ready to be implemented at the other sites and was, therefore, handed over to the external agency responsible for network maintenance. The second site was Book's office site in Balungu as they had to replace all their hardware equipment. This replacement was handled by the external agency, as the LAN replacement was considered a re-configuration of the Network switches and, therefore, could be defined as maintenance. While the external agency did solve this task, several challenges arose. The external consultant responsible for maintenance, External B, reported that the LAN reconfigurations expanded beyond the scope of maintenance and that it was beyond their capabilities to solve the problems that were arising, and they declined to proceed with the following sites. The IT Conductor was appointed to the Network Project, and through discussions with External B, they defined requirements for accomplishing the replacement. The

IT department requested a report from the external agency outlining the specific requirements to complete the work, and the external agency, in turn, requested a project manager and a detailed plan for the replacements. A team comprising three workers from the internal IT department – the IT Conductor, the IT Architect, and an IT Engineer – was established to create the detailed script of actions required for replacing the LAN. In this reprocess, the newly established network team realized the work's level of complexity. The work was dependent on not only technical work but also detailed communication and coordination work across the organization. The IT Conductor explained:

> 'With this script of actions, we realized that replacing the LAN is not just a reconfiguration of the switches, it requires detailed information from each of the individual sub-sites, that could not be handled by [an external agency] but must be handled internally [within GlobalContent's IT department]. We therefore agreed that it must be a joined project performed in collaboration between us [IT] and the external agency [responsible for Network maintenance]'. (IT Conductor)

The changed perception of the Network Project evolved over more than six months, shifting from merely a design task to a complex undertaking involving replacement and reconfiguring of the LAN on a global scale. During this time, managing positions were replaced with new individuals, and the organization continuously underwent structural changes, leading to changes in the roles of individuals involved in the LAN replacement. Exploring the activities that led to the establishment of the Network Project provides insights into how the complexity of even recognizing the nature of work was indeed a transformation of the information infrastructure. The task description evolved continuously with the organizational structure. The individuals involved in the management and performance of the work simultaneously redefined the conditions and requirements. These redefinitions led to neglect of interconnected relations and consequences of the procedure, requiring the work to not only be seen as a technical task but as an infrastructural transformation dependent on actions beyond the immediately linked individual doing the technical procedure.

4.2 Implementing infrastructural transformations

A detailed workflow was established, addressing both technical and cooperative tasks to plan the implementation of the LAN changes. The IT Conductor was responsible for coordination and communication, while the IT Architect, who designed the LAN, continued to support the implementation. The IT Engineer provided technical assistance, which included local site visits. GlobalContent collaborated with an external agency to define the necessary technical knowledge for specific tasks. The LAN replacement relied on the

expertise of two external consultants, External C and External D, who managed the technical aspects of the LAN reconfigurations. Although these individuals constituted the Network Project team, the success of the project hinged on additional roles within the organization. Each office site appointed a contact person responsible for providing local knowledge that was crucial for planning the replacement event as well as coordinating activities during the event itself. In some cases, this contact person was the local IT department manager, while in others, it was the local facility manager.

Due to the impact of the work on the local sites, all LAN replacement events were required to go through a specified acceptance process before proceeding with any implementations. This process is illustrated in Figure 3. First, a written request for the procedure had to be submitted, including a description of the procedure covering both the goal and technical details. Then, the potential impact of the procedure should be rated, which was high in this case since the LAN would be disconnected, preventing local workers from having Internet access. Further, the individuals involved in and responsible for the procedure and the relevant divisions covering the local sites were listed. Additionally, an evaluation of potential risks should be listed with their rating of likelihood, impact rating, and mitigation plan. Finally, a fallback plan was required in case of problems in the replacement. This request was assessed by a board with representatives across the organization, which had to approve the procedure before it was performed. This meeting occurred weekly, and, besides the mandatory participants, it extended an open invitation to anyone who deemed it relevant. All LAN replacement events were required to adhere to this process.

This detailed workflow shows how the implementation of the LAN configurations was approached completely differently in the summer of 2023 compared to the initial replacement events in the previous winter. All LAN procedures required preparatory planning activities involving several people

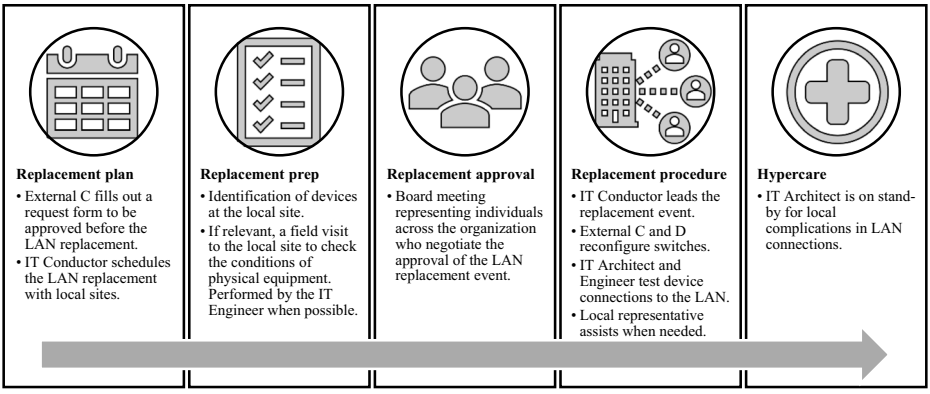

Figure 3. The envisioned workflow for LAN replacements and the individuals involved.

across the organization. Although only a few of these individuals were directly related to the Network Project, the work was highly dependent on their actions. Despite the detailed plan, various breakdowns occurred during the execution of the work, which we will elaborate on in the following sections.

4.3 Breakdowns in boundary-crossing activities

During the fieldwork, we observed different breakdowns despite the predefined workflow related to both relational and technical actions. The breakdowns can be categorized into the cooperative work, technical work, and organizational negotiations. While all three aspects are interlinked, we take different analytical perspectives to present the different sources of the breakdowns. We present two different examples of breakdowns under each category: First, a breakdown occurring locally within the recognized field of work, making it possible to identify the sources for misalignment, and, secondly, a breakdown manifested in people, artifacts, or policies that are not immediately linked to the work yet having a significant impact on the progress of the Network Project. Since all the breakdowns happened despite the envisioned flow being followed, analyzing them reveals connections to relevant people and components across the broader infrastructure, which severely impacted the work's success.

4.3.1 Collaboration across Subgroups

The first breakdown centers on scheduling the LAN replacement event. Due to the nature of the work required for the LAN replacement, i.e., turning off network access at local sites and connecting distributed individuals from different organizations, scheduling an appropriate time for the work was an important activity, depending on a tight schedule. We draw on two incidents: one within the project team and the second that emerged as an unexpected event at the sub-company's local site.

Misalignment within the project

Team The technical work configuring the LAN required at least six people, whereas three were from GlobalContent's IT department, two were from the external agency, and one was from the local sites where the LAN was implemented. As these people had to be available at the same time, any cancellations affected the Network Project substantially. GlobalContent hired two external consultants to decrease the risk of cancellation and ensure a consistent workflow. During our observations, we observed instances where the external consultants did not show up for the planned replacement event. While this was caused by natural circumstances like sickness and personal occupations, the consequences of the cancellation were impactful. The work planning assigns specific individuals to specific roles in the execution. What was perceived as a small change from the external consultant – rescheduling to a

different day – added additional work for rescheduling within an already tight timeline involving numerous individuals across the organization.

Invisible local event

Moving to a breakdown that occurred outside the immediate project group, we examine an incident where a LAN replacement event was planned to be conducted simultaneously as a local event that took place at Movie's office site in Goshal. The scheduling of the LAN replacement followed the planned workflow and was therefore approved by various people. Two hours before the LAN replacement was planned to be executed, the IT Engineer visited Movie's office site in Goshal for maintenance work not related to the Network Project. When the IT Engineer arrived at the site, they noticed extensive preparation for a major event, including red carpet, reception staff, and presence of celebrities. The IT Engineer contacted the IT Conductor to confirm the scheduled plan of the LAN replacement and informed them about the local event. After some inquiry, they discovered that Movie hosted a local event on that day, within the same scope as the planned LAN replacement. Recognizing the potential impact of shutting down the LAN and preventing network access during the event, they immediately canceled the replacement event.

The discovery of Movie's event was purely coincidental, as the IT Engineer visited the local site earlier than planned and for work related to a different activity. Given the significant impact shutting down the network would have had on Movie's work, discussions later ensued on how the scheduling agreement could happen. However, they found that the planning *did* follow the envisioned workflow, meaning that both managing positions, technical workers, and local representatives from Movie had approved the execution of the LAN replacement event within the timeframe.

This breakdown is interesting because all individuals involved consider their work to have been successfully completed, and no one, whether internally or externally, would have done anything differently. The local representatives from Movie explained that they cannot be expected to be familiar with such events as this is out of their work context, and they cannot guarantee that the same incident will not happen again in the future. The project team cannot implement any actions into the workflow to prevent this from happening again, as they do not have access to information on local activities.

Comparing this breakdown to the misalignments within the project group, both are challenged in planning the replacement. However, this breakdown reveals that the work on the LAN had dependencies that were out of sight, as information on local activities was missing. Interestingly, this information is not only outside the scope of the individuals associated with the Network Project and the IT department in general but also outside the local representative's view of the local context.

4.3.2 Identifying and connecting devices

In the second category of breakdowns, we explore the technical work and misalignment of connecting and identifying the physical devices. Before a LAN replacement event, devices at the local site must be identified to plan for any unique items requiring special attention. A subgroup in the IT department is responsible for managing devices across the organization and they therefore provided this information to the project team. However, we observed instances where this information exchange did not occur smoothly, leading to delays in the project.

Forgotten devices

The first breakdown occurred during a LAN replacement event at two of Book's sites, Cordina and Drome. The replacement included seven people over a time span of 5 h; the IT Conductor was placed at the IT department office, while the remaining participants, the IT Architect, IT Engineer, and two external consultants, were working remotely from home. Further, two local representatives joined the work when needed, and both were placed at their local office sites in Cordina and Drome. The communication and collaboration were facilitated by Microsoft Teams, with two separate calls – one for each of the sites. The two local representatives joined the respective calls from their local office. The LAN replacement was estimated to take one hour, with the event in Cordonia planned for 3 PM and the event in Drome planned for 4 PM. At 3 PM, all participants joined the MS Teams call. The manager confirmed with the two external consultants which change they were about to perform and informed the local representative about the expected time frame. Hereafter, the local representative left the MS Teams call but stayed accessible to assist with the testing from the local site.

The external consultant began the procedure of replacing the network. While the technical work on reconfiguring the LAN switches went successfully, they encountered difficulties in connecting the local devices to the new network. To identify the problem, they discussed the types of devices in use and determined that one of the external consultants had identified it as a Dell computer. After an hour of troubleshooting without finding a solution, the local person joined the call. During the discussion, they realized that it was a Mac computer, and the local person did not have access to a Windows computer. Mac devices require special configurations to be connected to the LAN. While the project team was aware of the need for special configurations, they did not know that the local site included Mac devices or that the configuration had not been implemented. Since it was not the project team's responsibility, this work was expected to have been performed by the IT department's subgroup for devices before the LAN replacement event. Therefore, the project team did not have either access or qualifications for implementing the reconfigurations during the replacement work. This

specific incident was solved by the coincidence that the representative in Drome had access to GlobalContent's internal documents and was knowledgeable about Mac devices. This was a fortunate coincidence, as he is the only external person with this access due to his expertise in Mac devices, yet he solved the situation as he assisted in the identification and configuration of devices at the Cordonia site. The issues caused a delay of two hours in LAN replacement at the Cordonia site, subsequently delaying the start time on the site in Drome, thus requiring the local person to remain at work for an additional five hours. The tight schedule for the LAN replacement event made the team proceed with the procedure, as rescheduling would have impacted the entire project plan and other office sites.

In this breakdown, the devices were not configured before the procedure, and the team was not prepared for the local representative to only have access to Mac devices. As a result, they could not ascertain whether the connection issues lay with the network replacement or with the devices themselves, causing delays in their work for several hours. However, this lack of workflow before the replacement event was not an isolated occurrence. A similar breakdown occurred during a LAN replacement at one of Book's office sites in Avalora, where a printer was not identified. This required the project team to handle the assignment of IP addresses to these devices and investigate the presence of other unique devices during the replacement event, which again caused delays in the work. In these breakdowns, the workers figured out *what* the issue is (devices not identified and configured beforehand), though the examples present the impact of breakdowns in the technical work not following the planned process. There were misalignments in the understanding of the individual's role in the Network Project, which consequently later made GlobalContent assign an additional person to the Network Project whose responsibility was to identify and configure devices.

Invisible devices

After a LAN replacement had been executed and completed at a Book site in Elexor, the old networks were removed, and all devices were successfully connected. However, the local office site in Elexor experienced unexpected network problems after the replacement, as they were unaware that having external guests would be an issue when using the new network. The morning after the implementation, the local representative from Elexor contacted the IT Architect to report that the network functioned differently than they expected. The local representative made use of the *hypercare* service, a five-day period during which sites were permitted to bypass the regular service request process and contact the IT Architect directly after a LAN replacement. The local representative described that not everyone present at the office could connect to the network. A meeting was arranged between the local representative and the IT Architect to identify the problem. During this meeting, they discovered that the Elexor site had individuals sitting at their offices, who were a special type of external guests associated

with a company owned by the Book organization but without affiliation to GlobalContent. Before the LAN replacement, the external guests had access to all services at the office, including printers and monitors. After the replacement, they no longer had access. Allowing external devices access to printers and monitors in the old setup was a security risk. This security vulnerability was one of the motivations for redesigning the network. In the new LAN architecture, this security breach was prevented by segregating internal, external, and IoT devices into separate networks. Consequently, this requires external guests to connect to the publicly available network that provides Internet access yet prevents access to internal systems, meaning they do not have access to local IoT devices.

In this incident, the newly implemented LAN functioned as designed – it provided access to their guests' devices while preventing them from accessing internal resources. However, the external guests in this situation needed access to internal devices doing their work, such as monitors in meeting rooms for online meetings. The new LAN infrastructure was, therefore, an insufficient solution for the Elexor site. This realization occurred eight months after the implementation of the new LAN, as the old options were removed. Since the core team cannot make changes to the network infrastructure design at this time, managers from both companies met to discuss the situation and possible solutions.

This breakdown is linked to the technical design of the LAN causing issues on connecting devices; however, it relates to the organizational structure of GlobalContent and its subsidiary companies. The breakdown became evident when the old LAN design was removed, but the challenge existed even before that, as the external guests had been using the internal resources without GlobalContent's knowledge. Compared to the challenge of connecting devices during a LAN replacement, this incident is related to external users that are not related to GlobalContent, but instead to GlobalContent's subsidiary Book organization. The IT department was not aware of the guests at the site, and until this point, the Director from the Book organization had not had a reason for sharing this information with GlobalContent. Interestingly, this specific site in Elexor was the site requesting a redesign of the LAN initiating the project. Exploring the details of this breakdown, we found that the misalignment had already occurred in the early design phases of the LAN when Books requested a new LAN infrastructure. The individuals from Book and the IT department did not have a shared understanding of what a "guest" is and what "connection" entails. When Book made the request, they wanted external guests to have equal access to internal devices, while the IT department designed a LAN that only allowed guests to access the Internet through the LAN. The consequences of this breakdown became apparent eight months later when it was realized that the implemented LAN did not sufficiently meet the requirements. This breakdown shows how the infrastructural setup can represent relevant subgroups that are not visible

from the local work context. In this situation, the work depends on information of technical components from people placed across the infrastructure, however, in this case, these people only had a reason to report on this *after* the breakdown had already happened.

4.3.3 Responsibility and ownership of an infrastructure

The third category of breakdowns concerns responsibility and ownership. The organizational structure of GlobalContent makes assigning specific roles important, yet sometimes challenging, as one component can represent responsibilities from different individuals or subgroups.

Local turnover

The first incident relates to a disagreement regarding responsibility arising from a request from the subsidiary Movie organization. The Movie Director requested that the IT department connect an iPad to the LAN. The iPad was placed in the reception area at the Honspain site for external guests, so it was mainly used by individuals not associated with GlobalContent. The request to connect the iPad to the LAN was sent to the IT department's subgroup managing devices. The Director further requested the IT Conductor to connect the iPad to the LAN. The IT Conductor guided the iPad to be connected to have a 'device' log-in, meaning that the device does not have a unique person connected to the account, but was contradicted by the IT department's manager for security. The IT Conductor and the security manager disagreed on how a device in a partly public reception should be connected. During the LAN design phase, the IT department's current security manager participated in the LAN design to ensure security requirements. However, this person had been replaced since the LAN was designed and when it should be implemented. The turnover of security responsible introduced new opinions on the security of the LAN design. This specific event consequently halted the process of connecting the iPad. The request from the Movie Director looped within the system, with different individuals in the IT department denying it due to disagreements on the security of the new design. The access required for this specific device, therefore, necessitated re-negotiations of the LAN design responsibilities. We include this breakdown to highlight the challenges of turnover of individuals assigned responsible roles, as the LAN redesign is a part of information infrastructure requiring a long-time scope for making the solutions last. The main point here is of both technical concern in terms of security on devices in public areas as well as organizational, since "who" would be the 'sign-in' user for public space devices.

Major incident

For this example, we draw on an incident of an unexpected LAN outage at Movie's office. On a Friday during the fieldwork, a local representative from

Movie in Elexor reported an incident of LAN outage, which must be filled out in a digital system. The external agency responsible for maintaining the network received the incident report in the internal system. External A handled the report and began troubleshooting to identify the cause of the LAN outage, though without success. Consequently, a local person at Elexor called the IT department directly, complaining about the LAN outage that had been ongoing for hours, making it impossible for the local employees to work. An IT manager from the network subgroup discussed the urgency of the incident with the local person and the need to declare a 'Major Incident.' Declaring a Major Incident is an option when the LAN outage prevents work, leading to significant damage, and requires top-level managers to halt their immediate tasks and focus solely on resolving the issue. Before the IT Manager called 'Major Incident', the IT Architect and IT Engineer from the Network Project stopped their own work to look at the problem. They restarted the APIs, which immediately solved the problem and made the LAN up and running. At this time, the LAN had been out for around 4 h but was solved by the IT Architect and Engineer in a few minutes. This incident was simply solved due to their knowledge of the LAN infrastructure, but this work was not their responsibility.

Concerning our analysis of the Network Project, this breakdown is interesting as it indicates the challenges in blurred responsibilities and knowledge in boundary-crossing activities. While investigating the sources of the LAN outage, we discovered that the external agency had conducted a minor repair to the LAN configuration the day before the outage as part of their maintenance duties. The team associated with the Network Project maintains a close collaboration with the external agency, sharing knowledge on how to maintain the LAN efficiently. Consequently, they have advised the external agency that restarting APIs should be mandatory for all LAN configurations due to past challenges when this step was omitted. It is through their involvement with the Network Project that they possess the expertise to resolve the outage and prevent major incidents quickly, though it is not their responsibility to do this work, as the responsibility for maintenance lies with the external agency.

5 Discussion

In our empirical exploration of the content and context of a specific work task at GlobalContent, we studied the dynamic and reciprocal relationship between local work contexts and global information infrastructures. A detailed analysis of various breakdowns in the work revealed the expanding boundaries of what entails "the work," allowing us to analytically unpack infrastructural transformations evolving in the background. In the discussion, we argue that these transformations are not only intertwined with articulation work, thereby *shaping* the nature of work (Kobayashi et al. 2005; Mark and Poltrock 2003; Schmidt and

Simone 1996), but further push the boundaries of how infrastructure transformations impact the nature of work in terms of *scoping* and *scaling*. The replacement of the LAN, as a transformative activity within our case, highlighted the intricate entanglements of organizational elements and ecological components (Star 1999). By adopting an infrastructural perspective, we uncover *the ripple effect of information infrastructures* that impacts local work contexts in unanticipated ways beyond the immediately visible work practices. This interplay adds complexity to the work, technical setups, and organizational policies, delineating the nature of work in transforming and maintaining information infrastructures. The hidden interdependencies between local work contexts and information infrastructures require an extended peripheral perception in shaping and scoping the work at multiple scales.

5.1 Shaping work

When transforming infrastructures, it is essential to understand the nature of the work, its impact, and the required activities to solve that task. The Network Project reminds us that identifying work as infrastructural transformations is not necessarily straightforward as the content and context of the work change and multiply over time. In hindsight, it might be simple to characterize the LAN replacement as a fundamental alteration to the organization's information infrastructure. However, our data present an empirical example of how large-scale transformations can begin as specific tasks – in this case, the redesign of a new LAN, initially involving only two individuals. As the work progresses, the challenges encountered reveal that, in practice, the Network Project extends beyond these initial boundaries due to the nature of the work and the context in which it is executed. Nonetheless, *recognizing the articulation work required* to bring these efforts into functional configurations remains a significant challenge (Ciolfi, Lewkowicz, and Schmidt 2023; Schmidt and Bannon 1992; Suchman 1996).

Our data demonstrated different situations where the work did not succeed as planned. When the work failed, it led to additional 'repairing' activities, and it is, in particular, the added effort put into repair work that reveals the local work required to have an infrastructural impact. Previous literature has identified various types of repair work, which, in our case, are associated with technical work, management, and organizational activities (e.g. (Cohn 2016; Graham and Thrift 2007; Henke 2017; Maestri and Wakkary 2011; Mikalsen, Farshchian, and Dahl 2018). Repair work, in our case, emerged as a consequence of the project's progressions yet also had implications that extended across the entire infrastructure, influenced by the local work contexts. Work and organizational structure are interdependent since adjusting one immediately impacts the other (Barley and Kunda 2001). This is particularly evident when transforming infrastructures. In our case, the Network Project was approached as a local work activity involving

technical implementation and scheduling among assigned project members. In practice, the work impacted the organizational structures, creating dependencies outside the project. Lacking accommodations for dependencies leads to breakdowns that require additional activities that are not directly related to the task but are "by-products" of these actions. This was an example seen in the technical breakdowns requiring not only work on the decay of technical components but also repairing activities related to the organizational relations between the individuals placed in the different sub-organizations. In these technical incidents, the breakdown related to the Network Project led to negotiations of ownership and contractual agreements.

Further, our empirical case demonstrates the challenges concerning the responsibility for actions and ownership of components when transforming infrastructures. The intertwinement of infrastructural elements makes it impossible to own an infrastructure (Langhoff et al. 2018) since the multiplicity of infrastructural components often necessitates distinctly divided responsibility and ownership areas (Bjørn and Boulus-Rødje 2018; Jabbar and Bjørn 2018b). This increases the risks of clashes at the borders of responsibility areas (Jabbar and Bjørn 2018a), which can create misalignments in the progress of the work. In our case, challenges of responsibility and ownership became evident in both local and distributed contexts (Jensen 2014; Olson and Olson 2000). Starting with the local, the LAN replacement procedure required four people to connect one device to the LAN: one must identify the device, one must reconfigure the LAN switch, one must connect the device, and finally, one must test the success of the procedure. One single replacement event, therefore, inherent overlaps in responsibility areas, yet these are blurred as some tasks are physical (opening the computer) while others are digital (reconfigurations), yet impacting the same part of the infrastructure. The LAN replacement is therefore not limited to the digital work nor the scheduling of actions across the involved entities but further to identify *which* parts of the infrastructural work everyone is responsible for, *where* these activities need to take place, and *when* they will take place. For example, the device team continuously delivered their work of maintaining the local devices, but the accomplishment of the LAN replacement required specific knowledge at a specific time to be prepared for implementation and testing. Furthermore, the Network Project was approached as a standardization project, where the design solution was planned to be suitable for implementation across various subsidiary organizations and geographical locations. Also, the procedure of implementing the LAN was standardized following the same workflow, not distinguishing between different local characteristics. However, the breakdowns show that while the workers (the project team) and the work (reconfigurations of switches) might be the same, the context and nature of this work set different requirements for the articulation work required, depending on the characteristics of the local sites, both concerning the required scheduling and the design of the

LAN. The perceived nascence of the work makes the project dynamically move across the continuum of being considered routine work due to the underrated complexity (Strauss 1988), as the approach to standardize design and process instead leads to breakdowns requiring additional work for "repairing" activities in order to accomplish the task.

From our analysis, we see that the work's nature drives the transformation of how it is executed and the evolvement of actors since it matters whether the work is a design task, network maintenance, or network replacement. While the Network Project was initially approached as a standardization project to reduce the complexity across sites, the progress of the work forced a change in the perception of the task to consider flexibility in use. Hanseth et al. (1996) explored the tension between standardization and flexibility when developing information infrastructures; similarly, our case embodied tensions created from approaching the work as standardizations yet being challenged by the number of unique requirements. The Network Project was an embedded part of the information infrastructure, and if the LAN malfunctions, local workers will be disconnected from the Internet, preventing them from working. The local work is embedded into the information infrastructures, shaping the nature of the work and the requirements for succeeding. In practice, it is almost impossible to distinguish between "work" and "articulation work" since they both shape each other (Schmidt and Bannon 1992). Looking into how the work is articulated, we agree with several other researchers that work and articulation is a seamless integration (Ciolfi, Lewkowicz, and Schmidt 2023) and confirm prior work that the evolving content and context of the multiple local work actions placed around the information infrastructure is *shaping* the nature of the work.

5.2 Scoping work

Work on transforming information infrastructure extends the local context where the work is articulated, as dependencies can be located across the infrastructural setup. Here, we argue that the multiplicity of information infrastructures is *scoping* the nature of work by pushing the boundaries for where to look for interdependent entities. Gerson (2008) adopts the term "bracket" to examine the coordination mechanism required for making connections across a larger system of dependencies. In our analysis, we identified different challenges related to 'bracketing the task' due to the reach of the work involved in transforming the infrastructure. Interestingly, the 'bracketing' challenges were linked to the work's hyper-distribution, i.e., the work taking place across several subgroups in different parts of the world. Subgroups are created in individuals and groups' attributes, locations, affiliations, or other cultures and characteristics, where the presence of faultlines between these groups increases the risk of misalignments (Cramton and Hinds 2004). In our case, the completion of the work depends on actions from individuals associated with different sub-organizations, creating

numerous subgroups across the organizational structure, covering both the local and global context. While the subgroups within the local context are easier identifiable, i.e. the subgroups within the IT department, including the project group, 'device' group, and 'security' group, the subgroups outside the local work context can be less visible.

In our case, the required knowledge from the local sites was a driver for the added complexity of the work. While designing the LAN was considered a "standard" solution, the breakdowns related to the implementation of the otherwise standardized design revealed the unique qualities of several of the local sites. The LAN replacement required expert knowledge on reconfiguring network switches, as well as local knowledge on the work characteristics of the work content and context at each of the sites. The last was managed by assigning a local contact person. However, possessing local knowledge is not necessarily an easy task in distributed settings, as describing local circumstances requires *access* to information and an *understanding* of the local circumstances (Gerson 2008). Further, being physically present does not necessarily mean access to the same and right information, as we see in the challenge of collocated distance (Duckert, Barkhuus, and Bjørn, 2023). During the Network Project, challenges related to both access and understanding arose in the use of local experts. The local person was defined to be available at the time of the local replacement, however, doing the work required more detailed knowledge. Concerning *access*, our data document a situation where the local person was accessible in the timespan requested yet was *placed in a different location* than the office (i.e. working remotely) and thus did not have access to the local information at the office. In a different situation, the role of being a local contact was assigned to a person from the finance department. The finance person did not have the required *understanding* and lacked important technical knowledge to work with the network components placed at the office. The lack of relevant knowledge at the local site thus complicated the coordination, requiring local assistance. In this way, the multiplicity of geographical locations and individual experts scopes the nature of the work. The need for local specialized technical knowledge at the distributed sites sets the requirements for the *'right' actor* to be located accurately next to the network racks and office devices to synchronize the local information needed.

The scoping of the work is not limited to individuals; replacing the LAN is highly physical, depending on hardware components placed at sites distributed away from the actors doing the work. The interdependent social or organizational *entities*, in our case, therefore, include both people, artifacts, and organizational agreements. Accomplishing the work involved in transforming the information infrastructure requires cooperation across different entities, which can inherit different characteristics. The reach of the work is scoped by the individuals involved, their geographical distribution, and which subgroups

they are associated with. Multiple entities include more people and characteristics of additional domains, places, and artifacts.

Considering the temporal dimension, we found that, similar to Grisot and Vassilikapoulou (2015, 219), the constellation of the collaborating individuals cannot be predefined but evolves dynamically. The *scoping* of work is, therefore, not a constant scope of relevant individuals but is a dynamically changing network of entities. This can challenge the work practices, for example, as seen in the turnover of the security manager. This replacement of the person prevented the work of connecting a device to the LAN due to the new security manager disagreeing with the design of the solution. Additionally, the example illustrates the dynamic scope of relevant devices. In this situation, the iPad was added to the subsidiary company's local office site after the implementation of the new LAN. The temporally dynamic constellation of individuals and devices can complicate the work, as relevant entities might be placed outside of the current timeframe.

In large infrastructures, the interdependency in work and the cooperative relationship between the entities is not necessarily equally visible for all engaged actors. In CSCW, we know the accomplishment of work requires mutual dependency between different entities (Ciolfi, Lewkowicz, and Schmidt 2023), though each entity's own perception of being relevant (and dependent) in the accomplishment of the work might not be shared. Our case illustrates this as the local workers are dependent on the LAN to access the Internet, just as the implementation of the LAN requires local knowledge from these actors, though this dependency only becomes visible for the local group when the network does not function. This was, for example, seen when one of the subsidiary company offices did not report on the specific needs of LAN availability to extend guests since they did not consider it relevant until they lacked Internet access from their devices. The loose connections and unequal perception of dependency in work can challenge progress when not all entities are aware of their relevance for the task at hand.

The co-evolution of local work contexts and the information infrastructure are dynamically scoping the content of the work, determining which actors, practices, and artifacts are involved in transforming the information infrastructure. The Network Project was initially approached as a simple task involving only two people but turned out to have dependencies around the entire information infrastructure involving 52 people from 36 different organizational subgroups. As these dependencies are associated with multiple local work contexts around the infrastructure, they might not immediately be visible. Acquiring this information to identify relevant dependencies can require additional excavation work (Matthiesen and Bjørn 2015).

5.3 Scaling work

All work in our empirical case arises from or is built on top of the existing infrastructure (including hardware, software, practices, policies, etc.) and is never "new" or independent, despite actors in the Network Project sometimes approaching it so. Work on infrastructure represents smaller components of a larger interconnected framework of people, policies, hardware, and software (Fürstenau et al. 2019; Sharma and Sawyer 2016; Star and Ruhleder 1996). Exploring the details of the breakdowns, the consequences linked to the inherent premise that infrastructures adopt historical decisions, interactions, and artifacts emerge – with infrastructures consequently *scaling* the nature of work.

The work required for replacing the LAN met unexpected complications due to previous actions and past decisions that are still embedded in the infrastructure. Infrastructures are a conglomeration of several individual components, and they represent multiple temporalities as all elements have individual age paths (Cohn 2016; Monteiro et al. 2013; Steinhardt 2016). This can lead to "invisible" hardware and organizational agreements that have previously been decided and implemented as part of the organizational work but are hidden within the infrastructure in the current work. These invisible elements and components can still be relevant; for example, agreements between organizational entities still exist despite the position being held by a new person. In our empirical case, the consequences of the legacy infrastructure became visible in the hardware components and organizational policies. Starting with hardware, the legacy of infrastructure became an indistinguishable part of the Network Project due to rack maintenance. Cleaning up the old racks was not a part of the Network Project, but the organization's storage of old racks affected the implementation of the new LAN, as no one had a status overview of the old racks. Additionally, the legacy concerning organizational management impacted the Network Project, particularly in cases where documentation or an overview of policies and agreements was lacking. Identifying which policies and agreements were relevant for the work was complicated, as this information was spread across the organizational sites, units, people, places, and artifacts, even extending to people who were no longer a part of the organization. For example, we identified stored organizational agreements on responsibility clashing with current organizational decisions on ownership, which, despite having no direct relation to the Network Project, challenged the progress of the LAN replacement. The specific task of replacing the LAN might happen on a local scale, though the actions required for accomplishing the transformations of the infrastructure, including both technical configuration and organizational negotiations, are shaped by these peripheral yet interrelated contexts. The existence of agreements, equipment, etc., that might seem peripheral to the work task, as well as the consequences and characteristics of these, are embedded within the infrastructure and critical for the work.

When looking at the nature of the work from a temporal dimension, we see that there are no predefined boundaries of the different stages of the infrastructure project, instead, the nature of the work forced the changing perspective of the project, which only in retrospect could be seen as transformation of an information infrastructure. Ribes and Finholt (2009) present the three scales of infrastructure: institutionalization, organizing work, and technology enactment, as analytical concepts for studying people's infrastructural work. In contrast, we do not look at the scales of the infrastructure but argue that the multiplicity of the infrastructure is *scaling* the nature of the work itself. The work of designing the LAN was initiated with a request from one of the subsidiary sites, with a limited scope of time and involving few people. However, from the beginning, the Network Project could have been approached as part of an infrastructural transformation across the organization. Such an approach would likely have involved more subgroups in the early design phase. The reason why this was *not* the case is that identifying work as an infrastructure transformation is in itself a challenge. When changes in infrastructures are initiated, the boundaries between the different stages are not pre-defined but evolve as the work unfolds. Karasti et al. (2010) studied the temporal dimension of infrastructure and differentiated between 'project time' and 'infrastructure time,' whereas a project perspective often has a start and end time for work activity, and infrastructural perspectives are temporally open-ended. Our findings confirm their argument and further show that different entities can have *different perceptions of the scope* impacted by both 'project time' and 'infrastructure time'. However, we also find that the boundaries between when or how to move from different perspectives are not pre-defined, leading to challenges in the unawareness of the potential tensions. The boundary of the work expands as the work progresses since more and more infrastructural transformations are made.

In our empirical case, individual age paths with unique legacies are also evident concerning tasks, projects, and organizational dependencies. For example, unique age paths are linked to organizational entities as new companies are continuously becoming a part of or leaving the holding company, as well as the hardware because the hardware equipment is continually added or removed. Initiating the LAN replacement in one part of the infrastructure and then distributing it to the different organizational entities risks overlooking the history and legacy associated with the individual sub-companies. Missing the legacy can lead to breakdowns in the execution of the work, which must be handled on short notice, acting as a "point of infrastructuring" adding additional work every time they must reconsider, redesign, or reschedule due to breakdowns (Ludwig et al. 2018). However, foreseeing these incidents is difficult (maybe even impossible) as the collisions can take place in different locations or exist across, beyond, and intertwined within the infrastructure, making the cause and reasons for breakdowns immediately invisible.

Ellingsen et al. (2013) studied how the local and global aspects interact and how local issues transform into large-scale global impacts. They find unforeseen circumstances emerging during the integration process, all rooted in existing policies, systems, and practices, but without a single concrete cause to be linked to why the envisioned workflow did not materialize. By taking different analytical lenses on the Network Project, we find that the complexity of the work (and possible sources for where the breakdown manifests) can co-exist but be hidden from view and misarticulated. This aligns with Latour's (1993) perspective on the interconnectedness of global and local, as we find that the content and context of the local work co-evolve with the information infrastructure. For example, a scheduled LAN replacement coincided with a local event, although all preparatory activities were completed. The event was not visible to all relevant actors as their work exists in different local contexts, yet both are a part of the information infrastructure. The complexity of the scheduling links to the coordination of relevant resources but further the organizational and infrastructure level of the subsidiary company. The different perceptions of infrastructure transformation indicate that information infrastructure represents several 'local work' contexts besides the shared global structures, where each work context adopts the characteristics and challenges of the other. The local work is impacted by the infrastructure, and the infrastructure is mutually shaped by the work. The characteristics of the sub-company in question, therefore, scale the work of the Network Project despite it not being related to any of the actions required for solving the task at hand. The hybrid nature of infrastructures can inherent loosely coupled relations within the organizational structures. This can impact the required articulation work as dependencies might be located in a shifting variety of places. Consequently, the impact of the work becomes visible in a variety of new ways. The nature of the work is, in this way, extended to also peripheral work contexts, as the individuals performing the work must consider activities outside of their focus because the work is related to the domain of the subsidiary company. When working on the infrastructure, the complexity of the work can impact both the organization and the infrastructure, which is scaling the boundaries of the work.

While an increased scaling may be an effect of an increased scope of work, the difference lies in the boundary-crossing activities needed to address the potential invisible people, places, and artifacts elsewhere in the information infrastructure. We can only explain the creation of faultlines in our empirical case by considering both the scoping and scaling of the work context. The consequences of shutting down the LAN (i.e., no Internet access) are different in the distinct domains and are more complicated to identify across the different subgroups. In this specific case, the nature of the work (removing and replacing the LAN) and the nature of the work at that particular organizational level where the work becomes visible (the local site) is scaling the work. The work related to developing and producing respectively Movies and Books have different characteristics, and

Table 3. The ripple effect of information infrastructures for CSCW research.

Ripple effect	Insights for CSCW research
Information infrastructures are *shaping* work	Understanding the nature of work, articulation work, and their seamless integration is essential for identifying strategies to reduce the effort of articulation work.
Information infrastructures are *scoping* work	The nature of work dictates the entities required to be involved, though the configuration of individuals, activities, and artifacts is a dynamic temporal network of entities, requiring attention to relevant actors and objects that may not be visible within the current time and space.
Information infrastructures are *scaling* work	Work impacts beyond the immediately visible work practices. To be aligned with the impact of the work involves looking at sites beyond the local work, paying attention to the readjusting of legacy systems, and the excavation, negotiation, and revision of organizational policies.

despite the work of replacing the LAN being the same, the unique characteristics of the local work sites are scaling when considering the nature of performing a certain transformation of the information infrastructure.

The mutual co-evolvement of work and information infrastructures during infrastructural transformation means that we, as CSCW researchers, must look beyond the immediately visible work practices to identify the impacts elsewhere in the infrastructure – the ripple effects. The ripple effect of infrastructural transformations is continuously scaling what must be included and considered in the articulation work required for performing the work. This involves paying attention to the readjustment of legacy systems and the excavation, negotiation, and revision of organizational policies to align with the impact. It is critical to understand how local work might impact areas *outside the peripheral perception* of the work. We must explore beyond immediate work practices, involve cooperative action, and consider how accomplishing work impacts otherwise invisible technologies, local site activities, and organizational policies that are situated around the multiple local work contexts shaping the information infrastructure and might be immediately out of sight Table 3.

6 Conclusion

This paper explored the impact of the information infrastructure on the nature of work, as demonstrated in a specific empirical case of a global organization replacing the local area network (LAN). We observed the activities in (re)designing, implementing, maintaining, and managing the sociotechnical aspects of the LAN, showing how the local work task emerged as an activity of infrastructural transformation. Breakdowns in the work revealed hidden interdependencies, such as people, artifacts, and policies, located across the

infrastructural setup. Information infrastructures represent multiple work contexts; our case uncovered how the content and context of a local work activity can be shaped not only by the nature of the work itself but also by inheriting the characteristics and legacy of multiple work contexts across immediate boundaries. We argue that *the ripple effect of information infrastructures* impacts the temporal and spatial boundaries of local work contexts in unanticipated ways beyond the immediate visible work practices. Adopting an infrastructural perspective in CSCW research is essential for understanding and managing infrastructural transformations, as the complexities of the work can be situated within different interrelated contexts, often beyond the immediate boundaries of where the work is articulated. The dynamic and reciprocal relationship between work and infrastructures requires an extended peripheral perception in shaping and scoping the work at multiple scales. Adopting this extended infrastructural perception supports the identification of invisible yet interdependent people, technologies, locations, and organizational policies, aligning with the ripple effect of working within an interconnected infrastructure.

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Data Availability Data sharing is not applicable to this study as no datasets were generated or analyzed. The data supporting the findings of this study are based on empirical collection through observations and interviews. Due to confidentiality concerns, the data cannot be made publicly available.

Declarations

Competing Interests The authors declare no competing interests.

References

Bardram, Jakob E., and Claus Bossen. 2005. A web of coordinative artifacts: collaborative work at a hospital ward. In *Proceedings of the 2005 International ACM SIGGROUP Conference on Supporting Group Work*, 168–76. GROUP '05. New York: Association for Computing Machinery. https://doi.org/10.1145/1099203.1099235.

Barley, Stephen, and Gideon Kunda. 2001. Bringing Work Back In. *Organization Science* 12. https://doi.org/10.1287/orsc.12.1.76.10122.

Bietz, Matthew J., Eric P. S. Baumer, and Charlotte P. Lee. 2010. Synergizing in cyberinfrastructure development. *Computer Supported Cooperative Work (CSCW)* (3–4): 245–281. https://doi.org/10.1007/s10606-010-9114-y.

Bjørn, Pernille, and Carsten Østerlund. 2014. *Sociomaterial-Design: Bounding Technologies in Practice*. Springer Publishing Company, Incorporated.

Bjørn, Pernille, and Lars Rune Christensen. 2014. Relation work in collocated and distributed collaboration. In *Proceedings of the 11th International Conference on the Design of Cooperative System*, 87–101. COOP. Nice. https://doi.org/10.1007/978-3-319-06498-7_6.

Bjørn, Pernille, and Lars Rune Christensen. 2014. *Sociomaterial-Design: Bounding technologies in Practice*. Incorporated: Springer Publishing Company.

Bjørn, Pernille, and Nina Boulus-Rødje. 2015. The multiple intersecting sites of design in CSCW research. *ComputerSupported Cooperative Work, CSCW* 24 (4): 319–51. https://doi.org/10.1007/s10606-015-9227-4.

Bjørn, Pernille, and Nina Boulus-Rødje. 2018. Infrastructural inaccessibility: Tech entrepreneurs in occupied Palestine. *ACM Transactions on Computer-Human Interaction* 25 (5): 1–31. https://doi.org/10.1145/3219777.

Blomberg, Jeanette, and Helena Karasti 2013. Reflections on 25 years of Ethnography in CSCW. *Computer Supported Cooperative Work* 22 (4–6): 373–423. https://doi.org/10.1007/s10606-012-9183-1.

Bly, Sara, and Susan Anderson. 1996. CSCW and the internet (workshop session) (abstract only). In *Proceedings of the 1996 ACM Conference on Computer Supported Cooperative Work*, 1. CSCW '96. New York: Association for Computing Machinery. https://doi.org/10.1145/240080.318348

Boden, Alexander, Bernhard Nett, and Volker Wulf. 2007. Coordination practices in distributed software development of small enterprises. In *Proceedings of the International Conference on Global Software Engineering*, 235–46. ICGSE. https://doi.org/10.1109/ICGSE.2007.18

Bødker, Susanne, Christian Dindler, and Iversen Ole Sejer. 2017. Tying knots: participatory infrastructuring at work. *Computer Supported Cooperative Work*, CSCW, 26 (1): 245–73. https://doi.org/10.1007/s10606-017-9268-y

Bowers, John. 1994. The work to make a network work: studying CSCW in action. In *Proceedings of the 1994 ACM Conference on Computer Supported Cooperative Work*, 287–98. CSCW '94. New York: Association for Computing Machinery. https://doi.org/10.1145/192844.193030

Bowers, John. 1995. Making it work: a field study of a "CSCW Network". *The Information Society* 11 (3): 189–207. https://doi.org/10.1080/01972243.1995.9960192.

Bowker, Geoffrey, Karen Baker, Florence Millerand, and David Ribes. 2010. Toward information infrastructure studies: ways of knowing in a networked environment. In *International Handbook of Internet Research*, 97–117. https://doi.org/10.1007/978-1-4020-9789-8_5.

Busboom, Juliane, and Nina Boulus-Rødje. 2023. Planning for hybrid cooperation - a design driven exploration. In *Proceedings of 21st European Conference on Computer-Supported Cooperative Work*. ECSCW, Exploratory Papers. Trondheim. https://doi.org/10.48340/ecscw2023_ep02.

Christensen, Lars Rune. 2010. *The Coordination of the Building Process: Articulation Work and Practices of Stigmergy*. PhD Thesis. IT University of Copenhagen.

Christensen, Lars Rune, Rasmus Eskild Jensen, and Pernille Bjørn. 2014. Relation work in collocated and distributed collaboration. In *Proceedings of the 11th International Conference on the Design of Cooperative Systems*, COOP '14, 87–101. Nice. https://doi.org/10.1007/978-3-319-06498-7_6.

Ciolfi, Luigina, and Myriam Lewkowicz, and Kjeld Schmidt. 2023. Computer-supported cooperative work. In *Handbook of Human Computer Interaction*, edited by Jean Vanderdonckt, Philippe Palanque, and Marco Winckler, 1–26. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-27648-9_30-1.

Cohn, Marisa Leavitt. 2016. Convivial decay: entangled lifetimes in a geriatric infrastructure. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*, 1511–23. CSCW '16. New York: Association for Computing Machinery. https://doi.org/10.1145/2818048.2820077.

Cramton, Catherine Durnell, and Pamela J. Hinds. 2004. Subgroup Dynamics in internationally distributed teams: Ethnocentrism or cross-national learning? *Research in Organizational Behavior* 26: 231–263. https://doi.org/10.1016/S0191-3085(04)26006-3.

Dourish, Paul. 2017. *The Stuff of Bits: An Essay on the Materialities of Information*. MIT Press.

Duckert, Melanie, Eve Hoggan, Louise Barkhuus, Pernille Bjørn, Nina Boulus-Rodje, Susanne Bødker, Naja Holten Møller, and Irina Shklovski. 2022. Work of the future. In *Adjunct Proceedings of the 2022 Nordic Human-Computer Interaction Conference*, 1–4. NordiCHI '22. New York: Association for Computing Machinery. https://doi.org/10.1145/3547522.3547707.

Duckert, Melanie, Louise Barkhuus, and Pernille Bjørn. 2023. Collocated distance: a fundamental challenge for the design of hybrid work technologies. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–16. CHI '23. New York,: Association for Computing Machinery. https://doi.org/10.1145/3544548.3580899.

Duckert, Melanie, and Pernille Bjørn. 2024. Revisiting grudin's eight challenges for developers of groupware technologies 30 years later. *I-Com*, Special Issue on Computer Supported Cooperative Work. https://doi.org/10.1515/icom-2023-0039.

Ellingsen, Gunnar, Eric Monteiro, and Kristoffer Røed. 2013. Integration as interdependent workaround. *International Journal of Medical Informatics* 82 (5): e161-169. https://doi.org/10.1016/j.ijmedinf.2012.09.004.

Fürstenau, Daniel, Abayomi Baiyere, and Natalia Kliewer. 2019. A dynamic model of Embeddedness in Digital infrastructures. *Information Systems Research* 30 (4): 1319–1342. https://doi.org/10.1287/isre.2019.0864.

Garfinkel, Harold. 1984. *Studies in Ethnomethodology*. Cambridge, UK: Polity.

Gerson, Elihu M. 2008. Reach, bracket, and the limits of rationalized coordination: some challenges for CSCW. In *Resources, Co-Evolution and Artifacts*, 193–220. Computer Supported Cooperative Work. London: Springer London. https://doi.org/10.1007/978-1-84628-901-9_8

Graham, Stephen, and Nigel Thrift. 2007. Out of order: understanding repair and maintenance. *Theory Culture and Society* 24. https://doi.org/10.1177/0263276407075954.

Grinter, Rebecca E., James D. Herbsleb, and Dewayne E. Perry. 1999. The geography of coordination: dealing with distance in R&D work. In *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work*, 306–15. GROUP '99. New York: Association for Computing Machinery. https://doi.org/10.1145/320297.320333.

Grisot, Miria, and Polyxeni Vassilakopoulou. 2015. The work of infrastructuring: a study of a national eHealth project. In *Proceedings of the 14th European Conference on Computer Supported Cooperative Work*, 205–21. ECSCW '15. Oslo. https://doi.org/10.1007/978-3-319-20499-4_11.

Hanseth, Ole, Eric Monteiro, and Morten Hatling. 1996. Developing information infrastructure: the tension between standardization and flexibility. *Science Technology & Human Values - SCI TECHNOL HUM VAL* 21 (October):407–26.https://doi.org/10.1177/016224399602100402.

Henke, Christopher. 2017. The sustainable university: repair as maintenance and transformation. *continent.*, 6 (1): 40-45.

Jabbar, Karim, and Pernille Bjørn. 2018a. Infrastructural grind: introducing blockchain technology in the shipping domain. In *Proceedings of the 2018 ACM International Conference on Supporting Group Work*, 297–308. GROUP '18. New York: Association for Computing Machinery. https://doi.org/10.1145/3148330.3148345.

Jabbar, Karim, and Pernille Bjørn. 2018b. Permeability, interoperability, and velocity: Entangled dimensions of Infrastructural Grind at the intersection of Blockchain and Shipping. *ACM Transactions on Social Computing* 1 (3): 1–22. https://doi.org/10.1145/3288800.

Jabbar, Karim, and Pernille Bjørn. 2019. Blockchain assemblages: whiteboxing technology and transforming infrastructural imaginaries. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 1–13. CHI '19. New York: Association for Computing Machinery. https://doi.org/10.1145/3290605.3300496.

Jensen, Rasmus Eskild. 2014. Why closely coupled work matters in global software development. In *Proceedings of the 2014 ACM International Conference on Supporting Group Work*, 24–34. GROUP '14. New York: Association for Computing Machinery. https://doi.org/10.1145/2660398.2660425.

Karasti, Helena, and Jeanette Blomberg. 2018. Studying infrastructuring ethnographically. *Computer Supported Cooperative Work*, CSCW, 27 (2): 233–65. https://doi.org/10.1007/s10606-017-9296-7.

Karasti, Helena, Karen S. Baker, and Florence Millerand. 2010. Infrastructure time: long-term matters in collaborative development. *Computer Supported Cooperative Work*, CSCW, 19 (3): 377–415. https://doi.org/10.1007/s10606-010-9113-z.

Khodeir, Laila M, and Mohamed Nabawy. 2019. Identifying key risks in infrastructure projects – case study of Cairo Festival City Project in Egypt. *Ain Shams Engineering Journal* 10 (3): 613–621. https://doi.org/10.1016/j.asej.2018.11.003.

Kobayashi, Marina, Susan Fussell, Yan Xiao, and F. Jacob Seagull. 2005. Work coordination, workflow, and workarounds in a medical context. In *Proceedings of the 2005 CHI Conference on Human Factors in Computing Systems*, Extended Abstracts:1561–64. CHI EA '05. New York: Association for Computing Machinery. https://doi.org/10.1145/1056808.1056966.

Langhoff, Tue Odd, Mikkel Hvid Amstrup, Peter Mørck, and Pernille Bjørn. 2018. Infrastructures for Healthcare: From synergy to reverse synergy. *Health Informatics Journal* 24 (1): 43–53. https://doi.org/10.1177/1460458216654288.

Latour, Bruno. 1993. *We have never been modern*. Cambridge, Mass: Harvard University Press.

Lee, Charlotte, and Drew Paine. 2015. From the matrix to a Model of Coordinated Action (MoCA): a conceptual framework of and for CSCW. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*, 179–94. CSCW '15. Vancouver, BC, Canada: Association for Computing Machinery, Inc. https://doi.org/10.1145/2675133.2675161.

Lee, Charlotte, and Kjeld Schmidt. 2018. A bridge too far? critical remarks on the concept of infrastructure in CSCW and IS. In *Socio-Informatics: A Practice-Based Perspective on the Design and Use of IT Artifacts*, edited by Volker Wulf, Volkmar Pipek, Dave Randall, Markus Rohde, Kjeld Schmidt, and Gunnar Stevens, 177–217. Chapter: 5. Oxford University Press.

Lucero, Andrés. 2015. Using affinity diagrams to evaluate interactive prototypes. In *Human-Computer Interaction*, edited by Julio Abascal, Simone Barbosa, Mirko Fetter, Tom Gross, Philippe Palanque, and Marco Winckler, 231–48. Lecture Notes in Computer Science. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-22668-2_19.

Ludwig, Thomas, Volkmar Pipek, and Peter Tolmie. 2018. Designing for collaborative infrastructuring: supporting resonance activities. In *Proceedings of the ACM on Human-Computer*

Interaction, 2:113:1-113:29. CSCW '18. New York: Association for Computing Machinery. https://doi.org/10.1145/3274382.

Maestri, Leah, and Ron Wakkary. 2011. Understanding repair as a creative process of everyday design. In *Proceedings of the 8th ACM Conference on Creativity and Cognition*, 81–90. C&C '11. Atlanta: Association for Computing Machinery. https://doi.org/10.1145/2069618.2069633.

Mark, Gloria, and Steven Poltrock. 2003. Shaping technology across social worlds: groupware adoption in a distributed organization. In *Proceedings of the 2003 ACM International Conference on Supporting Group Work*, 284–93. GROUP '03. Sanibel Island: Association for Computing Machinery. https://doi.org/10.1145/958160.958205.

Matthiesen, Stina, and Pernille Bjørn. 2015. Why replacing legacy systems is so hard in global software development: an information infrastructure perspective. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. CSCW '15. Vancouver: Association for Computing Machinery. https://doi.org/10.1145/2675133.2675232.

Mikalsen, Marius, Babak A. Farshchian, and Yngve Dahl. 2018. Infrastructuring as Ambiguous repair: a case study of a surveillance infrastructure project. *Computer Supported Cooperative Work*, CSCW, 27 (2): 177–207. https://doi.org/10.1007/s10606-017-9302-0.

Møller, Naja Holten, and Paul Dourish. 2010. Coordination by avoidance: bringing things together and keeping them apart across hospital departments. In *Proceedings of the 16th ACM International Conference on Supporting Group Work*, 65. GROUP '10. Sanibel Island: ACM Press. https://doi.org/10.1145/1880071.1880081.

Monteiro, Eric, Neil Pollock, Ole Hanseth, and Robin Williams. 2013. From artefacts to infrastructures. *Computer Supported Cooperative Work*, CSCW, 22 (4–6): 575–607. https://doi.org/10.1007/s10606-012-9167-1.

Neang, Andrew B., Will Sutherland, David Ribes, and Charlotte P. Lee. 2023. Organizing oceanographic infrastructure: the work of making a software pipeline repurposable. *Proc. ACM Hum.-Comput. Interact.* 7 (CSCW1): 79:1–79:18. https://doi.org/10.1145/3579512.

Olson, Gary M., and Judith S. Olson. 2000. Distance matters. *Human-Computer Interaction* 15 (2–3): 139–178. https://doi.org/10.1207/S15327051HCI1523_4.

Paine, Drew, and Charlotte Lee. 2020. Coordinative entities: forms of organizing in data intensive science. *Computer Supported Cooperative Work*, CSCW, 29 (3): 335–80. https://doi.org/10.1007/s10606-020-09372-2.

Randall, David, Mark Rouncefield, and Peter Tolmie. 2021. Ethnography, CSCW and ethnomethodology. *Computer Supported Cooperative Work*, CSCW, 30 (2): 189–214. https://doi.org/10.1007/s10606-020-09388-8.

Ribes, David, and Thomas Finholt. 2009. The long now of technology infrastructure: articulating tensions in development. *Journal of the Association for Information Systems* 10. https://doi.org/10.17705/1jais.00199.

Schmidt, Kjeld, and Carla Simone. 1996. Coordination mechanisms: Towards a conceptual Foundation of CSCW Systems Design. *Computer Supported Cooperative Work* 5 (2): 155–200. https://doi.org/10.1007/BF00133655.

Schmidt, Kjeld, and Ina Wagner. 2004. Ordering systems: coordinative practices and artifacts in architectural design and planning. *Computer Supported Cooperative Work*, CSCW, 13 (5): 349–408. https://doi.org/10.1007/s10606-004-5059-3.

Schmidt, Kjeld, and Liam J Bannon. 1992. Taking CSCW seriously supporting articulation work. *Computer Supported Cooperative Work*, CSCW 1: 7–40

Sharma, Sarika, and Steve Sawyer. 2016. Comparing internal and external interoperability of digital infrastructures. *Proceedings of the Association for Information Science and Technology* 53 (1): 1–6. https://doi.org/10.1002/pra2.2016.14505301091

Star, Susan Leigh. 1999. The ethnography of infrastructures. *American Behavioral Scientist* 43 (3): 377–391.

Star, Susan Leigh. 2002. Infrastructure and Ethnographic Practice: Working on the fringes. *Scandinavian Journal of Information Systems* 14 (2): 107–122.

Star, Susan Leigh, and Karen Ruhleder. 1996. Steps toward an Ecology of infrastructure: Design and Access for large information spaces. *Information Systems Research* 7 (March): 111–134. https://doi.org/10.1287/isre.7.1.111.

Steinhardt, Stephanie B. 2016. Breaking down while building up: design and decline in emerging infrastructures. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 2198–2208. CHI '16. New York: Association for Computing Machinery. https://doi.org/10.1145/2858036.2858420.

Strauss, Anselm. 1988. The Articulation of Project Work: An organizational process. *The Sociological Quarterly* 29 (2): 163–178. https://doi.org/10.1111/j.1533-8525.1988.tb01249.x.

Suchman, Lucy. 1996. Supporting articulation work. In *Computerization and Controversy*, 407–23. Elsevier. https://doi.org/10.1016/B978-0-12-415040-9.50118-4.

Suchman, Lucy. 2006. *Human-Machine Reconfigurations: Plans and Situated Actions*. 2nd ed. Learning in Doing: Social, Cognitive and Computational Perspectives. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511808418

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PAPER IV

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2024

Revisiting Grudin's eight challenges for developers of groupware technologies 30 years later.

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Revisiting Grudin's eight challenges for developers of groupware technologies 30 years later

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Abstract: In 1994, Jonathan Grudin wrote his famous paper Eight Challenges for Groupware Developers; The question is whether these challenges still persist, or have we moved on here 30 years later? We revisit the challenges empirically through ethnographic observations in two companies examining their work practices, organizational structure, and cooperative setups concerning their use of groupware technologies. Today, groupware is seamlessly integrated into organizations, considered essential infrastructure that becomes part of the daily work routine. Contextualizing the original challenges proposed by Grudin, we categorize them into cooperative challenges, social challenges, and organizational challenges, and refine their phrasings to reflect present and future considerations faced by developers of groupware technologies. While the main arguments of the social and organizational challenges remain consistent, we rephrase the cooperative challenges as *emergent exception handling* and *exaggerated accessibility* to reflect the emerging characteristics associated with the ubiquity and seamless integration of groupware.

Keywords: cooperative technologies; groupware; future work; cooperative work; distributed work; hybrid work

1 Introduction

In 1994, Jonathan Grudin proposed eight challenges for developers of groupware technologies [1]. Today, three decades later, groupware technology has gone through a huge development – from the 1990s when we discussed email and electronic calendars as new types of groupware technologies that potentially could have a dramatic impact on organizational practices, to 2020 where videoconferencing technologies and the ability to work from home using Internet and groupware technology to get us through the pandemic. The technologies designed to support cooperative engagements within and across organizations were adopted at a rapid pace during the COVID-19 pandemic where worldwide lockdowns forced millions of people to work from home. When the regulations were lifted, people returned to their offices, however, this transition has not been without difficulties [2–4]. The post-pandemic has not been a simple return to the "pre-pandemic status quo", instead, the new situation has initiated discussions and negotiations within organizations about "the nature of the workplace", and what is desirable and efficient for different organizational members [5–10]. The changing perspectives on *work* and persistent demands from organizational members for flexible work conditions with remote opportunities [11–14] have created a work environment where people are partially distributed, and working from different locations has become the norm rather than the exception. The term *hybrid work* has become popularized to describe the work model where some employees work from home, while others are physically located at the office [15, 16]. Hybrid work introduces new challenges for cooperative work [15–18] also impacting the design challenges for cooperative technologies [19–21]. Therefore, it is relevant to consider, which challenges are prominent for developing CSCW systems for work environments today – as well as for the future [8, 22–24]. With such dramatic changes, the fundamental question remains as to whether the eight challenges proposed by Grudin in 1994 still stand, or whether we need to re-consider these challenges three decades later.

In this paper, we ask the research question: *What are the challenges for developers of groupware technologies in 2024?* To answer the research question, we revisit the challenges identified by Grudin three decades ago [1] and interrogate these challenges in the empirical perspectives from ethnographic studies of hybrid office work today. We report from two empirical studies conducted in 2023 at two

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different organizations both struggling with establishing a modern workplace allowing the employees to occasionally work remotely from home, while still encouraging physical presence at the office.

We find that groupware today is ubiquitously integrated into organizations and is regarded as part of the fundamental infrastructure in organizations, often fading into the background as taken-for-granted technology. The use of groupware is consequently viewed as an everyday aspect of work, influencing the challenges associated with developing new groupware systems. Based on our analysis, we categorize the three-decade-old challenges [1] into three main categories: cooperative challenges (no. 4, 5), social challenges (no. 1, 2, 3), and organizational challenges (no. 6, 7, 8). This classification aims to capture the evolving considerations and refine the phrasings to reflect the present and future challenges faced by groupware developers. While the main titles and primary arguments of the social and organizational challenges remain unchanged (yet with added complexities), we rephrase the cooperative challenges to reflect the emerging considerations of groupware being seamlessly integrated into work practices. We find that enabling the design of groupware technologies as "open-ended" and "immediate availability" is critical, yet these characteristics also introduce new complexities. For example, when organizational cooperative practices are produced through continuously malleable configurations of locations, people, and groupware – the additional challenge for groupware design is the requirements to support continuous reconfiguration (sometimes on a day-to-day basis) while allowing people to create sociomaterial bounding of technologies in practice.

The paper is structured as follows: First, we contextualize the eight challenges for groupware developers in current CSCW research. Then we introduce our methods, and the two empirical cases, before we dive into interrogating each challenge, with empirical observations from our empirical data. This work includes suggestions for re-focusing some of the challenges. Finally, we discuss how the foundation for groupware design has changed since the early 1990s and speculate on the future challenges that contemporary groupware developers face when designing technologies for cooperative environments for the next three decades.

2 Challenges for groupware developers

In the early 1990s, Computer Supported Cooperative Work (CSCW) emerged as a coherent research field in light of existing insufficient approaches to the design of technologies [25–27]. The CSCW focus is on *supporting* people via the design of computer tools [25] in cooperative arrangements [26] where people are mutually dependent in work [28]. CSCW systems are interacted with by individuals and therefore possess the same interface challenges as individual user applications, however, new challenges arise when technologies should support cooperative work [1]. In 1994, Jonathan Grudin's publication summarized and highlighted the challenges identified by multiple researchers [1], and the paper has been highly cited (more than 2000 citations and in 2023 alone the paper has been cited 24 times[1]), and in 2014, Grudin received the CSCW long-term impact award celebrating his work.

The 1994 paper does not introduce empirical data, instead, the paper is written as a reflective essay, where the author considers suggestions for the nature of specific challenges that arise with the introduction of groupware technology into organizational practice. It is evident that, at the time of writing the paper, the actual empirical insights and experiences from empirical examples were less, as only a few had the privilege to access and research organizational practices utilizing groupware systems. Two examples of the few researchers who successfully were able to gain access to and study groupware in organizations was Wanda Orlikowski, who with her famous paper 'Learning from Notes' from 1992 [29] studied how groupware technology was implemented and potentially failed within organizational practices – a paper which also was celebrated with the Lifetime Impact award in CSCW in 2015; and Paul Dourish and Victoria Bellotti [30] who studied the use of video-conferencing tools within Xerox Parc in the early 1990s (again winning the long-term impact award in CSCW, this time in 2016). Groupware technology was a key area of important research in thinking about how organizational practices were impacted by technologies designed to support the work of groups.

Groupware technology is fundamental to the very definition of CSCW research, as Irene Greif (cited in Ref. [28]) defines CSCW as "*… an identifiable research field focused on the role of the computer in group work*" [28, p. 9]. While the focus on 'groups' has been debated, researchers generally agree that the fundamental concern for CSCW research concerns situations where at least two or more actors are mutually dependent upon each other while being involved in a common field of work using computer systems [31–35]. This means that groupware technology is not the sole interest of CSCW technologies, but instead, a specific type of

1 The numerical counts are based on Google Scholar.

CSCW application where the aim is to design technologies that support groups in their joined engagement [36–39]. Grudin made the distinction between individual usages of technology (single-user technologies), large main frame systems (organizational software systems), and then groupware [1]. Cooperative work entails situations where at least two people are engaged in a common field of work in such a way that they experience interdependence [40–43] – then technology support depends upon the nature of articulation work required for handling this extra work. In Lee and Paine's work on coordinative action, they unpack the dimensions of the cooperative engagements in terms of the number of participants, different communities, nascence, etc., suggesting these dimensions as a scale to determine the boundaries between the group as the smaller unite of cooperative action and the infrastructure of more than 1000 people being part of a larger coordinative action [34]. Thus, the discussions on cooperative technologies are much larger than simply groupware – however, our interest in this paper remains on groupware and the challenges that developers of these technologies face today. But first, let us remind ourselves about the nature of the original eight challenges for groupware developers proposed by Grudin [1].

2.1 Disparity in work and benefit

This challenge points to that groupware applications do not apply the same benefit for all the people involved in using the technology. In 1994, electronic shared calendars were introduced into the offices as a new groupware technology. These digital calendars were accessed through large desktop computers, and organizational members did not have a mobile phone in their pocket with access to their calendars. Thus, for mobility in office work, members would carry paper-based calendars reminding themselves of appointments and meetings. The electronic calendar requires people to add their appointments and meetings to the shared digital calendar, for the benefit of other organizational members, such as the actors whose job it is to identify availability for planning meetings. However, allowing others access to your calendar required extra work from organizational members in updating both their electronic as well as their paper-based calendars. Further, allowing access also risks reducing the autonomy of the individual by allowing others to take control of their time and schedule. Thus, the transparency of the shared calendar introduces extra work of the individual while reducing the autonomy of the individual. The question then arises as to who benefits from the shared electronic calendars. The benefit of electronic calendars is for the organizational members involved in planning meetings. The shared electronic calendars allow organizational members to compare and identify space for shared meetings, which otherwise would be the tedious work of calling around and checking people's availability. However, the work of planning meetings would often be the work of secretaries while the extra work of calendar updating between electronic calendars and paper-based calendars would be done by other organizational members (e.g., salespeople) who did not plan meetings initially. In the last decades, multiple studies have demonstrated different technologies that add work on individual groups of organizational members for the benefit of others [44, 45], like the work of healthcare professionals recording additional data (or checking boxes) while interacting with patients for the benefit of hospital management [46]. Thus, the challenge for groupware technology is the challenge of creating technologies that consider and accommodate the disparity of work and benefit between different individual organizational members. Mitigating the challenge is about ensuring that the additional work required for the groupware technology to function is not experienced as unbeneficial for the people doing this work.

2.2 Critical mass and Prisoner's dilemma problems

This challenge points to that for groupware technology to work, enough people must use the systems for the shared functions to work properly. Fundamentally, if an organization has implemented a groupware system allowing members to for example share documents (such as shared folder systems) or communicate (e.g., email and Slack) the groupware system will only be useful if enough organizational members use this system. If only a few people use the shared calendar system, the person planning meetings still needs to request additional information about individuals to identify appropriate times and places for planned meetings. Similarly, if only a few organizational members use a shared file system, people would not be able to identify relevant files, since several files would be outside the shared system requiring organizational members to request and share files in other ways (e.g., by email attachments). Thus, for organizations to benefit from a groupware system, enough people need to use it – however, getting people to use a newly implemented system (before the benefits arrive) is a challenge. Groupware technologies are not instantly producing cooperative efforts by simply being installed on the computers [29], instead, it takes time for groupware systems to gain a critical mass of users. Thus, the challenge for groupware developers is to design a groupware system that considers the critical mass problem within the design to make it a

successful tool, otherwise, the users will not experience the advantages of using the system.

2.3 Disruption of social processes

This challenge points to that the introduction of groupware technology can interfere with social dynamics and implicit information such as social taboos and political structures. Organizations have embedded hierarchies, and while these hierarchical structures might take different forms and be structured quite differently dependent upon the structures shaping the social dynamics of the organization [47–49]. For example, walking over to a colleague asking for assistance with a specific task would be viewed as appropriate in many organizations, while taking the elevator to the top floor and knocking on the door of the CEO requesting to be involved in creating the strategic plan of the company would not be appropriate in many organizations. The social dynamics are thus shaped by the organizational structures of hierarchy, politics, and implicit organizational practices. When groupware technology is implemented into organizations, these technologies risk disrupting the social processes within the organization [50], since organizational members might have different types of access and navigation [51]. For example, while only a few would take the elevator and knock on the door of the CEO, the bar to send an email to the CEO might be lower. Or as we have seen in recent years with social media, citizens have direct access to politicians or other public figures by commenting, liking, and sharing posts which they otherwise would not have been able to do. Groupware technology impacts social dynamics and interaction, and not always for the better, as we have seen with the challenge of misinformation about disasters, health, and politics [52, 53]. Thus, the challenge for groupware developers is to design technologies that consider the risk of disrupting social processes appreciating productive interruptions while reducing problematic disruptions.

2.4 Exception handling

This challenge points to the fact that cooperative work never just follows the plan; instead, disruptions occur and are requiring exception handling. Groupware technology at its core is about reducing the efforts of articulation work for a cooperative engagement with the purpose of allowing organizational members to focus on other activities, finish tasks faster and more efficiently, or simply spend time on the content of the task rather than the articulation work [54]. This intention for groupware has caused developers of groupware technologies to focus on efficiency and streamlining the work-embedded coordination strategies [55, 56]. Workflow systems are a specific type of groupware technology designed to make coordination easier by allowing users to organize their individual, yet interdependent tasks, in tandem [57–59]. However, a crucial problem with these workflow systems is that cooperative work very seldom follows the predetermined path and workflow [60–64]. Instead, organizational members do what is required to make the work function, and often this includes exception handling to resolve breakdowns [65, 66]. For example, while bed management coordination in hospitals supposedly follows a certain pattern, the actual work involved in bed management might differ greatly from the prescribed processes [67]. Exception handling is not something that will be mitigated by technology. Instead, the design of groupware technology needs to support exception handling required for the work – and often we do not know which type of exception handling to expect. Thus, the challenge for developers of groupware is to create technologies that are open-ended and flexible in use allowing organizational members to accommodate and enact required exception handling.

2.5 Unobtrusive accessibility

This challenge points back to the balance between when organizational members are engaged in cooperative work, and when they are engaged in individual work. In all cooperative setups, people do not always and only collaborate. Instead, there are times when organizational members simply work individually. For example, co-authoring an academic paper does not mean that authors write all sentences together, but often co-authoring includes individuals writing drafts or revising draft text to later discuss between all authors. Cooperative work has dependencies, but there will be times when cooperative actors engage in individual tasks. Unobtrusive accessibility points to the fact that when designing cooperative technologies, it is important to ensure that the groupware allows for individual work and does not always have the cooperative engagement in focus. Thus, groupware technologies should be able to stay in the "peripheral background", while individuals work alone, and then be able to zoom into focus when actors need to cooperate. Groupware should be accessible in an unobtrusive manner, blending into the background and only appear when needed. Fundamentally the challenge of unobtrusive accessibility is highly related to awareness in cooperative engagement. Awareness as a feature of cooperative work entails making activities visibly available for others can monitor these actions and act accordingly [68]. Awareness has been explored as a critical characteristic of cooperative work [69] as well as a design requirement for groupware technology

[70] and continues to be a core area of research in CSCW [71]. While the conceptual understanding of 'unobtrusive accessibility' can be identified to consider concerns for the delivery of awareness data (such as how actors can unobtrusively access the cooperative engagement considering the infrequent use of groupware) the conceptual understanding of awareness has developed tremendously since 1994 [72]. Thus, the challenge for developers of groupware technology in 1994 centers around the assumption that teams are often organized to minimize social interdependencies, causing groupware features to be used less frequently than features for individual work. This infrequent use is a challenge when designing new groupware technologies, thus Grudin suggests that different design strategies should prioritize adding cooperative features into existing systems – turning these into groupware technologies [1].

2.6 Difficulty of evaluation

This challenge concerns the user-testing and evaluation of groupware technology features and design decisions. The methodologies for usability testing or user experience evaluation are appropriate when evaluating single-user systems. Differently, these methodologies are not appropriate nor useful to evaluate the quality of groupware systems [73, 74]. The problem is that the evaluation of the groupware is closely connected to the context of use, and thus evaluating groupware includes considerations for hierarchy, motivations, and social engagement which single-user methodologies do not allow us to capture. Usability testing methods are not equipped to consider social interaction. There are many empirical examples from CSCW research where cooperative technologies have been implemented into an organizational practice only to reveal fundamental design problems that only became pertinent after the groupware system had been implemented in real-life situations [75–77]. In some cases, expensive IT systems were taken out of use due to these problems [78], while in other cases organizations were forced to live with problematic systems and identify workarounds to survive [79, 80]. Concretely, usability evaluation does not reliably capture the complexities of cooperative engagements making it more challenging to evaluate groupware systems than single-user applications. Thus, the challenge for groupware developers is that groupware systems are difficult to evaluate as they are context-dependent [81–84] and affected by other actors involved in the work, thus developers might not know central design problems before the system has been fully implemented.

2.7 Failure of intuition

This challenge is directed at the decision-makers and managers who are responsible for identifying and requiring groupware technology to be implemented in their organizations. In 1994, when email was still a novelty in organizations, managers had little experience in knowing which groupware technologies would be relevant to acquire and implement supporting the organizational practices. Mostly, this was due to the lack of experience organizations had concerning groupware, making it impossible for them to rely upon their intuition when making decisions on IT systems. The famous empirical case 'Learning from Notes' is an excellent example of this challenge. Here Orlikowski documents how top management invested in acquiring Lotus Notes as a cooperative technology for the whole organization with the aim of creating 'instant collaboration', however, the systems did not have the expected effect in use [29, 85]. CSCW research has documented several cases of failed implementations of groupware systems and many of these are based upon a gap between the expectations of the groupware and then the actual use and effort required to make the IT system function in the organization [86–88]. Managers can fail in their intuition in assessing the value of implementing a system compared to the extra work required to make the system successful when they decide if the system should be purchased. Thus, the challenge for developers of groupware technology includes that managers often underestimate the additional work that is needed when using groupware applications.

2.8 The adoption process

This challenge concerns the organizational practice where groupware is implemented and brought into use in the organization. Unpacking this challenge, we start by making a distinction between different concepts; 'Implementing groupware' refers to the process of installing software on machines while setting up access to the system for different users. However, having groupware installed on computers in an organization does not mean that these technologies will be used. 'Organizational implementation of groupware' acknowledges that implementation is not just a technical issue but includes concerns about organizational changes [89, 90]. Research into organizational implementation has suggested to be affected by the timing within the organization [91] and that the introduction of new IT systems always will include a reduction in productivity, which is why we cannot measure the success of groupware

immediately after the implementation [92–94]. Further, there is a large tradition within information systems research focusing specifically on the 'acceptance' of technology based upon organizational members 'perceived' usefulness and 'ease-of-use' [95–97]. In more recent years the focus has been more on the 'appropriation' of technology highlighting that when cooperative technologies are introduced into an organization, both the organization as well as the technology are transformed and hereof, they are transforming each other. Across this large literature on the adoption of groupware, it is clear that adopting a groupware application requires carefully planned activities where the group of future users is introduced to a clear purpose of the groupware system, as well as how to use the system in practice [98]. Thus, the challenge for developers of groupware technology is that groupware needs to be introduced carefully as different actors involved in the common field of work can have different perceptions of its usefulness. Groupware applications which are *only appreciated by a minimum* of the involved actors in the organization, risk becoming a disaster.

3 Methods

The empirical data presented in this paper is part of a larger research project investigating the future of work and the design of cooperative technologies for hybrid settings (ReWork Research Project [8, 99]). While the research interest of the ReWork project is at a larger scale, this paper focuses on challenges for developing groupware technologies. To investigate the challenges for developing groupware technologies today and reassess whether the challenges from three decades ago still persist, we employed empirical ethnographic research methods. Ethnographic methods provide insights into work and collaboration [100] and have previously been used to unpack office work [48, 60]. Drawing on current empirical data from two organizations, our analysis of challenges provides insights into present work conditions, particularly the hybrid organizational setup faced by most companies. Hybrid conditions manifest in various formats and constellations [16, 17, 101]. The flexibility and dynamic nature of geographical locations inherent in hybrid work models contribute to a growing adoption of computer-supported work practices facilitated by various groupware technologies to accomplish tasks. The groupware technologies employed in our empirical cases comprise a mix of systems used before the pandemic lockdowns, those that were introduced or intensively utilized during the lockdown to enable distributed team members to collaborate, and new technologies implemented after the pandemic to support the continuing partial remote work. This diversity in technologies and work practices makes these cases particularly interesting for studying the challenges that groupware developers face in 2024, by leveraging empirical data about how groupware is enacted in work *within* and *across* separate departments, small project teams, and organizations.

When initiating the empirical work, we (expectedly) realized that office work today is impacted by the possibility of remote work, creating hybrid work arrangements across departments as well as smaller project teams. Exploring the question of which challenges exist for groupware developers today, therefore, also forced us to navigate these challenges ourselves in our methodological considerations. The fact that work today involves collocated and online interactions, as well as physical and digital technologies, sets different requirements for ethnographic methods [58, 102–104]. Cooperation unfolds in different contexts, at different sites, both collocated and digitally. Capturing these elements using ethnographic strategies requires considerations for how to capture insight on 'online interaction' unpacking organizational members' perceptions of the successes and failures of groupware technologies by different individuals or sub-groups in a context-dependent perspective. Studying hybrid environments can pose challenges similar to the findings of the challenges existing for designing technology supporting such work conditions [103]. To navigate these, we focused the ethnography on the office workplace, shifting our focus depending on different days (digital vs. physical), and incorporated archival data to recapture aspects of online interactions and cooperative work activities (e.g., text archives from messaging).

The ethnography was conducted in 2023 to understand how work unfolds in organizations striving to rebuild a "vibrant office atmosphere" after the pandemic. Before initiating the ethnography, we engaged with representatives from the organizations through workshops with multiple companies under the theme "The Future of Work". Through these interactions, we learned about the companies, their departments, and some of their challenges with hybrid work. These insights were critical for initiating the ethnography within the companies. Being familiar with the organizations beforehand allowed us to build on existing discussions and concerns while directing our ethnographic work both be relevant for us as researchers as well as the organizations. This was crucial for providing access to conduct the empirical work. We studied ethnographically how cooperative groups within the two organizations arranged their cooperative work, which groupware technologies they used to support their work, and how different organizational members perceived the work conditions before, during, and after the COVID-19 pandemic. Particularly the new hybrid setup was important for the organizations to understand, thus we explored how work was performed after the reopening of the offices (for example, how hybrid configurations influenced work and use of artefacts). We focused on one department at each of the companies including conversations with department managers. For each department, we identified teams, and comparing the managerial perspectives with the everyday work practices of teams operating under different contexts allowed us insights into difference characteristics and nuances in the work.

3.1 Empirical cases

The two empirical studies were conducted in two distinct organizations operating within different business domains, yet both being mainly computer-based and therefore less reliant on the physical company facilities. The organizations differ in the type of work conducted, the size, (global) team distribution, and degree of coupling, as well as the need for collaboration across different groups (Table 1). The specific departments in each of the companies were chosen based on their willingness to be involved, access to data and office buildings concerning GDPR, as well as the companies' non-disclosure obligations.

3.1.1 InterFin (Org1): InterFin is an IT company with 1700 employees designing, implementing, and maintaining IT infrastructure for the

Table 1: Empirical cases.

	InterFin (Org1)	GlobalContent (Org2)
Employees (total in organization)	1700	6600
Employees (department for observation)	20	55
Countries (total in organization)	2 (6 office sites)	30 (200 office sites)
Countries (department for observation)	2 (4 office sites)	1 (1 office site)
Work domain	Finance	Entertainment
Main groupware applications	Office, Jira, Confluence	Office, Workplace, SolarWinds
Work model	Agile	Post agile[a]
Team sizes	8–10 people	3–12 people
Working across teams	Yes	Yes

[a]The organization previously followed the agile work model but transitioned away from it a month before we started the ethnography.

financial industry. The company operates in two countries, Denmark and Poland, and has multiple office buildings (five in each of two cities in each country). InterFin expanded beyond its original presence in Denmark in 2017 by establishing an office in Poland and later opening a second office in a new city in Poland. Today, all 1700 employees are evenly distributed between the two countries. During the pandemic, all employees worked from home. In Denmark, pandemic-related restrictions were in place from March 2020 until the end of January 2022, when all restrictions were lifted. In Poland, the restrictions were lifted in March 2022.

The data collection took place in the Winter and Spring of 2023, initiated with interviews with the department manager, followed by empirical observations. We studied one department consisting of two teams in total including approximately 20 employees with a focus on respectively development and implementation of agile work practices.[2] All teams adhere to the agile work model, defining their processes and use of software tools for collaborative work. Both teams maintain close coupling in their work, conducting team meetings every morning, and engaged in collaborative activities throughout the day involving the entire teams or sub-groups within the teams. Moreover, both teams are interdependent, working across the department and collaborating with individuals and sub-groups from other departments within the organization. For example, they regularly meet with team managers from various departments to educate and coach on how to structure and manage in line with the agile work mindset. Although our primary focus is on work within the department, we also consider the cross-department nature of the work, including findings from collaboration with individuals outside this specific department.

The department in focus is situated in one office building in Denmark and another in Poland, with additional locations being private homes. The department as well as the sub-teams, are globally distributed and therefore never able to be physically collocated at the company office. Due to geographical constraints, our on-site visit was limited to the office in Denmark. However, we virtually met with the workers in Poland and were informed that their office mirrored the one we visited in Denmark. For subsequent references to the company, we use the designation 'Org1'.

3.1.2 GlobalContent (Org2): GlobalContent is a holding company with a presence in 200 location sites worldwide. As a holding company, its relationship with subsidiary companies varies. In our data collection, we focused on four companies that directly provide content to the parent company and engage with organizational members daily. Throughout the COVID-19 pandemic, the office experienced a lockdown, aligning with the same period as InterFin, following regulations set by the Danish government. Upon the reopening of the offices, teams were rotated to gradually reintroduce people to the workplace.

The data collection took place in the Summer and Fall of 2023, with a focus on the IT department, which is located at the headquarters. This data collection was also initiated with an interview with the responsible manager for the department, followed by a period of ethnographic observations. The IT department was chosen because it maintains close ties with subsidiary companies worldwide, by being responsible for parts of their IT solutions and infrastructure. The organizational members are dependent on global cooperation involving various stakeholders. The department is structured around four sub-areas focusing on data, security, infrastructure, government, and business partnering, comprising a total of approximately 55 employees. The cooperative group activities are structured within the departments, the sub-teams within the department areas, project teams collaborating across the sub-areas, and individuals from department and subsidiary companies. Depending on the work task, the teams sometimes collaborate with coworkers within the department or with external parties. For example, the 'data' group mainly collaborates within the team, while the 'business' group must visit the subsidiary companies weekly.

All employees associated with the IT department are based in Denmark and have geographical access to GlobalContent's office building. However, work activities may necessitate collaboration with individuals placed in other areas of the organizational structure. The ethnographic work primarily focused on groups within the IT departments, but due to the nature of the work, we include data from collaboration across the organization. For subsequent references to the company, we use the designation 'Org2'.

3.2 Data collection

The department managers at Org1 and Org2 allowed us to join their offices and observe their work activities. These activities include cooperative work both internally within the individual teams and across departments, as well as with external stakeholders. We observed both synchronous and asynchronous work. We quickly realized that most

2 Agile work methodology is a project-based management approach, where each project is broken down into separate phases to support a consistent development phase with aim of improving job satisfaction and flexible work practices.

work activities were planned as meetings, so to observe synchronous work activities, we participated in different types of meetings between different groups of people. In this way, we got insights into the current projects in the companies, who collaborated with whom, and the general work goals and activities in the respective departments. Moreover, we used the meetings to identify specific projects and/or sub-groups who were willing to let us observe their work in more detail.

To study the asynchronous work, we identified team members who allowed for observation of their work activities during the day. This includes their location, which technologies were enacted (including the written communication, and use of software tools), and general work practices and task goals. The observations were conducted by the first author who sat next to the employees on different days. We observed the work practices and asked elaborating questions to clarify observations on what and why. This was either in the moment when it was appropriate to interrupt or otherwise noted down and asked at follow-up interviews later. This approach provided insights into the work task in focus, which sub-groups the person engaged in, and which technologies were used for which activities. Additionally, this approach revealed specific events that could be followed up on during the following weeks, and therefore get a timely perspective on the simultaneously synchronous/asynchronous work performed in the cooperative practices required to accomplish work. When allowed to, we documented the work events with pictures and screenshots. Otherwise, all observations were written down in detail in a notebook. Due to GDPR, we were not allowed to record employees' voices, and therefore made sure to write memos and generally document all observations in written format.

When collecting data, we were aware of the limitations due to only conducting ethnography at the office when hybrid work also takes place at other locations. We did not have access to people's private homes beyond what the participants expressed themselves about these places during interviews. We focus our analysis on the groupware, which technologies and applications were in use, how collaboration unfolds in different groups, and how groupware enables and constrains work. See Table 2 (Data sources).

3.3 Data analysis

To explore challenges for groupware developers, we gathered all collected data, encompassing observation notes, site pictures, company documents, screenshots, and similar materials. We carefully reviewed all data to categorize empirical insights, focusing specifically on challenges in cooperative work and the support of groupware systems.

We identified all technologies in use – hardware and software – to understand how they supported various work activities. Across the two organizations, these applications included email, calendar, intranet, MS Teams, PowerPoint, Word, Excel, Jira, Confluence, Workplace, SolarWinds, DataDog, CiscoBoard, and FixIt. The physical artefacts include phones, laptops, keyboards, additional screen monitors (personal at desks, shared at meetings rooms, and office space), paper/tablets, pens, headphones, chargers, cameras, speakers, and relevant adapters/cables. Subsequently, we mapped out cooperative activities observed during the ethnography such as planning, evaluation, production, coordination, monitoring, documentation, data analysis, testing, information sharing, knowledge sharing, and ideation.

For the identification of challenges in groupware technologies, we employed a deductive orientation for the analytical process [105], considering original phrases of Grudin's challenges as our main themes [1]. We directly converted the challenges into thematical descriptions relying on both the descriptive parts of the challenges and the examples given in the paper [1], as well as exemplifying specific groupware technologies the challenge was referring to at that time (e.g., email application). The analysis was an iterative process, involving continuous scrutinizing of our empirical data and exploration of theoretical concerns. In the categorization process, we included observation data from actions, statements during interviews, and information from both managers and organizational members, considering all information across all teams and both organizations. In this analytical work, we use 'post-it' notes of relevant empirical observations inspired by affinity diagramming [106]. This included the technologies that we mapped out (physical and digital), the cooperative activities, the members involved and their geographical locations, specific events observed during the observation as well as statements from the organizational members. For our analysis, we identified empirical scenarios supported by diverse groupware technologies in both organizations, encompassing departmental activities and concerns (e.g., cross-department information sharing) and smaller team configurations (e.g., project work). These scenarios represented various cooperative distributions (i.e., collocated, hybrid, and remote setups). The empirical scenarios include events such as managers' decision process on which groupware to implement, applications used to stay updated on activities in the department (i.e., MS Teams and Workplace), and communication/coordination within project teams (i.e., MS Teams, Excel, Jira).

Through several iterations of analytical discussions, we linked the challenges in the empirical examples to the thematic descriptions of the original challenges. First, we selected a specific groupware technology from the empirical data as an example to analyze the original

Table 2: Data sources.

Empirical cases	InterFin (Org1)	GlobalContent (Org2)
Interviews/*in-situ* conversations	10 (5–70 min)	7 (10–90 min)
Observation	55 h	75 h
Meetings	22	28
Teams	2	6
People	70	55
Observation notes and rich descriptions	107 pages	138 pages
Office visit	12	16
Document analysis	2	8
Capturing digital interactions	9 scenarios	7 scenarios
Documenting office layout	Pictures	Floor plan

challenges, assessing whether they persist, change, or become irrelevant (e.g., file sharing in MS Teams application). In the next analytical iteration, we focused on specific challenges presented in the original paper, relating these individually to empirical examples and situating concrete challenges in various scenarios. Then, we examined diverse empirical descriptions to identify which of the historical challenges that effectively pictured the current implications for groupware developers that were illustrated in our empirical data. Combining different analytical approaches allowed us to iteratively consider which challenges exist today, how these are different from 30 years ago, and how potential revision of the original challenge most accurately would represent our new empirical findings.

Throughout the process, we continually explored whether new challenges had arisen or if original challenges had become irrelevant. For example, while we initially considered if the challenge of *unobtrusive accessibility* had been conquered and thus ceased to be a challenge, we also identified a new challenge of creating *boundaries across artefacts*. Through our discussions, we found that proposing the challenge of unobtrusive accessibility as "conquered" and the challenge of creating boundaries across artefacts as "emerging" fail to acknowledge the link between what has been "solved" and what has been "introduced". Instead, a revision of the challenges indicates how the challenges have historically evolved. The challenge of unobtrusive accessibility has transformed from the challenge of allowing multiple applications to run in parallel simultaneously allowing actors to easily shift across applications while working to instead introduce extra work of handling multiple artefacts (physical and digital) and their boundaries in as ecologies of artefacts (*exaggerated accessibility*). Moving back and forth between empirical data and theoretical concerns of the eight challenges, we iteratively discussed and reframed the challenges as we identified empirical examples in the data demonstrating how the challenges emerge today. In our results section, we selected empirical scenarios exemplifying each of the challenges, outlining how groupware is perceived today, how the challenges have evolved, and how these insights can assist developers of groupware systems in the future.

4 Results

4.1 Disparity in work and benefit

The disparity between work and benefit refers to the potential misalignment between who benefits from the use of the technologies and who needs to do the required work for the technology to work. Examining the empirical observations from Org1 and Org2 on their use of groupware technologies supporting their hybrid synchronous meetings, we identified several examples where the increased work of making the hybrid technology function relied on specific people, while others benefitted. What was pertinent in these empirical observations is how the sub-group of collocated participants must engage in additional work activities to accommodate the work of others – namely the individuals who were geographically distributed from the collocated sub-group. This additional work took different forms and shaped activities in certain ways, however, all the work of accommodating and adjusting the socio-technical setup for including remote participants in the meeting was left to a few people. Below we provide a few examples across both cases.

4.1.1 Teamwork in software tool rollout

The first example concerns a situation where a project team at Org2 was assigned the task of implementing a new software tool into the organization. Part of the implementation process includes detailed work of aligning multiple tasks and activities across the participants within the project team. This work includes creating a long-term plan for the implementation, developing the educational material based on information from the external provider of the tool as well as getting an understanding of the new features of the tool. When the project implementation was to be executed, different team members were responsible for various parts of the project, which required them to continuously align and coordinate their tasks. Since the team members are also new to the software tool, participants also need to learn about the tool, while planning the implementation and education. The project manager of the team is responsible for making the plan and structure of the team meetings throughout the project. The project team includes six participants who are physically located in Denmark working either from the office or remotely from home. The providers of the software tool are located in Britain. The geographical distribution required all meetings to be organized as hybrid meetings of blended collocated and geographically distributed members. The hybrid setup shaped the project team's collaboration as well as the conditions of using a collection of groupware systems including video conferencing tools and associated digital applications. Below we go into more detail.

Initiating the software tool implementation project, the project manager created a kick-off meeting, where all members of the project were introduced to the scope and plan for the project. The initial meeting only included organizational members who were all internal to the organization and the meeting was performed in a hybrid setting with four collocated team members attending from the office in Denmark and two team members attending online from home. The collocated project members conducted the kick-off meeting in a room six floors from their office, in a space close to the canteen of the building. This room was large enough for all project members and available, whereas all the other rooms closer to their desks were too small and reserved for others. During the kick-off meeting, different

challenges occurred, and they experienced several technological issues delaying the work. The project manager connected his laptop to the shared screen in the meeting room and another collocated participant joined the MS Teams meeting together with two other geographically distributed team members who both worked from home. Sound issues arose as the project manager connected a cable to their laptop attaching the speaker in the room. The speaker did not work. One of the team members went to the office six floors down to get a new cable, which did not solve the problem. One of the other team members changed the setting on the screen setup in the room, which provided sound from the speaker, however, echoing all that was said. After 10 minutes of troubleshooting, they gave up, and disconnected from the speaker and microphone in the meeting room, to use the laptop's speakers instead. The project members introduce themselves, starting with the virtual attendees. When the physically collocated participants start talking, new sound issues arise by echoing the sound, making it impossible for the virtual attendees to hear the collocated participants. The echo was also interrupting the collocated sub-group. To solve the issue, the collocated sub-group had to turn on and off the sound and the speaker several times during the meeting depending on who (collocated or virtual participants) was talking. When forgetting to do so, the sound issues interrupting the meetings continued, either by echoing the sound or preventing playing the sound. This happened several times during the meeting, preventing the online participants and collocated group from hearing each other and delaying the meeting as participants had to repeat themselves several times confused by who was muted, and the constant attention to which speaker and microphone to turn on and off and when. Likewise, there were challenges in the online setup – the camera in the meeting room was used. The video feed showed only the end of the table in the frame, making it impossible for the online attendees to see the collocated project members when they talked. The project manager connected to the shared screen to share his slides, however, during the meeting, they realized that none of the online attendees were able to see these slides, as the project manager mirrored his laptop's screen on the shared monitor but had not shared the slideshow in the video conferencing tool. One of the participants should have attended a new meeting at the time this meeting ended, but as he needed to go down six floors, he had to leave before the meeting ended.

Interestingly, zooming out from the details on the kick-off meeting for the software tool implementation project, it is evident that the additional work required to include geographically distributed team members is no small task and that all the work is done by the collocated project members. The collocated team members have much work to do in order to allow for remote participants to join – while the work remote participants can provide to solve the issues is limited. Remote workers depend upon the collocated team members to do the work of allowing them to join. They are 'passive' by design since their digital presence relies upon how collocated team member adjusts their bodies, the technologies, and connect the digital and the physical setup. While you can say that for the hybrid setting to work the remote participants depend upon the collocated members to engage in articulation work of the digital setup, while the remote participants mostly are involved by logging in to the groupware technology. Remote workers need to do extra work to make sure that they can be heard – for example, in this scenario see that the remote participants talk for around 30 s before the collocated team members manage to turn on and off the right microphones and can inform the remote participant that they are muted. Because the camera does not display any of the collocated participants in the video feed, the remote participant does not know that he is muted. The remote worker then needs to repeat himself. Thus, there is a disparity in work and benefit between the people doing the required work, and the people being able to benefit from the work. Based upon the experienced challenges of the hybrid setup, the project manager afterward plans an additional 15 min before all their meetings to test the technology setup. Due to logistic reasons, the meeting room was also changed across meetings, thus the project manager began to bring a speaker, microphone, and camera for every meeting as a backup in case the equipment within the rooms did not work.

Challenge: In our empirical data, the challenge of disparity in work and benefit from groupware use continues to exist. Concretely we showed the extra work required for accomplishing the cooperative work is related to the work of including all individuals into the common field of work. The project manager is required to do extra work to include participants from different locations, and the remote participants need to adapt to technical conditions produced by the collocated sub-groups and adjust their actions during breakdowns, like repeating themselves if required. Furthermore, the project manager stated when asked about hybrid meetings, that it is "easier to do the meeting as virtual [only]". However, remote work without hybrid options also disregards the advantages of the cooperation of collocation. Leveraging on the physical collocated combined with remote participation might not be perceived as beneficial by the project manager as an individual; however, a hybrid arrangement does support the

cooperative work when it is impossible to have everybody collocated. We therefore suggest reframing the challenge of disparity in work and the benefit to *always* depending on additional work from individuals or sub-groups, as today the increasingly digitally performed work and the possibility to work from different locations require cooperative activities and/or information to include digital features.

4.2 Critical mass and Prisoner's dilemma problems

Critical mass refers to the challenge that for groupware to be useful, a high percentage of the involved actors must use the groupware system. In our empirical cases, we found that the cooperative participants all used the groupware applications required for them to conduct their work. For example, organization members in Org1 are present on the Microsoft Teams application and engaged in different sets of sub-group classification structures within the groupware technology. Thus, in our empirical data, we did not identify specific challenges related to critical mass. Instead, we saw how the critical mass challenge was related to access to technologies. For groupware to function, all involved people must have user access to the groupware platform. Therefore, in our cases, the challenge of critical mass was not related to the number of participants refusing to use the application, but instead, the challenge was in producing access (as in security access) to the relevant technology. We will provide an example below.

4.2.1 Mix-up in team scheduling

In Org2, we observed a team tasked with a substantial project, namely, to replace the fundamental Internet network infrastructure across 26 subsidiary office sites. This intricate endeavour involves members from various internal departments, the wider organization, and external consultants. The project encompasses different roles: internally within the main company is the Network Team, dedicated to designing the new network infrastructure and ensuring alignment with the subsidiary sites' needs. Another internal team, the Device Team, focuses on managing devices across different sites. Externally, external consultants are hired for the technological procedures associated with replacing the network at the sites, as well as ongoing network maintenance.

The challenge in this empirical example arises from scheduling network replacement events to avoid disruptions to essential work activities at the local sites, ensuring all relevant sub-groups are available at the specified time. External consultants create and update the schedule weekly, sending it to the Network Team within the internal department. However, without specific updates explicitly outlined, confusion arises within the internal teams. As part of their coordination responsibilities, the Network Team organizes various activities based on a larger schedule, including coordination with the internal team responsible for devices. In preparation for a network replacement event, a joint meeting is held between a member of the Network Team and the Device Team to identify devices at the local site that must be enrolled on the new networks. The meeting is put into place to identify which devices are in use at the local site before replacing the Internet within increased security measures in order to prepare for any devices that require special attention (e.g., printers, shared tablets) allowing for a smooth transition.

In this specific example, the network replacement occurs in Norway, necessitating the company's physical presence during the event to test its functionality on different devices. Consequently, a team member from the Device Team organizes a flight trip to Norway, as this team is responsible for identifying and managing devices. A coordinative complication arises when the two teams during the meeting realize that the planned trip to Norway does not align with the day scheduled for replacing the network. While it is the responsibility of the Device Team to manage devices, it is the responsibility of the Network Team to test the network functions ensuring these behave as expected after replacing the Internet. It is therefore a grey area who should be physically present at the site in Norway during the replacement event. The Device Team can identify devices on the same day as the testing of the devices, and it is therefore agreed to send only a person from the Device Team from Denmark to Norway for the network replacement event to reduce travel.

All the scheduling of the project is done by external consultants. To share the schedules, they are distributed to the Network Team by sending "photos" of the schedule. The absence of direct access to the planning tools and actual scheduling creates uncertainty in the team. It is unclear who updates the schedule, when, and where – and this opaqueness in coordinative processes exacerbates the situation, as the different sub-groups do not have the same updated schedule available or are able to monitor changes to the schedule. The external group of consultants is in charge of scheduling, while the Network Team is responsible for coordination across different geographical sites and sub-teams. This coordination includes securing agreements with local representatives to turn off the network on the

designated day of replacement. The complexity of the work demands intricate coordination across different organizational groups. Unfortunately, the sub-groups involved in various tasks lack access to the same tools. The internal Network Team is without access to the tools used by the external consultants, potentially leading to misalignments. In this instance, conflicting information results in different sub-groups planning the same network replacement activity on different dates.

Challenge: For groupware to function effectively, access to the information stored in the groupware system (in this case scheduling) is critical for all relevant individuals, irrespective of their organizational conditions (internal employees as well as external consultants). Failure to do so risks the groupware application's failure and impedes cooperative work. In the current landscape, most technologies are designed for collaborative use, and the critical challenge lies in ensuring that these systems accommodate the appropriate number of users and individuals. This appropriate number is not necessarily the majority of employees in the organization but includes all individuals relevant to the common field of work, regardless of their organizational affiliations. If the relevant individuals involved in the shared work activities do not have access, there is a risk of miscommunication and failure in coordination. Thus, based upon our empirical data on hybrid work, we propose to rethink the critical mass challenge from being 'the majority' of all employees to being relevant individuals for the common field of work.

4.3 Disruption of social processes

Disruption of social processes covers the challenge that groupware can interfere with social dynamics and implicit information such as social taboos and political structures. Going through our empirical data, we find examples of collocated sub-groups who interact directly person-to-person, circumventing the groupware technology protocols for interacting digitally to ensure that all participants in the group have equal access to important information.

4.3.1 Oversight in shared folder structure negotiations

Exploring the complexities of managing social dynamics in hybrid office environments, we turn our attention to a team in Org1. This team operates across at least four locations spanning two countries, engaging in daily collaboration. They commence each day with a daily meeting to synchronize current tasks and challenges. The team manager is stationed at the company office in Denmark along with two team members. Two other team members are geographically located in two different regional areas in Denmark, unable to commute to the office, while the remaining team members are situated in Poland. The Microsoft Teams application serves as the central hub for their communication including daily video meetings, direct messaging, updates, and file sharing. Beyond internal organizational collaboration, the team plays a pivotal role in coaching and educating other company departments and teams in agile work practices, sharing teaching materials, and more.

Due to the growing sets of files shared within the groupware system, two team members from the Denmark office requested a restructuring of the folder system from the team manager on behalf of the entire team. Subsequently, the team manager restructured the folders and informed the two team members in a team chat, including the three individuals who had previously discussed the need for restructuring. While this communication continues a conversation that originated in the office, communicating between members of the sub-group from one Danish location, it was only shared across the team digitally after the fact. Thus, other members remote to the sub-group who are restructuring are presented with the result of the conversations, but not included in the conversation to find the solution. It should be mentioned that the two collocated team members initiated the restructuring on behalf of the entire team, but having a direct conversation with the manager, detached the rest of the team from the conversation. Since the folders are shared across the entire team, the restructuring has an impact on all team members.

This scenario illustrates how collocated sub-groups risk inadvertently sidelining a broader discussion by circumventing the groupware tool for dialogue. The manager's exclusive response to the two collocated team members creates distinct sub-groups within the cooperative team, impeding seamless information sharing. In hybrid work configurations, there is a high risk that sub-groups will emerge due to a lack of collocation. The risk of sub-groups necessitates cohesive teamwork to counteract potential negative social dynamics. In our empirical case, Microsoft Teams serves as a central platform for information and knowledge sharing, facilitated through shared folders and a chat forum, however, if only part of the conversation is displayed digitally the risk of exclusion is high.

Challenge: Cooperative groups consist of different sub-groups with varying conditions for accessing other individuals or sub-groups engaging in the shared work activity, presenting new challenges for violating social processes. While the groupware MS Teams enables access between different individuals and sub-groups, the organizational members

risk violating social processes, if individuals engaged in the common field of work choose to interact in the (collocated) sub-groups either by circumventing the groupware technology and interacting directly with collocated individuals or by turning towards (existing or new) sub-groups within the existing groupware technology.

4.4 Exception handling

The challenge of exception handling refers to the difficulty of groupware being used differently than expected, especially when the cooperative work is organized variously making exception handling critical to solve a given task. Examining our empirical data, we see that groupware technology in our cases allows for exception handling by being designed priori as open-ended, and therefore not stipulating any specific ways of use. However, the open-ended design requires that organizational members engage to configure the groupware technology over time to accommodate for emergent exception handling.

4.4.1 Teams application used in multiple contexts

Examining the reconfigurations of Microsoft Teams within Org1 during the COVID-19 pandemic, which physically separated collaborating teams, sheds light on the challenges of exception handling. The adjustments aimed to make the software tool versatile for various work activities, evolving from its original purpose of primarily facilitating online meetings to becoming the central hub for all activities during the pandemic-induced shift to remote work.

As the agile coaches in Org1, responsible for teaching work practices to different departments, transitioned their activities online due to social distancing and work-from-home arrangements, Microsoft Teams became the platform for seminars and coaching sessions. This period coincided with Org1 revising its strategy, expanding activities, and hiring new employees in Poland. Even as regulations eased and some employees returned to the office, the workforce remained evenly distributed between Denmark and Poland. This led to a strategic management decision that all teams must include members from both countries, which consequently alters work conditions where teams will never be geographically collocated. Post-pandemic, despite some employees returning to the office, many activities, including teaching activities, continued to be conducted online due to the geographical distribution of team members.

Interestingly, one of the activities, the core agile practice of PI (Program Increment) planning, was referred to as crucially requiring individuals to be geographically collocated. PI planning involves the planning of the company's goals and objectives for the following time scope. However, the post-pandemic work conditions did not allow for collocation among all team members, initiating discussions within the team on how to adapt to the partial distribution of team members. This included discussions before the event on possible ways to conduct PI planning and post-reflections. The team started using virtual digital whiteboards shared in the Microsoft Teams folder, for example, to brainstorm personal experiences of the PI planning event. Recognizing the importance of team and departmental cohesion, the organization initiates prioritization of social activities for relationship-building. These social events, mirroring the format of planning and evaluation meetings, were also conducted on Microsoft Teams. Each team member attended these activities individually from their personal workspace. During one such event, they engaged in a team-building game.

This example showcases how the Microsoft Teams application, initially used for specific meeting functions, evolved, and was adapted to multiple cooperative contexts, becoming integral to various aspects of work, collaboration, and team building in response to external challenges like a global pandemic, and the partial distribution of closely collaborating teams after the pandemic. What is important and interesting is that we across both Org1 and Org2 saw several examples where the same groupware system was used in multiple different ways and that the design of groupware technologies introduced all were fundamentally open-ended by design allowing for participant to configure and re-configure their used as needed. In this way, participants would not experience the need for exception handling – as in identifying a workaround to allow for smooth interaction. Instead, we, in both organizations, witnessed how the open-ended design of groupware technologies made the participants reflect iteratively while making it possible for organizational members to adjust the technologies addressing emergent situations of potential exception handling before these became an issue.

Challenge: The dynamic reconfigurations of the MS Teams application to accommodate diverse work scenarios are possible due to the open-ended and flexible conceptual structural design of the groupware technology. Teams as a groupware application extend beyond routine patterns of use to encompass various activities like quarterly planning, goal setting, evaluations, teaching, and social engagements. The adaptability of the groupware proves invaluable for supporting work in different contexts. The flexibility demands ongoing adjustments of the groupware based on reflection and action initiated by organizational members. The continuous addition of activities to be done using the

same groupware system necessitates new ways to share files, link new applications, modify folder structures, and more. Surprisingly, we found that in both organizations the need for exceptional handling 'outside the groupware' to accommodate emergent situations did not exist, since the participants were able to adjust the technology.

4.5 Unobtrusive accessibility

Unobtrusive accessibility refers to the challenge of cooperative features to be infrequently used. Examining our empirical data, we saw that the groupware used in our cases enables unobtrusive accessibility by including intuitive built-in cooperative features. Concretely, the groupware technologies used allowed participants to engage in multiple, parallel, and different types of activities simultaneously. The multiple and parallel use however also creates challenges, since by allowing people to do multitasking, shifting across individual tasks and cooperative tasks seamlessly creates the challenge of creating boundaries for and around activities and technologies. In this way, the groupware used emerged as exaggerated accessibility that requires individuals engaging in group work to create boundaries in technologies in practice.

4.5.1 Re-bounding technologies in practice

Considering the groupware technology used it is evident across Org1 and Org2 that none of the organizations could be said to have 'one type of groupware'. Instead, both organizations had an infrastructure of artifacts, including physical technologies like laptops, mobile phones, tablets, notebooks, keyboards, monitors, cables, and wires, and digital artifacts such as Microsoft Teams, Cisco Webex, Word, PowerPoint, Jira, and Datadog. All these artifacts and devices were interlinked; for example, it is possible to connect to Teams on both laptops and cell phones, and participants can share Word files in Teams folders or share an individual screen displaying Datadog in Cisco Webex. All these interconnections and relations created groupware setup as an ecology of artifacts enabling exaggerated accessibility supporting different types of activities, which blurred the boundaries between artifacts (devices and groupware applications), necessitating continuous reconfiguration of the setup.

Let us focus on one organizational member, Sophie, to illustrate. Sophie, an agile coach at Org1, commutes to the office three days per week, starting her day by picking up her physical devices from the locker and setting up her workstation. Her work setup for the daily catch-up meeting involves connecting her computer to two monitors, arranging her keyboard and mouse, and placing her notebook and pen next to the laptop. The first meeting is the daily catch-up meeting with the team. Sophie facilitates the meeting using notes on her laptop's screen, with Microsoft Teams on the second monitor, occasionally sharing her screen to display a Jira board scheduling the team's tasks and using her notebook for meeting notes. During the meeting, a backchannel is initiated, where team members share text messages; however, she refrains from checking it until after the meeting concludes to maintain focus on facilitating the meeting. The timestamp in the backchannel assists her in understanding the context in which the texts were sent during the meeting. Sophie has meticulously organized both physical devices and groupware applications to accommodate the needs for specific work tasks, creating boundaries for the artifactual setup.

After the meeting, Sophie worked on a task related to educating managers in agile work practices. Her setup includes Microsoft Teams on the laptop for immediate responses, a workboard on one monitor, and an Excel sheet on the third monitor. When collaborating with an organizational member (Bent) outside the team, Sophie goes to the Teams application and makes a Teams call directly to Bent. Bent and Sophie collaborate using the digital Board, sharing screens in the video call setup during their synchronous interaction. Sharing screens is the most essential functionality for their work including sharing the digital Board or other digital content like illustrations. Sophie continuously adapts her technical setup to support the collaborative work at hand considering collaborating partners, the content of the shared task, the digital opportunities as well as what shall happen after concrete engagement.

As part of agile coaching, Sophie meets with a manager in Microsoft Teams to discuss improving agile work practices within the team. For this personal coaching meeting, Sophie moves to a small meeting room, disconnects her laptop, and reconfigures the technical setup for a two-person meeting. Beyond office meetings, Sophie also works from home, adapting her technical setup accordingly. For example, she had a meeting with a colleague from the team by the end of the day, thus she decided to leave the office and then have the meeting when she arrived home. In this situation, she brought her laptop home instead of putting it back into the locker and then reconnected it to the setup she had at home.

The flexible work conditions and dynamic contexts require organizational members to rebound the technological setup – both physical and digital devices – to fit the specific work situation. For example, a manager at Org2

is taking early morning meetings on the Microsoft Teams application on his phone from the car due to a long commute time.

Challenge: Groupware supporting multiple, parallel types of use simultaneously is transforming the prior challenge of unobtrusive accessibility towards a revised challenge of participants bounding and creating boundaries around technologies. Instead of the challenge being the possibility of running multiple applications simultaneously, the challenge emerges as the difficulties of creating boundaries for the use of artefacts ecologies with an increased risk for mental overload constantly shifting between multiple interrelated contexts, artefacts, locations, applications, and devices simultaneously.

4.6 Difficulty of evaluation

Groupware systems are difficult to evaluate as they are context-dependent and affected by other actors involved in the work. The work scenarios in our empirical data exemplify this through the malleable team configuration continuously changing the context for the work. Despite engaging in a common field of work engaging the same individuals, the flexibility of the geographical locations of the different team members and the sub-groups, affect the context for work, making different technologies available to support the work.

4.6.1 Dynamic team configurations

Our research reveals that the dynamic nature of team compositions poses a significant challenge, especially within evolving group structures. Both Org1 and Org2 grapple with hybrid distributed teams, each navigating distinct geographical configurations. While Org1 consistently maintains geographical dispersion, both Org1 and Org2's organizational members have the flexibility of accessing shared office spaces and working occasionally from home, allowing employees to seamlessly transition between working from the office and remotely. Org1 holds a free seating policy while Org2 has permanent seats for the employees in the organization. Both organizations have open office spaces requiring employees to move to meeting rooms when engaging in meetings either digitally or with collocated colleagues. Both organizations employ consistent department teams including the same individuals and project teams that are formed across departments working on a common field of work within a time-limited scope.

To illustrate, we draw on the example from the beginning of the Result section, which describes a project team working in changing contexts. The team engages in collaborative work, discussing specific steps in transitioning to a new software tool during internal project meetings and participating in educational sessions where external providers present the tool's capabilities. However, the composition of these sessions varies on different days. During some internal project meetings, team members work from home while others are in the office, each day with new configurations. The same variability occurs in the case of educational sessions, where physical presence at the office differs. The project manager planning these sessions is unaware of the specific locations of team members for each session. Consequently, the project manager plans the sessions uniformly – booking a meeting room, bringing a camera, and microphone, and connecting his laptop to a second monitor. However, in some meetings, he is the sole physical attendee, while in others, the team is fully collocated, rendering the room size inadequate. Moreover, the nature of the meetings varies, ranging from 1-h external presentation to 10-min internal team discussions. This example highlights how the practical work context of the same project team can be entirely different, despite appearing similar in theory.

Challenge: While evaluation of groupware has always been challenging outside of real-life use cases, this challenge is further complicated as the cooperative configuration changes from day to day, due to the floating locations of individuals shaping the perceived usefulness of the groupware. The same systems must support work performed in various surroundings. Difficulties of evaluation refer to that we cannot simply test groupware within an experimental setting, since the cooperative engagement is shaped by the contextual nature of the work – which as the above example shows constantly changes. Testing groupware technology cannot be done outside the contextual use. Conducting a lab study to test if the groupware technology is suitable for Org2 or Org1 is not feasible because their work is shaped by the contextual contingencies that change daily (locations, rooms, content, people etc.). In this way, the dynamic nature of team compositions and contextual contingencies underscore the heightened complexity in evaluating groupware technologies as it was back in 1994, but moreover, we see how the locations are an added dynamic complexity when considering hybrid settings.

4.7 Failure of intuition

Failure of intuition refers to the challenge of managers' decision-making regarding the implementation of cooperative systems. In our data, we see how managers strive to provide a vibrant and attractive workplace and office

environment, however, question the quality of managerial decision-making related to groupware and the organizational conditions to perform the work.

4.7.1 Cultivating vibrant and attractive office environment

Our engagement with Org1 and Org2 unveiled a shared aspiration to foster vibrant and attractive hybrid offices. Working with the organizations we had several meetings with the managers from both organizations who openly acknowledged the challenge of creating a physical workspace infused with a lively atmosphere – especially after the pandemic. The ongoing process of achieving the vision of an attractive office involves intricate considerations. Org1, in an attempt to cultivate a vibrant office, has implemented policies mandating physical presence for a certain number of days a week, but this effort has not been seamlessly translated into the desired lively atmosphere. Despite recent physical renovations of the office space geared towards supporting various collaborative activities, employees often find themselves engrossed in online meetings at their laptops with headphones on and the challenge of finding a location in the office without disturbing others.

In contrast, Org2 adopts a different managerial approach refraining from enforcing physical attendance. Instead, the organization aspires to create an inviting, attractive, and innovative workspace that naturally draws employees in. However, both the *push* towards mandatory presence and the *pull* towards creating an appealing environment fall short of realizing their objectives. Notably, in terms of technology, both organizations have strategically equipped their offices with an array of groupware and devices, including laptops, tablets, and monitors at each desk, shared monitors in meeting rooms, and hubs for seamless connectivity. Org2 even invested in a Surface Hub (85′ screen on wheels) that can be moved around the office floor, for example, to be used for department meetings with partially hybrid participation. However, during the period of fieldwork at the office space, this screen was never in use, and employees also commented that it was not utilized.

The crux of the challenge lies in selecting a groupware portfolio and related devices that can effectively support the diverse work contexts prevalent in these organizations. Managers at both organizations express eagerness to implement strategies that cultivate a vibrant atmosphere and work environment. However, they grapple with deciding on specific actions to take. Cooperative groups within these entities may operate in fully collocated settings at times, shift to distributed work in various configurations, or navigate hybrid arrangements. Each of these work contexts imposes distinct requirements on the groupware technology, emphasizing the intricate balance needed to create a vibrant and effective hybrid office environment.

Challenge: The manager's role in determining the appropriate groupware has evolved. While the historic challenge revolved around selecting specific groupware technologies for distinct activities (such as email for communication), the contemporary landscape presents a more intricate obstacle. Today's challenge lies in curating a portfolio of diverse groupware technologies and devices capable of supporting a spectrum of work activities across different contexts. The complexity arises from the varied configurations, contexts, and purposes for which groupware is expected to provide support. The critical decision of which groupware to incorporate carries the risk of failure if it does not effectively cater to the diverse needs inherent in the organization's multifaceted work environment.

4.8 The adoption process

The adoption process for cooperative systems is challenging as the value and usefulness of the groupware system are likely perceived differently by various individuals with a high risk of failing the implementation. In both our empirical cases the groupware systems were already in use when we arrived and thus it is difficult for us to see whether specific groupware technologies in use had adopting challenges. However, what we did witness was that any groupware application cannot be considered as a single entity. Instead, groupware technology in organizations today is always and immediately part of a larger infrastructure, thus the groupware adoption process is fundamentally about how new groupware systems extend the existing infrastructure supporting the work.

4.8.1 Implementation of cross-organizational social platform

In the intricate landscape of Org2's organizational structure of subsidiary companies, with cooperative activities across different entities, the organization has incorporated the Workplace[3] software application into its extensive ecosystem. Crafted by Meta, Workplace stands as an online platform meticulously designed for fostering company-wide collaboration. Encompassing a rich array of features such as instant messaging, pages, and groups, WorkPlace positions itself as the professional sibling of Facebook. The

3 https://www.workplace.com/.

primary objective of Workplace is to facilitate the sharing of work-related updates, critical information, IT developments, and events across diverse departments, subsidiary companies, and various groups within the organizational framework.

To encourage transparent communication and information exchange, Workplace is to become a shared platform accessible to different subsidiary companies at Org2. However, the assimilation of Workplace into Org2's existing communication landscape encounters a challenge as the features of the social platform overlap with features of existing groupware used for their work, making the employees characterize Workplace as "yet another platform."

Org2 heavily relies on Microsoft Teams as the primary tool for communication, serving as the cornerstone for sharing updates and information. The introduction of Workplace is met with skepticism by employees who view it as an additional layer of complexity. Microsoft Teams, a frequently used groupware system for employees, already offers a comprehensive suite of features, including shared 'walls' for information exchange, knowledge sharing, file sharing, direct messaging, and more. Deciding when to use Workplace instead (or additionally) is challenging due to the ingrained use of Teams, which can sometimes cause employees to forget about the new application. Introducing a new platform demands extra effort from the organizational members to post updates and stay informed. However, this work is not just about doing the work but remembering and considering when it is relevant to use. Org2 faces the delicate task of articulating Workplace's unique value proposition and relevance, ensuring it does not become an additional burden for employees already adept at utilizing other groupware systems (such as Microsoft Teams). The challenge lies not just in technological integration but in delineating Workplace's distinctive role to avoid redundancy and ensure seamless integration into the organization's collaborative tapestry.

Challenge: While Workplace shares similarities with Teams, including group connections, post sharing, and direct messaging, the lack of a distinct value in use and the redundancy of features make it an additional, rather than an essential, tool. Consequently, the adoption process of Workplace necessitates a thoughtful implementation strategy, clarifying its unique value and relevance compared to the existing Teams platform. The challenge lies in articulating Workplace's distinctive role, ensuring that it does not become an extra burden for employees who are already adept users of Microsoft Teams. During the adoption process of groupware applications and technologies, organizational members must integrate seamlessly with the existing infrastructure supporting common work processes. Failure to do so may result in these tools being perceived as additional tasks and, consequently, overlooked, or underutilized.

5 Discussion

Groupware technology is not just about designing and deploying technology into an organization but includes all the work of crafting socio-technical circumstances ensuring that the technology enables rather than constrains the work practices in which the technology is going to be situated. We sat out to explore whether the eight challenges for developers identified by Grudin in 1994 [1] were still pertinent in terms of creating and organizationally implementing groupware technologies in organizations today three decades later. We interrogated the challenges by introducing empirical observations from ethnographic work conducted in two organizations during 2023. By analytically considering our empirical data in terms of Grudin's eight challenges, we were able to identify patterns across organizations and challenges, which allowed us to examine the empirical data in specific ways focusing on the groupware design, use, and adaption into the organizations. What is interesting about these cases is that after the pandemic the use of groupware has been ubiquitous within the organizations. This means that the way the organizations consider the fundamental technical infrastructure of the organization includes access and use of groupware technologies including, but not limited to, video-conferencing tools, shared folders, electronic calendars, and digital messaging systems (email, slack, etc.). Thus, when we went through the data to identify empirical observations that allowed us to comprehend more details about the design, use, and adaption of groupware, we quickly learned how groupware technology no longer is viewed as a potential add-on application within an organization. Instead, groupware technology tends to blend into the background assumptions of organizations and thus becomes a taken-for-granted infrastructure. Thus, the work people do to make groupware systems function is viewed as everyday circumstances of work, and thus requires an analytical gaze to pick apart for scrutiny. During this analytical scrutiny, it became clear to us that the original challenges for groupware developers were grouped into different overall categories of how groupware systems functioned.

The categories of the eight challenges are cooperative challenges, social challenges, and organizational challenges. *Cooperative* challenges (no. 4, 5) are related to how the cooperative engagement is conducted (in terms of articulation

work and situated practices) and how well the groupware technologies support these cooperative practices. *Social* challenges (no. 1, 2, 3) are related to the social relations of the work, and in particular how groupware systems enable or constrain relationships among each other (including concerns of sub-group dynamics). *Organizational* challenges (no. 6, 7, 8) are related to the hierarchy and motivations embedded into decisions on groupware technology to support organizational practices. Together these three areas of challenges produce a set of relevant concerns that continue to be critical for groupware developers in 2024.

5.1 Cooperative challenges

The cooperative challenges for developers of groupware technology center the organization of work including procedures and protocols for work as well as the informal structures of the work organization. Work procedures and protocols are important for the design of groupware systems since these entail what people do, when and where [43, 56, 84]. Groupware systems embedded into organizations create the boundaries for which activities organizational members can do, and thus also bear the risk of constraining crucial activities of cooperative actors if these are not considered [54]. Cooperative work is always immediately socially organized [35], which means that the way participants interact and engage in the common field of work produces certain needs for groupware support. Different from single-user technology, Groupware cannot be understood outside the collective activities, making the design of generic groupware vulnerable, since the risk of producing a system that is completely aligned with an organizational practice is difficult [66, 82]. Organizational practices can be slippery, flexible, malleable, and unpredictable. The way people plan activities is rarely completely aligned with the way the activities actually are acted out in real-life practices [73, 74]. In practice when people act, they simply do what is necessary to accomplish the task, and often this is different from the actual prescribed practices [65, 80]. Paraphrasing Lucy Suchman, plans are only resources for practice, and situated practices are what actually takes place [61–63]. This is not to say that protocols and scripted activities are never followed and are unimportant [59] – they clearly are important and critical procedures following protocol (e.g., air traffic control). Instead, what CSCW researchers say is that the open-endedness, malleability, and reconfigurability of groupware systems are critical for success since groupware systems require organizational members to have the opportunity to change, revise, and realign the organizational procedures embedded into the design [83]. Without such opportunities, the participants would need to create workarounds (often in parallel systems) in order to accommodate the exception handling that often (close to always) is embedded in any kind of cooperative task [58].

Surprisingly, we did not detect the challenge of exception handling in the ways the two organizations enacted their groupware systems. Instead, our empirical data illustrated how the enacted groupware systems were open-ended in use, and how the organizational members were able to use the technologies across contexts and activities. We were very surprised to experience two cases, where the challenge of exception handling did not appear. Any literature review or summaries of empirical cases published in CSCW will demonstrate a wide range of exception-handling problems [77, 81]. Reflecting analytically upon this surprise, we discovered that the list of groupware systems that we have explored in the empirical cases were all fundamentally open-ended in nature as well as re-configurable – and thus the success of these concrete systems within the two organizations is very much due to that the technologies used, have in the very design of the groupware, including users' ability to revise, re-structure, and re-organize content, folders, and structures. Further, we found examples where participants discussed and re-negotiated the conceptual structure of the groupware systems as part of their cooperative engagement. This is not to say that developers of groupware technologies now have solved the issue of exception handling; there are still multiple cases of for example workflow systems documenting the challenges arising when systems are not reconfigurable [74], and constraining important organizational practices, for example, in healthcare [57]. Instead, our argument here is that designing for exception handling in groupware systems continues to be crucially important to enable rather than constrain organizational practices, and our cases demonstrate how such designs can be successful. Further, our empirical cases suggest that organizational members have developed ways and practices that include configuration and reconfiguration of groupware technology as evidently important recurrent practices relevant to groupware technology use.

In our two empirical cases, the organizational members expected the groupware systems to blend into the background and thus to some extent support seamless cooperation in hybrid work arrangements. The seamless interaction took the form of organizational members taking for granted that they could work at various locations since the groupware systems allow them to access files and documents, as well as people and activities. The hybrid workplace 'fantasy' grew out of the 'work-from-home-emergency' during the pandemic, and thus organizational members knew from experience that working from different locations is

possible. However, as we also document in the empirical data, the hybrid organization of work is severely more difficult than the complete geographical distribution of all participants. Further, our empirical cases demonstrate how access to groupware is not about 'one groupware system', but instead about a wide infrastructure of multiple parallel groupware applications that are interlinked across applications and digital devices. Organizational members move across organizational-, geographical-, application-, and device-contexts, thus, the current challenge on accessibility is not about allowing for unobtrusive accessibility [1], instead, the current challenge arises as mental, organizational, and technical overload, which risk stressing the individual [50]. Rather than focusing on designing groupware systems that allow for unobtrusive accessibility, the challenge for groupware developers is to find ways to reduce the mental load of navigating across contexts, applications, and devices.

Challenge 4: Emergent exception handling: For groupware flexibility to facilitate a wide range of activities (e.g., exception handling and improvisation) requires participants to reconfigure the groupware over time to accommodate emergent use reducing exception handling.

Challenge 5: Exaggerated accessibility: Groupware supporting multiple, parallel, and different usages of applications and devices simultaneously, requires participants in creating boundaries in technologies in practice.

5.2 Social challenges

When people cooperate, they are simultaneously engaged in social activities and relationships. How people engage socially includes considerations of motivational drivers and different forms of hierarchy. How cooperative work is organized socially matters for how people cooperate, and thus is also critical for the designers of groupware systems to ensure that technology enables rather than constrains the social organization of work. In our empirical cases, the social organization of work is shaped by the hybrid work organization [16], and this organizational structure shapes the cooperative work, and thus also the requirement for groupware technology in important ways. Re-thinking the social challenges for groupware developers, a core challenge for hybrid organizations is that organizational members are immediately and always in transition between locations [15]. This 'space between' is difficult to navigate [27] and the efforts of addressing relations work between artefacts, locations, and people increase in complicity in hybrid settings [47, 48]. This means that hybrid social organizations always are at risk of creating sub-groups. Sub-groups are not necessarily problematic, however, if the sub-groups align with the physical locations, there is a risk of faultlines [60].

Faultlines increase the risk of disrupting social processes, which often is related to hierarchy and motivation within the work. However, interestingly we found that the risk of disrupting social processes also arises when organizational members circumvent the technology. If an organizational member chooses to interact directly with another member engaged in the work, they create sub-groups within the team, consequently risking misalignment and faultlines [60]. Problematic sub-groups can jeopardize the creation of trust and commitment, which ultimately can lead to a 'them/us' binary [49, 51]. Organizational members working in different contexts are thus at risk of developing problematic relationships across members. Simultaneously, we found that for the hybrid interaction to function, it is required that cooperative actors are ready to collaborate [36], since without collaboration readiness the extra effort required to bridge across contexts risks being neglected [39]. Our empirical observations demonstrated that individuals working remotely in hybrid contexts are dependent upon the extra work of collocated members in making sure to include them remotely in the conversations. However, this additional articulation work required does not necessarily benefit the collocated members, especially in situations where organizational or geopolitical concerns make the dependencies asymmetric [37, 38, 44]. The challenges related to the disparity between work and benefit [1] thus remain today in 2024, however, this adds to existing complexities. The social organizational challenge in hybrid workplaces introduced concerns about the extra work required to execute and conduct hybrid meetings for the people who are collocated in the same room. The collocated sub-group must create a setup that supports both the collaboration with the physically present individuals and the individuals participating remotely, without this extra work benefiting themselves directly.

The social organization of work supported by groupware also requires that there is a critical mass of users to make the technology useful. Numbers of users are important for success with groupware technology, however in our empirical observations the challenge was not merely about the number of users but instead included an important extra concern. Namely, the groupware system needs to give the 'appropriate users' access to the system. We observed the importance of the *relevant members* engaged in the common field of work having access to the groupware. When organizations have complex organizational setups, such as multiple sub-companies, multiple different consultancy organizations involved, or engage in outsourcing or

offshoring [45, 87], then the risk of people requiring access to certain systems but not having access to these systems increases. Access to technology and applications risks being constrained due to security concerns or simply misunderstandings; however, being excluded from important technologies jeopardizes both the organization, the team, and the individual. In one of our cases, external members had key areas of responsibility in the team, however, due to the limited access to internal resources, they did not have access to groupware applications and systems.

We acknowledge that our empirical cases both focused on hybrid cooperative work, and we are aware that not all types of organizational work are structured in a hybrid setting. Thus, we cannot assert that the social challenges we identified necessarily apply in the same way to organizational structures outside hybrid. However, the challenges of cost/benefit, critical mass, and disruption of social processes exist in hybrid contexts (with some additional twists). And we speculate that social challenges for developers of groupware technologies still exist in various other contexts, potentially with the 'hybrid twists'. We did observe that the empirical examples were not only linked to the hybrid setup but to the organizational structures (complex subsidiary structures etc.). The use of groupware and the related challenges, therefore, arise not only from the location of the organizational members but also from the individual's organizational association. For example, a flexible seating policy produces the constraints of organizational members to always think about and put together the technological setup each time they enter the office space, which is not the case if organizational members always are seated in the same place. We observed that organizational members sometimes refer to the groupware technology when collaborating with other organizational members even when being physically present at the office, due to the efficiency of accessing the digital application independent of where cooperative members are located on the current day. This is a complex and interesting challenge for developers of groupware – also taking into account the hardware and devices available.

Challenge 1: Disparity in work and benefit: Groupware always depends on additional work from individuals and/or sub-groups to support the cooperative work, which is not necessarily perceived as beneficial by the individual doing the work.

Challenge 2: Critical mass and Prisoner's dilemma problems: Groupware must be accessible for and in some sense used by all individuals relevant to or being part of the common field of work.

Challenge 3: Disruptions of social processes: Subgroup dynamics risk violating negotiated social processes, if participants circumvent the groupware technology and instead interact directly with specific actors while neglecting others.

5.3 Organizational challenges

The final set of challenges for groupware developers is the organizational structures for which the groupware application is situated. These challenges concern decision-makers' choices and processes of investing in groupware, implementing groupware systems into the organization, and finally being able to assess and evaluate whether these groupware systems are supporting the organization in important ways. Groupware technology is known to be considerably more difficult to implement in an organization because it requires convincing multiple stakeholders at multiple levels in the organization [1, 85].

Our empirical data observations focused on work practices and the use of groupware, and we did not follow decision makers' process of selecting and implementing groupware technologies. However, our interviews and conversations with managers, as well as empirical study of organizational members did provide insights into the considerations for which technologies the organization chooses to invest in, and how the cooperative workers engaged in activities of adopting groupware into their work practices. Implementing groupware will always create reduced productivity for a while, and if successful hopefully reach a higher productivity after a while of use [93]. When new technologies are implemented, it takes time for the organization to fully comprehend and learn how the technology can assist organizational members in supporting their work [94], and often success with new technology relies upon the concrete moment where the technology presents itself as a new relevant opportunity [91]. In our empirical cases, the 'windows of opportunity' which was present before our entrance into the field was the pandemic, where organizational members and organizational decision-makers were presented with the constrain of going to the office thus the opportunities of groupware entering the organizations presented a way to solve this challenge. Investing in technologies allowing employees to work remotely was thus implemented and adapted into the organizational structures since 2020 – and now several years later have emerged as everyday technologies within the organization. The technology has been adopted into the work practices. However, as the pandemic ended, and organizational members could return to the office, it became clear that managers' vision of groupware technology and work practices did not align

with how the organizational members acted. Managers continue to struggle to get employees back into the office and thus confirm previous empirical observations [6, 10, 18]. Our empirical data demonstrated the risk of managers selecting groupware technology that potentially can support their vision about work, while the organizational workers choose to adopt the groupware technology to support the way they want to work (in this case independently of being at the office). Interestingly, the concrete groupware system implemented in both cases allowed for both managers' and employees' different visions, since the open-ended design could accommodate diverse ways of working. Thus, the groupware system did not constrain the different perceptions of use, and the conflicting agenda was visible in order ways than the lack of use which prior work suggests [46]. Thus, managers' failure of intuition is not so much related to the actual purchase groupware system, but rather to their ability to imagine use.

Increased challenges of predicting the use of groupware technology in situated organizational practice are introduced with hybrid work since work in this setting is conducted in dynamic contexts where the location of the individual members changes on different days, weeks, and times. The dynamic reconfiguration of the work setup across days challenges both the technical infrastructure and the asymmetries arising due to connecting distributed subgroups [88]. Predicting the organizational use of groupware technology in hybrid organizational work is thus very difficult (maybe even impossible), and only after an appropriate time after the implementation would it be possible to evaluate whether the technology features are appropriate for the situated practices [63]. Our empirical data hint that the use of groupware in the hybrid setting caused organizational members to not take advantage of the physical spaces within the office during work (invested in during a larger renovation of the office building) nor take advantage of the technological artefacts (large screens and video-equipment etc.) invested in to support collocation in hybrid events, since the effort of connecting the infrastructure of the groupware system to the larger infrastructure of buildings and devices were not viewed as beneficial in comparison with the extra effort of articulation work [43] and relation work [47, 48].

It is an organizational challenge for decision-makers to provide a portfolio of groupware technologies and infrastructures available for organizational workers that support cooperative work conducted in various and dynamic contexts, from different locations, and that which the organizational workers simultaneously adopt in the ways that are successful for the cooperative work.

Challenge 6: Difficulty of evaluation: Groupware is difficult to evaluate outside real-life use practices, compounded by flexible work conditions creating insurmountable obstacles for meaningful, generalizable analysis of evaluation of groupware use.

Challenge 7: Failure of intuition: Manager's intuition, for selecting the specific portfolio of groupware applications to be implemented in an organization, risks failing, if managers are not aware nor in alignment with employees' needs for groupware support in relation to different cooperative organizational setups (collocated, hybrid, distributed).

Challenge 8: The adoption process: Groupware requires careful implementation to meaningfully extend the existing infrastructure supporting the common field of work.

6 Conclusions

We revisited Grudin's Eight Challenges for Groupware Developers, published three decades ago, to explore challenges for developing cooperative work technologies across the past, present, and future. Applying the challenges from 1994 to empirical examples of cooperative work in 2023, we reframed these challenges to reflect contemporary issues in designing groupware technologies supporting work in the future. Analyzing empirical data from two organizations practicing hybrid office work, we identify how groupware enables and constrains cooperative work in order to investigate associated challenges. Examining cooperative teams, the utilization of groupware within teams and across organizations, and the various ways in which groupware technologies are employed, we analyze the challenges that arise. Today, groupware is seamlessly integrated into an organization, becoming an essential part of daily work practices. Grounded in the challenges from 1994, we refined the original phrasings to reflect current work practices (Table 3).

We categorized the challenges into cooperative challenges, reflecting exception handling and accessibility (no. 4, 5), social challenges encompassing disparity in cost/benefit, critical mass, and social processes (no. 1, 2, 3), and organizational challenges including evaluation, intuition, and adoption (no. 6, 7, 8). We find that the *social* and *organizational challenges* face additional complexities related to factors such as sub-groups' locations and organizational association, malleable group configurations, and dynamic contexts, yet the main arguments concerning the challenges from 1994 remain consistent. Differently, our empirical data revealed insights into the *cooperative challenges* being revised in light of the open-ended design of contemporary

Table 3: Eight challenges for developers of groupware technology in 2024.

1	**Disparity in work and benefit.** Groupware always depends on additional work from individuals and/or sub-groups to support the cooperative work, which is not necessarily perceived as beneficial by the individual doing the work
2	**Critical mass and Prisoner's dilemma problems.** Groupware must be accessible for and in some sense used by all individuals relevant to or being part of the common field of work
3	**Disruption of social processes.** Sub-group dynamics risk violating negotiated social processes, if participants circumvent the groupware technology and instead interact directly with specific actors while neglecting others
4	**Emergent exception handling.** For groupware flexibility to facilitate a wide range of activities (e.g., exception handling and improvisation) requires participants to reconfigure the groupware over time to accommodate emergent use reducing exception handling
5	**Exaggerated accessibility.** Groupware supporting multiple, parallel, and different usages of applications and devices simultaneously, requires participants in creating boundaries in technologies in practice
6	**Difficulty of evaluation.** Groupware is difficult to evaluate outside real-life use practices, compounded by flexible work conditions creating insurmountable obstacles for meaningful, generalizable analysis of evaluation of groupware use
7	**Failure of intuition.** Manager's intuition, for selecting the specific portfolio of groupware applications to be implemented in an organization, risks failing, if managers are not aware nor in alignment with employees' needs for groupware support in relation to different cooperative organizational setups (collocated, hybrid, distributed)
8	**The adoption process.** Groupware requires careful implementation to meaningfully extend the existing infrastructure supporting the common field of work

groupware, as well as the immediate accessibility and interconnectedness in the portfolio of groupware applications. In the future, developers of groupware technologies are hereof challenged by the ways in which social relations are enabled or constrained by the technology, the motivations for embedding groupware into the organization, and how cooperative engagements with groupware require continuous reconfiguration and rebounding of technologies in practice.

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References

1. Grudin J. Groupware and social dynamics: eight challenges for developers. *Commun. ACM* 1994, *37*, 92—105.
2. Aksoy C. G., Barrero J. M., Bloom N., Davis S. J., Dolls M., Zarate P. Working from home around the world. In *Working Paper Series*; National Bureau of Economic Research, 2022.
3. Liu Z., Van Egdom D., Flin R., Spitzmueller C., Adepoju O., Krishnamoorti R. I don't want to go back: examining the return to physical workspaces during COVID-19. *J. Occup. Environ. Med.* 2020, *62*, 953—958.
4. Murphy K. R. Life after COVID-19: what if we never go back to the office? *Ir. J. Manag.* 2021, *40*, 78—85.
5. Boland B., Smet A. D., Palter R., Sanghvi A. *Reimagining the Office and Work Life After COVID-19*; McKinsey & Company: New York, NY, USA, 2020.
6. Busboom J., Boulus-Rødje N. Planning for hybrid cooperation — a design driven exploration. [Online] 2023. https://dl.eusset.eu/handle/20.500.12015/4680 (accessed Nov 09, 2023).
7. Cheon E., Zaga C., Lee H. R., Lupetti M. L., Dombrowski L., Jung M. F. Human-machine partnerships in the future of work: exploring the role of emerging technologies in future workplaces. In *Companion Publication of the 2021 Conference on Computer Supported Cooperative Work and Social Computing, in CSCW '21*; Association for Computing Machinery: New York, NY, USA, 2021; pp. 323—326.
8. Duckert M., Hoggan E., Barkhuus L., Bjørn P., Boulus-Rødje N., Bødker S., Møller N. H., Shklovski I. Work of the future. In *Adjunct Proceedings of the 2022 Nordic Human-Computer Interaction Conference, in NordiCHI '22*; Association for Computing Machinery: New York, NY, USA, 2022; pp. 1—4.
9. Helmold M. New office concepts in the post COVID-19 times. In *New Work, Transformational and Virtual Leadership: Lessons from COVID-19 and Other Crises, in Management for Professionals*; Helmold M., Ed. Springer International Publishing: Cham, 2021; pp. 79—89.
10. Smite D., Christensen E., Tell P., Russo D. The future workplace: characterizing the spectrum of hybrid work arrangements for software teams. *IEEE Software* 2023, *40*, 34—41.
11. Cook I. Who is driving the great resignation? *Harv. Bus. Rev.* 2021. https://hbr.org/2021/09/who-is-driving-the-great-resignation.
12. Hite L. M., McDonald K. S. Careers after COVID-19: challenges and changes. *Hum. Resour. Dev. Int.* 2020, *23*, 427—437.
13. Sull D., Sull C., Zweig B. Toxic culture is driving the great resignation. *MIT Sloan Manag. Rev.* 2022. https://sloanreview.mit.edu/article/toxic-culture-is-driving-the-great-resignation/.

14. Ferreira R., Pereira R., Bianchi I. S., da Silva M. M. Decision factors for remote work adoption: advantages, disadvantages, driving forces and challenges. *JOItmC* 2021, *7*, 70.
15. Neumayr T., Saatci B., Rintel S., Klokmose C. N., Augstein M. What was hybrid? A systematic review of hybrid collaboration and meetings research. arXiv, 2022; https://doi.org/10.48550/arXiv.2111.06172.
16. Duckert M., Barkhuus L., Bjørn P. Collocated distance: a fundamental challenge for the design of hybrid work technologies. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems, in CHI '23*; Association for Computing Machinery: New York, NY, USA, 2023; pp. 1—16.
17. Neumayr T., Jetter H.-C., Augstein M., Friedl J., Luger T. Domino: a descriptive framework for hybrid collaboration and coupling styles in partially distributed teams. *Proc. ACM Hum.-Comput. Interact.* 2018, *2*, 128:1—128:24.
18. Saatçi B., Akyüz K., Rintel S., Klokmose C. N. (Re)Configuring hybrid meetings: moving from user-centered design to meeting-centered design. *Comput. Support. Coop. Work* 2020, *29*, 769—794.
19. Grønbæk J. E., Saatçi B., Griggio C. F., Klokmose C. N. MirrorBlender: supporting hybrid meetings with a malleable video-conferencing system. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, in CHI '21*; Association for Computing Machinery: New York, NY, USA, 2021.
20. Tang J. C., Inkpen K., Junuzovic S., Mallari K., Wilson A. D., Rintel S., Cupala S., Carbary T., Sellen A., Buxton W. A. S. Perspectives: creating inclusive and equitable hybrid meeting experiences. *Proc. ACM Hum.-Comput. Interact.* 2023, *7*, 351:1-351:25.
21. Mu Q., Borowski M., Grønbæk J. E., Bødker S., Hoggan E. Whispering through walls: towards inclusive backchannel communication in hybrid meetings. In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24)*, 2024; p. 16.
22. Alaqra A. S., Kitkowska A. Impact of intrinsic factors and COVID-19 pandemic on the use of technology. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*; ACM: Yokohama, Japan, 2021; pp. 1—7.
23. Tang J., Inkpen K., Luff P., Fitzpatrick G., Yamashita N., Kim J. Living through a crisis: how COVID-19 has transformed the way we work, live, and research. *Comput. Support. Coop. Work* 2023, *32*, 211—213.
24. Flügge A. A., Møller N. H. The role of physical cues in co-located and remote casework. *Comput. Support. Coop. Work* 2023, *32*, 275—312.
25. Bannon L. Perspectives on CSCW: from HCI and CMC to CSCW. In *Proceedings of EWHCI'92, East — West International Conference on Human-Computer Interaction*: St. Petersburg, Russia, 1992; pp. 148—158.
26. Bannon L. J., Schmidt K. CSCW: four characters in search of a context. [Online] 1989. https://dl.eusset.eu/items/6d7cbaa8-e9e5-4cb8-84d0-5a016a5083bc (accessed Oct 27, 2023).
27. Mark G., Abrams S., Nassif N. Group-to-group distance collaboration: examining the "space between". In *ECSCW 2003*; Kuutti K., Karsten E. H., Fitzpatrick G., Dourish P., Schmidt K., Eds. Springer Netherlands: Dordrecht, 2003; pp. 99—118.
28. Schmidt K., Bannon L. Taking CSCW seriously supporting articulation work. *Comput. Support. Coop. Work* 1992, *1*, 7—40.
29. Orlikowski W. J. Learning from notes: organizational issues in groupware implementation. In *Proceedings of the 1992 ACM Conference on Computer-Supported Cooperative Work, in CSCW '92*; Association for Computing Machinery: New York, NY, USA, 1992; pp. 362—369.
30. Dourish P., Bellotti V. Awareness and coordination in shared workspaces. In *Proceedings of the 1992 ACM Conference on Computer-Supported Cooperative Work — CSCW '92*; ACM Press: Toronto, Ontario, Canada, 1992; pp. 107—114.
31. Ackerman M. S., Dachtera J., Pipek V., Wulf V. Sharing knowledge and expertise: the CSCW view of knowledge management. *Comput. Support. Coop. Work* 2013, *22*, 531—573.
32. Bjørn P., Østerlund C. *Sociomaterial-Design: Bounding Technologies in Practice*; Springer International Publishing: Switzerland, 2014.
33. Ciolfi L., Lewkowicz M., Schmidt K. Computer-supported cooperative work. In *Handbook of Human Computer Interaction*; Vanderdonckt J., Palanque P., Winckler M., Eds. Springer International Publishing: Cham, 2023; pp. 1—26.
34. Lee C. P., Paine D. From the matrix to a model of coordinated action (MoCA): a conceptual framework of and for CSCW. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*; ACM: Vancouver BC Canada, 2015; pp. 179—194.
35. Schmidt K., Bannon L. Constructing CSCW: the first quarter century. *Comput. Support. Coop. Work* 2013, *22*, 345—372.
36. Bjørn P., Esbensen M., Jensen R. E., Matthiesen S. Does distance still matter? Revisiting the CSCW fundamentals on distributed collaboration. *ACM Trans. Comput. Hum. Interact.* 2014, *21*, 27.
37. Bjørn P., Boulus-Rødje N. Infrastructural inaccessibility: tech entrepreneurs in occupied Palestine. *ACM Trans. Comput. Hum. Interact.* 2018, *25*, 26:1—26:31.
38. Boulus-Rødje N., Bjørn P., Ghazawneh A. "It's about business not politics": software development between Palestinians and Israelis. In *ECSCW 2015: Proceedings of the 14th European Conference on Computer Supported Cooperative Work, 19—23 September 2015, Oslo, Norway*; Boulus-Rødje N., Ellingsen G., Bratteteig T., Aanestad M., Bjørn P., Eds. Springer International Publishing: Cham, 2015; pp. 43—61.
39. Matthiesen S., Bjørn P., Petersen L. M. "Figure out how to code with the hands of others": recognizing cultural blind spots in global software development. In *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing, in CSCW '14*; Association for Computing Machinery: New York, NY, USA, 2014; pp. 1107—1119.
40. Bannon L. J. Understanding common information spaces in CSCW, *Position paper for Workshop on Common Information Spaces*, 2000.
41. Bjørn P., Bardram J., Avram G., Bannon L., Boden A., Redmiles D., de Souza C., Wulf V. Global software development in a CSCW perspective. In *Proceedings of the Companion Publication of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing, in CSCW Companion '14*; Association for Computing Machinery: New York, NY, USA, 2014; pp. 301—304.
42. Lipset S. *Social Organization of Medical Work*; Routledge: New York, 2017.
43. Strauss A. The articulation of project work: an organizational process. *Socio. Q.* 1988, *29*, 163—178.

44. Bjørn P., Søderberg A.-M., Krishna S. Translocality in global software development: the dark side of global agile. *Hum. Comput. Interact.* 2017, *34*, 174—203.
45. Heeks R., Krishna S., Nicholson B., Sahay S. Synching or sinking: global software outsourcing relationships. *Software IEEE* 2001, *18*, 54—60.
46. Bjørn P., Balka E. Health care categories have politics too: unpacking the managerial agendas of electronic triage systems. In *ECSCW 2007*; Bannon L. J., Wagner I., Gutwin C., Harper R. H. R., Schmidt K., Eds. Springer: London, 2007; pp. 371—390.
47. Bjørn P., Christensen L. R. Relation work: creating socio-technical connections in global engineering. In *ECSCW 2011: Proceedings of the 12th European Conference on Computer Supported Cooperative Work, 24—28 September 2011, Aarhus Denmark*, 2011; pp. 133—152.
48. Bjørn P., Christensen L. R. Relation work in collocated and distributed collaboration. In *COOP 2014 — Proceedings of the 11th International Conference on the Design of Cooperative Systems, 27—30 May 2014, Nice (France)*; Springer International Publishing: Cham, 2014; pp. 87—101.
49. Boden A., Nett B., Wulf V. Trust and social capital: revisiting an offshoring failure story of a small German software company. In *ECSCW 2009*; Wagner I., Tellioğlu H., Balka E., Simone C., Ciolfi L., Eds. Springer London: London, 2009; pp. 123—142.
50. Akbar F., Bayraktaroglu A., Buddharaju P., Da D., Silva C., Gao G., Grover T., Gutierrez-Osuna R., Jones N., Mark G., Pavlidis I., Storer K., Wang Z., Wesley A., Zaman S. Email makes you sweat: examining email inter-ruptions and stress with thermal imaging. In *ACM Conference on Human Factors in Computing Systems (CHI)* 2019, https://doi.org/10.1145/3290605.3300898.
51. Matthiesen S., Bjørn P., Trillingsgaard C. Attending to implicit bias as a way to move beyond negative stereotyping in GSE. In *Proceedings of the 15th International Conference on Global Software Engineering, in ICGSE '20*; Association for Computing Machinery: New York, NY, USA, 2020; pp. 22—32.
52. Hecht B., Terveen L., Starbird K., Shneiderman B., Golbeck J. The 2016 US election and HCI: towards a research agenda. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '17)* 2017, pp. 1307—1311; https://doi.org/10.1145/3027063.3051140.
53. Starbird K. Examining the alternative media ecosystem through the production of alternative narratives of mass shooting events on twitter. In *Proceedings of the International AAAI Conference on Web and Social Media*, 2017; pp. 230—239.
54. Rönnberg E., Larsson T. Automating the self-scheduling process of nurses in Swedish healthcare: a pilot study. *Health Care Manag. Sci.* 2010, *13*, 35—53.
55. Gerson E. M. Reach, bracket, and the limits of rationalized coordination: some challenges for CSCW. In *Resources, Co-Evolution and Artifacts, in Computer Supported Cooperative Work*; Springer London: London, 2008; pp. 193—220.
56. Gerson E. M., Star S. L. Analyzing due process in the workplace. *ACM Trans. Inf. Syst.* 1986, *4*, 257—270.
57. Mesman J. Disturbing observations as a basis for collaborative research. *Sci. Cult.* 2007, *16*, 281—295.
58. Randall D., Harper R., Rouncefield M. Fieldwork for design. In *Computer Supported Cooperative Work*; Springer London: London, 2007.
59. Schmidt K. Of maps and scripts: the status of formal constructs in cooperative work [1999]. *ACM International Conference on Supporting Group Work (GROUP '97)* 1999, 138—147.
60. Cramton C. D., Hinds P. J. Subgroup dynamics in internationally distributed teams: ethnocentrism or cross-national learning? *Res. Organ. Behav.* 2004, *26*, 231—263.
61. Suchman L. *Plans and Situated Actions: The Problem of Human-Machine Communication*; Cambridge University Press: Cambridge, England, 1987.
62. Suchman L. *Human-Machine Reconfigurations: Plans and Situated Actions, in Learning in Doing: Social, Cognitive and Computational Perspectives*, 2nd ed.; Cambridge University Press: Cambridge, 2006.
63. Suchman L. A. Office procedure as practical action: models of work and system design. *ACM Trans. Inf. Syst.* 1983, *1*, 320—328.
64. Suchman L., Wynn E. Procedures and problems in the office. *Inf. Technol. People* 1984, *2*, 133—154.
65. Bjørn P., Rødje K. Triage drift: a workplace study in a pediatric emergency department. *Comput. Support. Coop. Work* 2018, *17*, 25.
66. Zuiderent-Jerak T. Preventing implementation: exploring interventions with standardization in healthcare. *Sci. Cult.* 2007, *16*, 311—329.
67. Clarke K., Hughes J., Rouncefield M., Hemmings T. When a Bed is not a Bed: Calculation and Calculability in Complex Organisational Settings. In Trust in Technology: A Socio-Technical Perspective. Computer Supported Cooperative Work, Vol. XXXVI; Clarke K., Hardstone G., Rouncefield M., Sommerville I., Eds. Springer, Dordrecht, 2006, *36*, pp. 21—38.
68. Heath C., Luff P. Collaboration and control crisis management and multimedia technology in London underground line control rooms. *Comput. Support. Coop. Work* 1992, *1*, 69—94.
69. Schmidt K. The problem with 'awareness': introductory remarks on 'awareness in CSCW'. *Comput. Support. Coop. Work* 2002, *11*, 285—298.
70. Gutwin C., Penner R., Schneider K. Group awareness in distributed software development. In *Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work, in CSCW '04*; Association for Computing Machinery: New York, NY, USA, 2004; pp. 72—81.
71. Gross T. Supporting effortless coordination: 25 years of awareness research. *Comput. Support. Coop. Work* 2013, *22*, 425—474.
72. Bardou M., Letondal C, Imbert J, Causse M, Bidegaimberry M, Dubus R, Marcon C. Redesigning systems for single-pilot operations: the mutual awareness problem for remote crews. [Online] 2022. https://dl.eusset.eu/handle/20.500.12015/4377 (accessed Dec 06, 2023).
73. Hanseth O., Jacucci E., Grisot M., Aanestad M. Reflexive standardization: side effects and complexity in standard making. *MIS Q.* 2006, *30*, 563—581.
74. Mørck P., Langhoff T. O., Christophersen M., Møller A. K., Bjørn P. Variations in oncology consultations: how dictation allows variations to be documented in standardized ways. [Online] 2018. https://dl.eusset.eu/items/d18afb85-8614-48ac-871c-d75145cecbbe (accessed Aug 15, 2023).
75. Ellingsen G., Monteiro E. A patchwork planet integration and cooperation in hospitals. *Comput. Support. Coop. Work* 2003, *12*, 71—95.

76. Ellingsen G., Munkvold G. Infrastructural arrangements for integrated care: implementing an electronic nursing plan in a psychogeriatric ward. *Int. J. Integrated Care* 2007, *7*, e13.
77. Fitzpatrick G., Ellingsen G. A review of 25 years of CSCW research in healthcare: contributions, challenges and future agendas. *Comput. Support. Coop. Work* 2013, *22*, 609—665.
78. Bjørn P., Burgoyne S., Crompton V., MacDonald T., Pickering B., Munro S. Boundary factors and contextual contingencies: configuring electronic templates for healthcare professionals. *Eur. J. Inf. Syst.* 2009, *18*, 428—441.
79. Ellingsen G., Monteiro E., Røed K. Integration as interdependent workaround. *Int. J. Med. Inf.* 2013, *82*, e161—e169.
80. Kobayashi M., Fussell S., Xiao Y., Seagull F. J. Work coordination, workflow, and workarounds in a medical context, presented at the CHI Extended Abstracts, 2005; pp. 1561—1564.
81. Boulus N., Bjorn P. A cross-case analysis of technology-in-use practices: EPR-adaptation in Canada and Norway. *Int. J. Med. Inf.* 2010, *79*, e97—e108.
82. Hanseth O., Monteiro E., Hatling M. Developing information infrastructure: the tension between standardization and flexibility. *Sci. Technol. Hum. Val.* 1996, *21*, 407—426.
83. Mazmanian M., Cohn M., Dourish P. Dynamic reconfiguration in planetary exploration: a sociomaterial ethnography. *MIS Q.* 2014, *38*, 831—848.
84. Møller N., Bjørn P. In due time: decision-making in architectural design of hospitals. In *COOP 2016: Proceedings of the 12th International Conference on the Design of Cooperative Systems* 2016, pp. 191—206; http://doi.org/10.1007/978-3-319-33464-6_12.
85. Orlikowski W. The duality of technology: rethinking the concept of technology in organizations. *Organ. Sci.* 1992, *3*, 398—427.
86. Langhoff T. O., Amstrup M. H., Mørck P., Bjørn P. Infrastructures for healthcare: from synergy to reverse synergy. *Health Inf. J.* 2018, *24*, 43—53.
87. Matthiesen S., Bjørn P. When distribution of tasks and skills are fundamentally problematic: a failure story from global software outsourcing. *Proc. ACM Hum.-Comput. Interact.* 2017, *1*, 74:1—74:16.
88. Saatçi B., Rädle R., Rintel S., O'Hara K., Klokmose C. Hybrid meetings in the modern workplace: stories of success and failure. In: Nakanishi H., Egi H., Chounta I. A., Takada H., Ichimura S., Hoppe U. (eds) *Collaboration Technologies and Social Computing. CRIWG+CollabTech 2019. Lecture Notes in Computer Science* 2019, Vol. XIMDCLXXVII, Springer: Cham, 2019, pp. 45—61.
89. Davidson E. A technological frames perspective on information technology and organizational change. *J. Appl. Behav. Sci.* 2006, *42*, 23—39.
90. Orlikowski W. Improvising organizational transformation over time: a situated change perspective. *Inf. Syst. Res.* 1996, *7*, 63—92.
91. Tyre M. J., Orlikowski W. J. Windows of opportunity: temporal patterns of technological adaptation in organizations. *Organ. Sci.* 1994, *5*, 98—118.
92. Grudin J. Why CSCW applications fail: problems in the design and evaluation of organizational interfaces. In *Proceedings of the 1988 ACM Conference on Computer-Supported Cooperative Work — CSCW '88*; ACM Press: Portland, Oregon, United States, 1988; pp. 85—93.
93. Grudin J., Grinter R. Ethnography and design. *Comput. Support. Coop. Work Int J.* 1995, *3*, 55—59.
94. Bjørn P., Scupola A., Fitzgerald B. Expanding technological frames towards mediated collaboration. *Scand. J. Inf. Sys.* 2006, *18*, 29—68.
95. Bjørn P., Fitzgerald B., Scupola A. The role of social awareness in technology acceptance of groupware in virtual learning teams. In *Proceedings of the 26th Information Systems Research Seminar in Scandinavia* 2003. https://api.semanticscholar.org/CorpusID:18346354.
96. Bjørn P., Scupola A. Groupware integration in virtual learning teams: a qualitative analysis based on the TAM-model, presented at the International Federation for Information Processing Digital Library; IT Innovation for Adaptability and Competitiveness, 2004.
97. Davis F. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q* 1989, *13*, 319—340.
98. Bjørn P. Re-negotiating protocols: a way to integrate groupware in collaborative learning settings. In *ECIS, New Paradigms in Organizations, Markets and Society, Proceedings of the 11th European Conference on Information System, Napoli*. [Online] 2003. https://researchr.org/publication/Rasmussen03%3A1 (accessed Sep 11, 2022).
99. Bjørn P., Busboom J., Duckert M., Bødker S., Shklovski I., Hoggan E., Dunn K., Mu Q., Barkhuus L., Boulus-Rødje N. Achieving symmetry in synchronous interaction in hybrid work is impossible. *ACM Trans. Comput.-Hum. Interact.* 2024, http://doi.org/10.1145/3648617.
100. Blomberg J., Karasti H. Reflections on 25 years of ethnography in CSCW. *Comput. Support. Coop. Work* 2013, *22*, 373—423.
101. de Souza Santos R. E., Ralph P. A grounded theory of coordination in remote-first and hybrid software teams. In *Proceedings of the 44th International Conference on Software Engineering, in ICSE '22*; Association for Computing Machinery: New York, NY, USA, 2022; pp. 25—35.
102. Jordan B. Blurring boundaries: the "real" and the "virtual" in hybrid spaces. *Hum. Organ.* 2009, *68*, 181—193.
103. Ruhleder K. The virtual ethnographer: fieldwork in distributed electronic environments. *Field Methods* 2000, *12*, 3—17.
104. Rosenberg D. Three steps to ethnography: a discussion of interdisciplinary contributions. *AI Soc.* 2001, *15*, 295—315.
105. Braun V., Clarke V., Hayfield N., Terry G. Thematic analysis. In *Handbook of Research Methods in Health Social Sciences*; Liamputtong P., Ed. Springer: Singapore, 2019; pp. 843—860.
106. Lucero A. Using affinity diagrams to evaluate interactive prototypes. In *Human-Computer Interaction — INTERACT 2015, in Lecture Notes in Computer Science*; Abascal J., Barbosa S., Fetter M., Gross T., Palanque P., Winckler M., Eds. Springer International Publishing: Cham, 2015; pp. 231—248.

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PAPER V

Melanie Duckert, Morten Hertzum, and Pernille Bjørn.

2024

How Distance Matters in Dynamic Work Environments.

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How Distance Matters in Dynamic Work Environments

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ABSTRACT

The long-term distributed work conditions during the COVID-19 pandemic normalized distance in teams that previously collaborated in a shared office setting. The continuing options for working remotely provide flexibility for employees to alternate between home and office locations, making distance a dynamic condition in contemporary work, with daily changes in team configurations. We explore how this *dynamic distance matters to individuals' work experience*. Building on the Distance Framework, which addresses factors for collaboration across distance, we introduce two new factors: collaboration effort and collaboration technology effort, reflecting the complexities of working in dynamic work environments. Through a survey (N=664) of employees from various companies, we investigate the interrelations between the six collaboration factors of our Extended Distance Framework, job satisfaction, and external factors of team distribution, organizational policies, and personal location preferences. We show that the Extended Distance Framework predicts 24% of the variation in job satisfaction. There is an equal distribution between respondents preferring to work from the office or from home. However, working from the office requires high collaboration effort with low technology readiness, highlighting the relevance of exploring how offices can support dynamically distributed teams while still providing employees the option of working from different locations.

KEYWORDS: distance, dynamics, team collaboration, employee experiences

1. Introduction

Organizational teams today rely on digital information systems to collaborate across distances (Chudoba et al., 2005; Gibson & Cohen, 2003; Martins et al., 2004; G. M. Olson & Olson, 2000). The forced remote work from home during the COVID-19 pandemic introduced distributed collaboration in teams that earlier had been collocated at a shared office (Ciolfi et al., 2020; Flex Index, 2024; Waizenegger et al., 2020). This shift accelerated the digitalization of work practices, enabling teams to manage and produce their work using online tools (Hacker et al., 2020; Madsen et al., 2020). After the pandemic lockdown, some employees continued to prefer remote work, prompting research into the contemporary challenges in combining remote and traditional office settings, leading to *hybrid work models* (Schoch et al., 2023; Zamani et al., 2024). Hybrid work is characterized by including *both* collocated and remote participants and encompasses the complexities of distributed work while introducing unique challenges to the collocated interaction (Duckert et al., 2023). For example, hybrid collaboration requires technology support to connect geographically dispersed sub-groups (Cramton & Hinds, 2004; Mark et al., 2003), which dynamically change over time, complicating the simultaneous integration of digital collaboration and collocated interaction (Duckert et al., 2023). In organizations that allow occasional remote work, hybrid teams emerge, with employees altering between working at the office or from home (de Souza Santos & Ralph, 2022; Smite et al., 2023). Consequently, teams with access to a shared office for collaboration do not necessarily utilize this option but work in constantly changing configurations across multiple office and home spaces (Duckert & Bjørn, 2025).

To present factors important for success in distributed work, Olson and Olson (2000) introduced the Distance Framework, emphasizing the need for high common ground, low coupling of work, high collaboration readiness, and high collaboration technology readiness (G. M. Olson & Olson, 2000). The post-pandemic normalization of employees working from varying locations makes distance a dynamic condition since all

collaboration must be conducted in hybrid, malleable team configurations that change on a day-by-day basis. Based on the Distance Framework, we explore *how dynamic distance matters to individuals' work experiences in contemporary cooperative teams*. Applying the Distance Framework allows us to build on research that, with more than 3000 citations,[1] is broadly recognized for presenting core aspects of collaboration across distance. We extend prior work updating (Bjørn et al., 2014; J. S. Olson & Olson, 2014) and quantifying (Caldeira et al., 2022) the framework to address contemporary challenges of dynamics in both cooperative settings and technologies (Bødker & Klokmose, 2012). Our revision introduces two new factors – *collaboration effort* and *collaboration technology effort* – reflecting the work required for collaborating in dynamically distributed teams. With the two new factors, we use our Extended Distance Framework to investigate employees' work experiences within cooperative teams across different organizations with varying approaches to managing post-pandemic work conditions.

Different from the original Distance Framework's focus on *success* in distributed work, we apply it to investigate individual work experiences. Contemporary work conditions have increased confidence in the use of cooperative technologies for varying work activities (Caldeira et al., 2022); for example, seen in the distributed work during the pandemic did not significantly impact productivity (Smite et al., 2021; Williams & Shaw, 2024). Instead, employees value the flexibility of choosing their own work location (Sako, 2021; Smite, Moe, Klotins, et al., 2022), leaving offices empty as employees never returned to fully onsite work after the pandemic lockdown (Appel-Meulenbroek et al., 2022; Smite, Moe, Tkalich, et al., 2022). Consequently, some organizations experience challenges in managing hybrid work environments that balance remote work and office presence. Providing remote and hybrid work options has become a competitive parameter for attracting employees (Winkler et al., 2022), highlighting its importance in individuals' experiences of contemporary work environments.

To study the relations between dynamic distance and individuals' work experiences, we conducted a survey to investigate the interrelations between the six collaboration factors of our Extended Distance Framework, job satisfaction (Macdonald & Maclntyre, 1997), and external factors of team distribution, organization policies, and personal location preferences. With 664 respondents from different organizations, we found that the Extended Distance Framework predicts 24% of the variation in job satisfaction. Dynamic distance in contemporary work environments impacts not only the geographical team distribution but also affects the office's ability to support collaboration, as well as employees' personal location preferences. With an equal distribution between respondents who prefer to work from the office and work remotely, we suggest the relevance of exploring ways to support dynamically distributed teams' collaboration at the office while still providing hybrid options.

2. Extended Distance Framework

The study is based on the Distance Framework, which outlines four socio-technical conditions to capture the complexities of working together across distance (G. M. Olson & Olson, 2000). The concept of *distance* is widely discussed, with explorations of proximity itself (e.g., Bradner & Mark, 2002; Kiesler & Cummings, 2002), as well as collaboration challenges of global team distributions across time zones and organizational cultures (e.g., Chudoba et al., 2005; Fang et al., 2022). The forced work-from-home during the pandemic lockdown reshaped the notion of distance by normalizing geographical separation in previously collocated teams (Smite et al., 2023). The post-pandemic combination of on-site office work and remote options requires collaboration across hybrid team arrangements where team members' locations change throughout the week (de Souza Santos & Ralph, 2022; Zamani et al., 2024). This mobility of each individual employee makes distance dynamic, as teams with hybrid options are inconsistently distributed due to variations in who is collocated at the office and who is working remotely.

[1] The citation count is based on Google Scholar.

Dynamic distance can increase the effort required for collaboration, as being in the office does not necessarily improve access to team members. For example, additional work is needed to compensate for asymmetric opportunities for cooperation (Busboom & Boulus-Rødje, 2024) and to navigate the unpredictability of hybrid configurations (Duckert & Bjørn, 2025). The experience and extra work required can vary depending on the location of the individual employee (Breideband et al., 2023; Waizenegger et al., 2020). For example, the effort required by remote participants working alone at home differs from that required by collocated groups at the office, which must create a technology setup that includes remote participants in a shared hybrid collaboration (Bjørn et al., 2024). Therefore, we add the concept of *effort* to our exploration of collaboration across dynamic distances. Distinguishing *effort* from *readiness*, as presented by Olsen and Olsen (2000), is relevant for understanding individuals' motivation to use technologies despite the increased effort required. In this way, we extend the Distance Framework's four factors – *common ground*, *coupling of work*, *collocated readiness*, and *collocated technology readiness* – with two new factors: *collaboration effort* and *collaboration technology effort*.

2.1 Common ground

Common ground describes different individuals' shared information and understanding of what they have in common (Clark & Brennan, 1991). Creating shared information requires individuals to communicate and interact with one another to make themselves understood and follow the perspectives and reasoning of their collaborators. Achieving common ground is challenged in geographically distributed work when individuals do not share the same meaning context (G. M. Olson & Olson, 2000). Shared understanding is necessary for coordination and awareness and should be facilitated by technology in distributed contexts (Dourish & Bly, 1992; Gutwin et al., 2004; Venolia et al., 2010). To create a shared meaning context, virtual team members must negotiate norms and work practices at both local and organizational levels to create a shared work language (Bjørn & Ngwenyama, 2009). Further, there is a high risk of breakdowns in communication among geographically dispersed sub-groups due to the lack of collocation (Bradner & Mark, 2002; Cramton & Hinds, 2004). In contemporary work environments with dynamic distance, establishing and maintaining common ground remains a complex challenge due to asymmetric conditions (Bjørn et al., 2024; Duckert et al., 2023). Common ground is important for the success of cooperative work in varying team activities and configurations and is therefore continually relevant to explore.

2.2 Coupling of work

Coupling of work refers to the degree of communication necessary for achieving common ground and solving the task at hand (G. M. Olson & Olson, 2000). Cooperative work inherently involves coupling through mutual dependencies among individuals engaged in a shared field of work (Ciolfi et al., 2023; Schmidt & Bannon, 1992). The degree of coupling varies, with some tasks requiring tight coupling with frequent and detailed communication, while others may involve loose coupling with less frequent interaction among the people involved in the work. Olson and Olson (2000) argued that loosely coupled work is easier to solve across geographical distances as it has fewer mutual dependencies, allowing one person to work on the task at a time, consequently requiring fewer interactions. In contrast, a later revision of this argument suggests that tightly coupled work will force participants to engage in frequent interaction (due to task dependencies) and consequentially facilitate virtual team members' engagement in investing time and effort into their remote team members (Bjørn et al., 2014). The inherent presence of distance in dynamically distributed teams requires work to be conducted in malleable configurations, whether it is determined by tight or loose dependencies. Therefore, organizational management of contemporary teams involves structuring work environments that consider the changing locations of employees in varying work activities (J. S. Olson & Olson, 2014; Wiatr & Skowron-Mielnik, 2023).

2.3 Collaboration readiness

Collaboration readiness describes the participants' motivation to engage in cooperative and shared work activity. In distributed work, readiness for collaboration is needed to make the cooperative work function (G. M. Olson & Olson, 2000). Collaboration readiness is impacted by the socio-emotional experiences of employees. For example, it matters whether individual employees experience autonomy in decision-making about how their work is organized (Cousins et al., 2007). Collaboration readiness is not necessarily the same across different individuals and subgroups (Bjørn et al., 2014), for example, in situations where collaboration across distance is about moving work from onsite to offshore, employees working onsite would be less likely to engage positively with the remote workers who are taking over their work. With distance as dynamic, the experienced collaboration readiness can vary depending on the individual's location at a specific time. For example, an employee's collaboration readiness may be high or low depending on whether one is collocated with their team at the office or working remotely from home. Being a remote participant can increase the feeling of being excluded from the team, potentially impacting the readiness for engaging in collaboration (Bjørn et al., 2024). Collaboration readiness is an important factor to explore in dynamically distributed teams because it impacts the outcome of the collaboration.

2.4 Collaboration technology readiness

Collaboration technology readiness reflects the motivation to use technology to support collaboration across geographical distances, including video conferencing tools and shared editing tools (G. M. Olson & Olson, 2000). The digitalization of work and confidence in technology use has increased since the original Distance Framework was published. In 2014 (Bjørn et al., 2014), collaboration technology readiness included concerns for organizational management of technology and technology stability rather than solely the willingness of individuals to engage and learn new technologies. With increased exposure to digitalized work practices, employees become increasingly confident in using technologies for various activities (Martins et al., 2004). Many companies (especially within office work) that began to work remotely from home during the COVID-19 pandemic experienced a steep increase in employees' confidence in using new technologies (Caldeira et al., 2022), which continued after the pandemic lockdown. Contemporary challenges in the use of collaboration technology relate to the continuous reconfiguration of the technology setup, which can impact employees motivation to add new technologies to their existing technology portfolio (Bjørn et al., 2024; Duckert & Bjørn, 2024). Exploring collaboration technology readiness is thus about people's perception of the usefulness and motivation to use existing and new collaboration technology as part of their everyday work practices.

2.5 Collaboration effort

Collaboration across dynamic distances can increase the effort required from employees due to the unpredictability of the team members' locations (Wiatr & Skowron-Mielnik, 2023). Furthermore, hybrid work scenarios involve not only geographical distance in teams but also collocated distance within the shared geographical context (Duckert et al., 2023). This means employees must navigate team collaboration and potential misalignments both across distances and within the collocated group located at the same office site. The work required to make others aware of activities and actions varies depending on the location of both the individual and the team members involved in the shared field of work (Dey & de Guzman, 2006; Gutwin et al., 2004; Hirata et al., 2008). Contemporary teams can, therefore, often not handle their work through everyday social interactions but require mechanisms of interactions to coordinate, increasing the articulation work required to solve various tasks (Schmidt and Bannon 1992). Collaboration effort is an important factor in dynamic work environments; if the effort is too high, people may not engage in the collocated subgroup at the office but solely rely on the convenience of the digital tools for collaboration as a strategy to manage the unpredictability of the dynamic team distributions (Duckert & Bjørn, 2025).

2.6 Collaboration technology effort

Distributed collaboration is enabled by various physical and digital technologies, which dynamically evolve over time as varying technologies support different activities (Bødker & Klokmose, 2012). Dynamic distances require cooperative technologies to be accessible from different locations, supporting continuous reconfigurations of the team arrangements, which can increase the required *collaboration technology effort* (Duckert & Bjørn, 2024; Fang et al., 2022). Several movable and digital technologies enable work, such as laptops providing access to a complex digital workspace. However, online digital work can challenge the utilization of the office (Sheikh et al., 2019), as aligning digital practices with the physical opportunities in the space is difficult (Duckert & Bjørn, 2025; Griva et al., 2024). For example, the whiteboard at the office is not accessible to remote team members and will be detached from the digital workspace unless additional work efforts are made. Collaboration technology effort is all the work required to make the collaboration technology function across the dynamics in cooperative teams and technology support (Bjørn et al., 2024). When exploring how dynamic distance matters, considering collaboration technology effort is essential for exploring when the extra effort for engaging in the dynamically distributed teams is perceived as relevant.

2.7 From success to satisfaction

The accelerated digitalization and increased confidence in collaborative technologies enabled work during the pandemic without significantly impacting productivity but affected collaborative and emotional experiences (Caldeira et al., 2022; Madsen et al., 2020; Smite et al., 2021). This shift from productivity to individual work experiences is evident in organizational explorations of how to manage contemporary work environments that support the preferences of both employees and companies (Cousins et al., 2007). The flexibility of working remotely and hybrid has shown to be important for employees' work experience. However, providing employees with the flexibility to choose their own work locations risks offices remaining empty in organizations where employees prefer remote work (Appel-Meulenbroek et al., 2022; Smite, Moe, Tkalich, et al., 2022). This leads some companies to enforce physical presence to protect innovation and engagement (Appel-Meulenbroek et al., 2022; Yang et al., 2022). However, such policies risk employees leaving the company if the management does not align with personal preferences – a phenomenon called 'the great resignation' (Cook, 2021; Sull et al., 2022). For example, software developers in Bangalore moved to their villages and families and resisted returning to a daily commute in heavy traffic (Bjørn et al., 2019; Matthiesen & Bjørn, 2016). Research on remote and hybrid work's impact on work experiences reveals mixed results. Flexibility in work locations can support work-life balance and increase job satisfaction (Orešković et al., 2024), but remote work also risks emotional experiences such as loneliness (Taser et al., 2022). Moreover, the technology effort required for efficient collaboration across dynamic distances can cause job stress and potentially reduce job satisfaction (Martin et al., 2022). Considering these varying insights into job satisfaction, we explore how dynamic distance matters to individuals' work experiences to understand the contemporary challenges of working within dynamically distributed teams, organizational policies, and personal location preferences.

3. Method

To investigate how dynamic distance matters to the individual's work experience, we conducted a survey exploring cooperative practices and experiences within organizational teams. The survey was based on the six factors in the Extended Distance Framework, supplemented with items to measure job satisfaction and five external variables. The survey was distributed in multiple companies in the summer and fall of 2024.

3.1 Respondents and procedure

The survey was distributed using various strategies to reach a wide range of respondents. We identified five companies that were interested in distributing the survey internally. We negotiated the strategy for distributing the survey with each company individually. A contact person was appointed in each company,

responsible for distributing an email to a defined group of employees with the survey link and sending a reminder one week later. Additionally, the survey was distributed on LinkedIn. The surveyed group varied in each company because of their size and domain, see Table 1. For example, two of the organizations distributed the survey across the entire organization (Org 1 and Org 4a), whereas Org 4 further distributed the survey to their customer base (Org 4b). The respondents were not compensated for their participation in the study.

Table 1. Survey distribution

Organization	Distribution scope	Surveyed	Respondents (N)	Response rate (%)
Org 1	Global	4431	231	5.21
Org 2	Department	67	11	16.42
Org 3	National	243	29	11.93
Org 4a	National	300	30	10.00
Org 4b	Customer Base	14800	349	2.36
Org 5	Collaborative Network	40	1	2.50
LinkedIn	Professional Network	-	13	-
SUM		19881	664	3.34

Regarding research ethics, we followed established practices for informed consent, anonymity, and the ethical conduct of research (Atkinson & Delamont, 2010; Brinkmann & Kvale, 2017). Specifically, we ensured the anonymity of the participants by not collecting any personal data that would enable us to identify the respondents. We also informed the participants about the purpose of the study and their right to withdraw from the survey at any time without consequences. We note that the authors' research institutions do not have a mandatory Institutional Review Board (IRB) for studies. Table 2 gives the respondent profile.

Table 2. Respondent profile, N = 664 respondents

Classification	*N*	%
Region of residence		
Africa	4	1
Asia	59	9
Australasia	2	0
Europe	573	86
North America	17	3
South America	9	1
Years in company		
0 – 1.9	221	33
2 – 4.9	208	31
5 – 9.9	122	18
10 – 19.9	75	11
20 – 39.9	38	6
Year of most recent graduation		
1970 – 1999	151	23
2000 – 2009	164	25
2010 – 2019	214	32
2020 – 2029	114	17
Unspecified	21	3
Gender		
Female	304	46

Male	337	51
Non-binary	1	0
Gender not listed	2	0
Prefer not to answer	20	3

3.2 Survey instrument

In addition to demographic questions for describing the respondent profile, the survey instrument contained 28 items for measuring the six collaboration factors, 10 items for measuring job satisfaction, and 5 items for measuring external variables.

The items for measuring the six collaboration factors were developed by the authors following the guidelines provided by DeVellis (2017). First, we generated a pool of items by browsing the transcripts of a set of interviews about contemporary work and by consulting the literature about the Distance Framework (Bjørn et al., 2014; Caldeira et al., 2022; G. M. Olson & Olson, 2000). Further, we referred to Schmidt and Bannon's (1992) mechanism of interactions and Davis's (1989) TAM model to capture the effort required in collaboration and for technology use. The items were refined through multiple rounds of discussion, external feedback, and rework. This process continued until the wording of the items began to stabilize. Second, we had the items reviewed by six research colleagues, all experts in cooperative work. We asked them to group the items into categories and to comment on the items and the categories. This review revealed several ambiguities, which we then addressed in the next rounds of revision. Third, we went through additional discussion rounds to remove ambiguities and finalize the items. Table 3 shows the resulting 28 items for measuring the six collaboration factors.

Job satisfaction was measured using the generic job satisfaction scale developed by Macdonald and MacIntyre (1997). Its ten items constituted a pre-validated, one-factor measure of job satisfaction.

To investigate how external variables affected the six collaboration factors, we devised items for tapping five such variables: participant distribution, improved access from the office, organizational policies, local arrangements, and office preference. Each of these variables was measured with a single item, see Table 4.

All items had five response options: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). In the survey instrument, the order of the items was randomized for each participant. The survey was created in SurveyXact, and the collected data were exported for analysis in SPSS version 28.0.1.0.

Table 3. Items for measuring collaboration effort (CE), collaboration technology effort (CTE), collaboration technology readiness (CTR), collaboration readiness (CR), coupling of work (CW), and common ground (CG)

Item	Item wording
CE1	All collaboration with my teams requires planning and scheduling.
CE2 *	In my teams, we cannot organize our collaboration exclusively through everyday emergent social interactions (e.g., unplanned face-to-face, phone, or email interactions).
CE3	To collaborate with my colleagues, I must constantly align my work with theirs.
CE4	In my teams, we spend considerable time keeping each other informed about what we are doing.
CE5	To be productive in my teams, I spend considerable time keeping abreast of what my colleagues are doing.
CTE1 R	Overall, the digital technologies and devices that support my teams' work are easy to use.
CTE2 R	It is easy to get the digital technologies and devices that support my teams' work to do what I want them to.
CTE3	Interacting with the digital technologies and devices that support my teams' work is often frustrating.

CTE4	It requires a lot of mental effort to use the digital technologies and devices that support my teams' work.
CTE5	It takes a lot of effort to become skillful in using the digital technologies and devices that support my teams' work.
CTR1	The digital technologies and devices that support my teams' work assist me in critical aspects of my work.
CTR2	Using the digital technologies and devices that support my teams' work improves my job performance.
CTR3	Using the digital technologies and devices that support my teams' work allows me to accomplish more work than would otherwise be possible.
CTR4	Overall, the digital technologies and devices that support my teams' work are useful in my job.
CR1	I like to work collaboratively with my colleagues.
CR2 *	As a team, my colleagues and I have the competencies necessary to get our work done.
CR3	I make an effort to foster a positive collaborative environment.
CR4	I make myself available for answering questions from my colleagues.
CR5 *	As a team, my colleagues and I are productive in professional collaboration.
CW1	My teams' work involves coordinating sequential tasks.
CW2	My teams' work requires coordinating tasks that are concurrent and interdependent.
CW3	My teams' work depends on integrating tasks assigned to different (groups of) people in our team.
CW4 *	My teams' work depends on collaboration among team members at different locations.
CG1 [R]	I often find it difficult to follow my colleagues' views and reasoning when collaborating.
CG2 [R]	It is often difficult to make myself understood by my colleagues when collaborating.
CG3	It is straightforward to plan and distribute tasks with my colleagues in our teamwork.
CG4	It is straightforward to sort out misunderstandings between me and my colleagues.
CG5	When collaborating with my colleagues, I rarely need to explain myself to be understood.

Note: * Dropped in the final factor model, see Section 4.1. [R] Reverse scored.

Table 4. External variables

Item	Item wording
Q1	On a daily basis, I work in teams whose participants are at different locations
Q2	When I am at the company office, I have improved access to all relevant colleagues with whom I work.
Q3	My company has organizational policies regulating work conditions, such as rules for office presence (e.g., at least three days a week) and office design (e.g., hot desking).
Q4	In my teams, we have made local agreements about how to structure our collaborative work.
Q5	I have a general preference for working at the office.

4. Results

We received 664 complete responses to the survey. With 28 + 10 + 5 = 43 items in the survey instrument, this corresponded to a very good 15:1 respondent-to-item ratio (DeVellis, 2017). Table 2**Table 3** gives the respondent profile. Table 3 and Table **4** give the wording of the survey items developed for this study.

4.1 Factor model

We first tested whether the data for measuring the six collaboration factors were suitable for structure detection. Bartlet's test of sphericity indicated factorability; that is, there were significant relations among the items, $\chi^2(378, N = 664) = 5759.65$, $p < 0.001$. In addition, the Kaiser-Meier-Olkin (KMO) measure of sampling adequacy was 0.888, indicating excellent sampling adequacy. Quantile-quantile plots of the data indicated that they were nonnormal. Therefore, we used principal axis factoring (i.e., common factors) for the factor extraction. This choice followed the best practice recommended by Costello and Osborne (2005). To allow for correlations among the factors, we chose the oblique rotation method Direct Oblimin. Factor correlations are common in social science data (Costello & Osborne, 2005; DeVellis, 2017). In our data, the factor correlations ranged from 0.064 to 0.399.

The "elbow" of the Scree plot suggested four to six factors, which all had eigenvalues above one and, thus, contained more information than the average item (DeVellis, 2017). We proceeded with six factors because that was consistent with our theoretical assumptions. Two items (CE2, CW4) had factor loadings below 0.30 and two items (CE2, CR5) had cross-loadings above their factor loading. To arrive at a clean factor structure, we dropped these four items and reran the factor analysis. Table 5 shows the factor loadings for the remaining 24 items. All factor loadings were above the minimum of 0.32 recommended by Costello and Osborne (2005), and all but one were above the threshold of 0.40 recommended by Stevens (2009). Only a single item had a cross-loading above 0.30. All factors had three or more items, as recommended by Costello and Osborne (2005). The total variance explained by the six factors was 59%.

Table 5. Factor loadings for the 24 retained items, $N = 664$ respondents

Item	1	2	3	4	5	6
CTE1	-0.564			-0.329		
CTE2	-0.551					
CTE3	-0.679					
CTE4	-0.638					
CTE5	-0.660					
CW1		0.595				
CW2		0.641				
CW3		0.579				
CG1			0.485			
CG2			0.594			
CG3			0.433			
CG4			0.551			
CG5			0.537			
CTR1				0.650		
CTR2				0.771		
CTR3				0.657		
CTR4				0.603		
CE1					0.346	
CE3					0.487	
CE4					0.530	
CE5					0.524	
CR1						-0.653
CR3						-0.578
CR4						-0.474

Note: Loadings below 0.30 are not shown. Extraction method: principal axis factoring. Rotation method: direct oblimin.

4.2 Model reliability and validity

Table 6 summarizes the reliability and validity of the factor model. With respect to internal consistency, Cronbach's alpha was above the widely used threshold of 0.70 for three factors. For the three other factors, it was below 0.70 but still above the minimum acceptable threshold of 0.60 (DeVellis, 2017). Composite reliability should preferably be above 0.60 (Bagozzi & Yi, 1988). It was slightly below for two of the factors, thereby indicating issues with internal consistency. With respect to convergent validity, the average variance extracted (AVE) was below the recommended 0.50 (Bagozzi & Yi, 1988) for all six factors, indicating that the factors captured less than 50% of the variance in the items. Discriminant validity was satisfactory because maximum shared variance was lower than AVE for all factors and because the square root of AVE for each factor was higher than its correlations with the other factors. That is, the six factors were sufficiently unrelated to one another to be considered separate constructs. On this basis, we proceeded with the factor model, but we acknowledge that it is somewhat fragile.

Table 6. Factor reliability and validity, $N = 664$ respondents

Factor	Mean of items	SD	Cronbach α	CR	AVE	MSV
Collaboration technology effort	2.332	1.008	0.805	0.757	0.385	0.156
Coupling of work	3.646	0.880	0.670	0.634	0.367	0.159
Common ground	3.686	0.894	0.735	0.650	0.274	0.127
Collaboration technology readiness	4.026	0.828	0.797	0.767	0.453	0.156
Collaboration effort	3.011	1.046	0.668	0.536	0.228	0.117
Collaboration readiness	4.261	0.720	0.611	0.591	0.328	0.159

Note: SD = standard deviation, CR = composite reliability, AVE = average variance extracted, MSV = maximum shared variance

4.3 Model relevance

To test the relevance of the factor model, we assessed its ability to predict job satisfaction. With a Cronbach alpha of 0.858, the job-satisfaction scale had good internal consistency. All its ten items loaded on a single factor with loadings between 0.436 and 0.835. The factor scores for the six collaboration factors and the job-satisfaction factor were computed using Bartlett's approach (DiStefano et al., 2009).

Linear regression with the six collaboration factors as predictors produced a significant model, $F(6, 657) = 26.53$, $p < 0.001$. The model explained 24% of the variation in job satisfaction, indicating that its factors captured aspects important to the respondents' work experience. The regression coefficients showed that common ground was the strongest predictor of job satisfaction, followed by collaboration readiness and collaboration technology readiness, see Table 7.

Table 7. Coefficients in regression model for predicting job satisfaction, $N = 664$ respondents

Factor	Regression coefficient	95% confidence interval	
	(unstandardized)	Lower bound	Upper bound
Collaboration technology effort	0.010	-0.055	0.075
Coupling of work	-0.024	-0.083	0.035
Common ground	0.259	0.199	0.318
Collaboration technology readiness	0.147	0.081	0.212
Collaboration effort	0.071	0.015	0.128
Collaboration readiness	-0.175	-0.231	-0.118

4.4 Effect of participant distribution

Table 8 shows the effect of the external variables on the six collaboration factors and job satisfaction. For each of the five variables, we compared the respondents who agreed or strongly agreed with those who disagreed or strongly disagreed. The neutral responses were left out.

The first variable (Q1) was about working on a daily basis, in teams whose participants were at different locations. For this variable, there were significant differences between agreeers ($N = 503$) and disagreeers ($N = 88$) for collaboration technology readiness, collaboration readiness, collaboration effort, and coupling of work, $F(1, 589) = 27.66$, 9.27, 5.75, and 4.73, respectively (all $p < 0.05$). Collaboration technology readiness was 0.594 standard deviations higher for agreeers than disagreeers, suggesting that distribution practices were aligned with readiness for using technology to collaborate. However, the significantly lower

collaboration readiness for agreeers indicated that respondents who on a daily basis worked in teams with distributed participants were less inclined to work collaboratively. In addition, collaboration effort and coupling of work were also significantly higher for agreeers. That is, working with distributed participants involved extra effort and occurred in spite of high coupling. There was no significant effect of participant distribution on collaboration technology effort, common ground, and job satisfaction, $F(1, 589) = 2.07$, 0.34, and 0.12, respectively (all $p > 0.15$).

Table 8. Effect of the five external variables on the six collaboration factors and job satisfaction. The table shows the difference in factor mean (expressed in standard-deviation units) between respondents agreeing and disagreeing on the external variables.

Factor	Participant distribution (Q1)	Improved access from office (Q2)	Organizational policies (Q3)	Local agreements (Q4)	Office preference (Q5)
CTE	0.166	-0.363 ***	0.128	-0.033	-0.353 ***
CW	0.250 *	0.169	0.105	0.142	0.161
CG	0.068	0.166	0.197 *	0.550 ***	-0.297 ***
CTR	0.594 ***	-0.186 *	0.197 *	0.325 **	-0.497 ***
CE	0.276 *	0.470 ***	0.262 **	0.349 **	0.383 ***
CR	-0.349 *	-0.159	-0.086	-0.182	-0.300 ***
JS	0.040	0.481 ***	0.293 **	0.662 ***	0.264 **

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (F-test). CTE = collaboration technology effort, CW = coupling of work, CG = common ground, CTR = collaboration technology readiness, CE = collaboration effort, CR = collaboration readiness, JS = job satisfaction

4.5 Effect of improved access from office

Regarding improved access to colleagues when working from the company office, there were significant differences between agreeers ($N = 320$) and disagreeers ($N = 170$) for collaboration technology effort, collaboration technology readiness, collaboration effort, and job satisfaction, $F(1, 488) = 15.05$, 3.87, 25.75, and 27.11, respectively (all $p < 0.05$). Collaboration technology effort was significantly lower for respondents with improved access to their colleagues when working from the company office, possibly suggesting that they often chose to benefit from the improved access by working from the company office. However, collaboration technology readiness was lower for these respondents and collaboration effort was higher. That is, the improved access to colleagues when working from the company office might be important for these respondents' ability to cope with the issues introduced by distributed and hybrid work. The agreeers also had 0.481 standard deviations higher job satisfaction, suggesting that the superior technological setup at the company office was appreciated and coincided with other positive job features. There was no significant difference between agreeers and disagreeers for coupling of work, collaboration readiness, and common ground, $F(1, 488) = 3.18$, 2.83, and 3.07, respectively (all $p > 0.05$).

4.6 Effect of organizational policies

Regarding organizational policies for regulating work conditions, such as rules for office presence or hot desking, there were significant differences between agreeers ($N = 399$) and disagreeers ($N = 139$) for common ground, collaboration technology readiness, collaboration effort, and job satisfaction, $F(1, 536) = 4.01$, 4.03, 7.18, and 8.96, respectively (all $p < 0.05$). These four factors were all higher when organizational policies were present, suggesting that the policies had a positive impact on collaboration and satisfaction but also that working under them made collaboration more effortful. There was no significant effect of organizational

policies on collaboration technology effort, coupling of work, and collaboration readiness, $F(1, 536) = 1.68$, 1.13, and 0.77, respectively (all $p > 0.15$).

4.7 Effect of local agreements

Regarding local, team-specific agreements about how to structure the collaborative work, there were significant differences between agreeers ($N = 395$) and disagreeers ($N = 106$) for common ground, collaboration technology readiness, collaboration effort, and job satisfaction, $F(1, 499) = 26.54$, 8.96, 10.36, and 39.48, respectively (all $p < 0.01$). These four factors were the same as those affected by organizational policies. However, local agreements led to larger differences than organizational policies for all four factors (Table 8). For example, common ground was 0.550 standard deviations higher in the presence of local agreements, compared to 0.197 standard deviations higher in the presence of organizational policies. There was no significant effect of local agreements on collaboration technology effort, coupling of work, and collaboration readiness, $F(1, 499) = 0.09$, 1.69, and 2.78, respectively (all $p > 0.05$).

4.8 Effect of office preference

Regarding general preference for working at the office, there were significant differences between agreeers ($N = 239$) and disagreeers ($N = 259$) for collaboration technology readiness, collaboration technology effort, collaboration effort, collaboration readiness, common ground, and job satisfaction, $F(1, 496) = 32.60$, 15.98, 18.94, 11.45, 11.22, and 8.78, respectively (all $p < 0.01$). Collaboration technology readiness and collaboration technology effort were both significantly lower for respondents with an office preference, suggesting that the preference was partly about leaving it to others to provide a functional technological setup for supporting distributed and hybrid work. However, collaboration effort was higher for respondents with an office preference, and both collaboration readiness and common ground were lower. That is, the preference possibly also indicated that it was experienced as challenging to collaborate in teams where other participants worked from locations external to the company office. Finally, respondents with an office preference were more satisfied with their job, suggesting that working at the company office had qualities important to job satisfaction and that these qualities suffered in out-of-office settings. There was no significant effect of office preference on coupling of work, $F(1, 496) = 3.23$, $p = 0.07$.

5. Discussion

This study investigated how distance matters in contemporary work, with dynamic conditions in both cooperative team setups and technology support. We extended the Distance Framework (G. M. Olson & Olson, 2000) and identified collaboration effort and collaboration technology effort as important factors for organizational teams working across dynamic distributions. Further, we showed that the factors of our Extended Distance Framework predict individuals' work experience, including that the model explains 24% of the variation in job satisfaction. This demonstrates that the Distance Framework is not only relevant for success in cooperative work (G. M. Olson & Olson, 2000) but also significantly affects individuals' work experience. Here, we discuss how the six collaboration factors relate to job satisfaction and the external factors of team distribution, organizational policies, and personal location preferences.

To measure the impact of our first category of external factors, team distribution, we analyzed the effect of participant distribution and whether offices provide improved access to colleagues. Our data showed that respondents who engaged in distributed teams experienced *higher collaboration effort* and *higher collaboration technology readiness* but *lower collaboration readiness*. Empirical studies on post-pandemic work environments have found remote options leading to unpredictable team configurations, which increase the effort required to collaborate (Duckert & Bjørn, 2025), which can add complexities in creating mutual awareness across all the multiple locations where team members are potentially placed (Dourish & Bly, 1992). When our data show that respondents engaging in teams with distributed participants relates to lower collaboration readiness, it is possibly associated with the increased effort required. Interestingly, we find that these respondents experience *higher coupling of work*. Coupling of work describes the degree of mutual

interdependency in work and, therefore, suggests that respondents in distributed teams engage in tightly coupled work with a high degree of interdependence. This finding differs from the study by Caldeira et al. (2022), who found no effect on the coupling of work in the distributed scenario during the pandemic. Further, it misaligns with Olsen and Olsen's (G. M. Olson & Olson, 2000) argument that work across distance requires low coupling of work. That the respondents who are involved in teams with distributed participation experience higher collaboration technology readiness can indicate that these employees engage in the extra effort needed when the work depends on it, which is similar to the findings by Bjørn et al. (2014). Therefore, our findings suggest that without interdependency in work, people do not prioritize the effort necessary for collaboration but instead decouple from each other.

Additionally, the data show that *improved access at the office correlates with lower collaboration technology effort and collaboration technology readiness* but with a *higher collaboration effort*. There can be different potential reasons for these results. Respondents experiencing improved access to colleagues at the office might engage in spontaneous face-to-face activities, increasing the collaboration effort as they engage in cooperative activities without requiring scheduling or technology. Collocated work can often be supported by already established technologies in which the workers are confident, such as PowerPoint, whereas distributed work requires technology support for all articulation work related to the cooperative task (Lamovšek et al., 2024). Another potential reason can be that dynamically distributed teams are not necessarily located at the office at the same time. In such scenarios, the office can support improved access *if* all relevant colleagues are situated in the office, yet remote and hybrid options allow relevant team members to be located outside the office, leading to higher collaboration effort (de Souza Santos & Ralph, 2022). Even in such cases, collaboration technology readiness and effort can be low if the individual employee chooses not to establish the technology setups required for hybrid engagement or if other employees, such as facility management, are responsible for doing this work. Differently, when a person is a remote worker, all collaboration with colleagues must be facilitated by technology, and they are the sole responsible for making this setup function (Ciolfi et al., 2020).

Our second category of external factors, organizational management, shows that respondents at organizations with policies regulating employees' locations experience *higher common ground, higher collaboration technology readiness*, and *higher collaboration effort*. Collaboration always introduces articulation work, which is justified by the necessity of collaboration because the work cannot be done by one person alone (Schmidt & Bannon, 1992). When our findings show that having organizational policies correlates with higher collaboration effort, it does not necessarily mean that it is problematic; for example, our data show that collaboration effort does not negatively correspond with job satisfaction. Introducing collaborative technologies into an organization does not create 'instant collaboration' (Orlikowski, 1992); instead, collaboration emerges. Our findings indicate that regulating team members' locations coincides with a higher level of collaboration, thus requiring more effort from the individual employee because navigating organizational policies is not necessarily straightforward. While our study is limited to showing the correlations among the factors, we speculate that alignment between the nature of the work and organizational policies is important for collaboration and technology readiness. Other researchers have found that performance expectancy, effort expectancy, and organizational support are key factors influencing technology use (Brown et al., 2010). Therefore, high collaboration effort can also indicate misalignment between individual preferences and enforced policies, and implementing policies that align with work practices might decrease collaboration effort while still promoting common ground.

Our third category of external factors, personal location preference, measures the effect of the individual's preference for working from the office. Our data showed that respondents who preferred to work from the office experienced *higher collaboration effort*, *lower collaboration technology effort*, and *lower collaboration technology readiness*. These findings are similar to those for respondents who had improved access to colleagues at the office, indicating that preference to work at the office and improved access to colleagues

align with lower use of technology due to increased challenges in making collocated collaboration function. However, unlike the effect of improved access at the office, common ground was lower for respondents who preferred to work from the office. Potential reasons for this can be that a personal preference for working from the office is not necessarily linked to improved access to colleagues, and therefore, collaboration challenges can arise from relevant team members being away from the office (Bjørn et al., 2024; Breideband et al., 2023).

Our study shows that collaboration effort differs significantly for *all five external factors.* In contrast, collaboration technology effort differs significantly for only office access support and personal office preference, both of which had a negative effect. These findings conflict with other research, which shows that technology use in dynamically distributed teams requires continuous reconfiguration (Duckert & Bjørn, 2024; Fang et al., 2022), assumedly increasing the collaboration technology effort. Potential reasons can be found in the effect of collaboration technology readiness, which is positively associated with team distribution, organizational policies, and job satisfaction. If users perceive technology as useful, it positively impacts their acceptance of it (Davis, 1989); the high motivation to use technologies, therefore, potentially positively affects the experienced effort or makes the effort worth the extra work. However, both collaboration technology effort and readiness are lower for respondents experiencing improved access from the office and personal office preference, suggesting that the office is potentially utilized to decrease both the need and effort of technology interaction.

Distance in contemporary cooperative work has become increasingly common, also evident from the majority of our respondents working in teams with distributed participants. Different from previous explorations into distributed teams, such as (Mark et al., 2003; G. M. Olson & Olson, 2000) with a focus on collaboration across geographically distributed sites, contemporary work practices also involve bridging collocated distances at the office due to individuals' continuous movement between multiple home and office locations (Duckert et al., 2023; Duckert & Bjørn, 2025). Our findings support this by suggesting that dynamic distances impact not only the geographical distribution within a team but also the role of the office. The two external factors questioning if the office supports access to relevancies and personal office preference have a significant impact on collaboration effort, technology effort, and job satisfaction, highlighting the relevance of office environments in contemporary work. While being in teams with distributed participants also affects collaboration efforts, its impact is less pronounced and has no correlation with job satisfaction.

Moreover, our study revealed an approximately equal distribution between respondents preferring to work in or outside the office. Although respondents preferring to work outside the office experience higher collaboration technology effort, they also experience lower collaboration effort, higher common ground, higher collaboration technology readiness, and higher collaboration readiness. Therefore, employees who prefer working outside the office experience the positive impact of location flexibility, while the employees at the office must navigate the increased collaboration effort. Together, the external factors explore different perspectives on distance as a dynamic condition in contemporary work environments. In this way, dynamic distance in contemporary teams impacts not only the hybrid and distributed work within a team but also significantly impacts the role of the office in the collaboration. This highlights the relevance of further exploring ways in which offices can support team collaboration across dynamic distances.

6. Conclusion

This study investigated how distance matters for individuals' work experience in contemporary cooperative teams. The post-pandemic continuing preferences for remote work normalize distributed collaboration in teams that have access to a shared office for collocated interaction. Employees' flexibility to choose which location they want to work from creates *dynamic distance* in contemporary cooperative work due to these daily changes in team confirmations. We built on the Distance Framework to explore individuals' work experiences of collaborating across dynamic distances. Adopting this framework allowed us to extend

recognized research presenting common ground, coupling of work, collaboration readiness, and collaboration technology readiness, to be important for distributed work. Our revision of the framework introduced two new factors - collaboration effort and collaboration technology effort – representing the increased work required for collaboration across the dynamics of team distribution and technology use. Based on our Extended Distance Framework, we conducted a survey and found that the collaboration factors of the framework predicted 24% of the variation in job satisfaction. Additionally, we identified external factors that explore *distance* in contemporary work beyond proximity in cooperative teams. The first category, team distribution, covers both collaboration in teams with distributed participants and the experience of improved access to relevant colleagues from the office. The second category, organizational policies, addresses the management of employees' location. The third category examines individuals' personal preferences for working in or outside the office.

The study showed that distance in team distributions affects collaboration readiness, effort, and technology readiness. However, distance in contemporary work environments also impacts employees' access to their colleagues at the office, as relevant coworkers are not necessarily located at the same office site at the same time. While our study does not indicate how often individuals work from different locations, it reveals an equal distribution between respondents who prefer to work from the office and those who prefer to work remotely. The factors related to the office, including access to colleagues and personal preference, significantly impact job satisfaction. Therefore, we suggest that distance in contemporary work is dynamic, with the role of the office having a more significant impact on employees' job satisfaction compared to the geographical distribution of cooperative teams. We suggest the relevance of exploring ways that offices can enhance employees' experiences and access to their colleagues without eliminating hybrid work options.

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The authors report that there are no competing interests to declare.

Disclosure statement

The data that support the findings of this study are available upon request.

References

Appel-Meulenbroek, R., Kemperman, A., Water, A., Weijs-Perrée, M., & Verhaegh, J. (2022). How to attract employees back to the office? A stated choice study on hybrid working preferences. *Journal of Environmental Psychology*, *81*, 101784. https://doi.org/10.1016/j.jenvp.2022.101784

Atkinson, P., & Delamont, S. (Eds.). (2010). *SAGE Qualitative Research Methods* (1st edition). SAGE Publications Ltd.

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, *16*(1), 74–94. https://doi.org/10.1007/BF02723327

Bjørn, P., Busboom, J., Duckert, M., Bødker, S., Shklovski, I., Hoggan, E., Dunn, K., Mu, Q., Barkhuus, L., & Boulus-Rødje, N. (2024). Achieving Symmetry in Synchronous Interaction in Hybrid Work is Impossible. *ACM Trans. Comput.-Hum. Interact.*, *31*(4), 49:1-49:34. https://doi.org/10.1145/3648617

Bjørn, P., Esbensen, M., Jensen, R. E., & Matthiesen, S. (2014). Does distance still matter? Revisiting the CSCW fundamentals on distributed collaboration. *ACM Transactions on Computer-Human Interaction*, *21*(5), 26. https://doi.org/10.1145/2670534

Bjørn, P., & Ngwenyama, O. (2009). Virtual team collaboration: Building shared meaning, resolving breakdowns and creating translucence. *Information Systems Journal*, *19*(3), 227–253. https://doi.org/10.1111/j.1365-2575.2007.00281.x

Bjørn, P., Søderberg, A.-M., & Krishna, S. (2019). Translocality in Global Software Development: The Dark Side of Global Agile. *Human–Computer Interaction*, *34*(2), 174–203. https://doi.org/10.1080/07370024.2017.1398092

Bødker, S., & Klokmose, C. N. (2012). Dynamics in artifact ecologies. *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, 448–457. https://doi.org/10.1145/2399016.2399085

Bradner, E., & Mark, G. (2002). Why Distance Matters: Effects on Cooperation, Persuasion and Deception. *CSCW '02: Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work*, 226–235. https://doi.org/10.1145/587078.587110

Breideband, T., Moulder, R. G., Martinez, G. J., Caruso, M., Mark, G., Striegel, A. D., & D'Mello, S. (2023). 'Location, Location, Location': An Exploration of Different Workplace Contexts in Remote Teamwork during the COVID-19 Pandemic. *Proceedings of the ACM on Human-Computer Interaction*, *7*(CSCW1), 71:1-71:22. https://doi.org/10.1145/3579504

Brinkmann, S., & Kvale, S. (2017). *The SAGE Handbook of Qualitative Research in Psychology*. SAGE Publications Ltd. https://doi.org/10.4135/9781526405555

Brown, S. A., Dennis, A. R., & Venkatesh, V. (2010). Predicting Collaboration Technology Use: Integrating Technology Adoption and Collaboration Research. *Journal of Management Information Systems*, *27*(2), 9–54. https://doi.org/10.2753/MIS0742-1222270201

Busboom, J., & Boulus-Rødje, N. (2024). The Quest for 'How to do Hybrid right': Moving Beyond Compensating Asymmetries to Experience-Driven Cooperation. *Proc. ACM Hum.-Comput. Interact.*, *8*(CSCW2), 444:1-444:30. https://doi.org/10.1145/3686983

Caldeira, C., R.B. de Souza, C., Machado, L., Perin, M., & Bjørn, P. (2022). Crisis Readiness: Revisiting the Distance Framework During the COVID-19 Pandemic. *Computer Supported Cooperative Work (CSCW)*. https://doi.org/10.1007/s10606-022-09427-6

Chudoba, K. M., Wynn, E., Lu, M., & Watson-Manheim, M. B. (2005). How virtual are we? Measuring virtuality and understanding its impact in a global organization. *Information Systems Journal*, *15*(4), 279–306. https://doi.org/10.1111/j.1365-2575.2005.00200.x

Ciolfi, L., Gray, B., & Pinatti de Carvalho, A. F. (2020). Making Home Work Places. *Proceedings of the 18th European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-Centred Computing on the Design of Cooperation Technologies - Exploratory Papers, Reports of the European Society for Socially Embedded Technologies*. https://doi.org/10.18420/ECSCW2020_EP10

Ciolfi, L., Lewkowicz, M., & Schmidt, K. (2023). Computer-Supported Cooperative Work. In J. Vanderdonckt, P. Palanque, & M. Winckler (Eds.), *Handbook of Human Computer Interaction* (pp. 1–26). Springer International Publishing. https://doi.org/10.1007/978-3-319-27648-9_30-1

Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. In *Perspectives on socially shared cognition* (pp. 127–149). American Psychological Association. https://doi.org/10.1037/10096-006

Cook, I. (2021, September 15). Who Is Driving the Great Resignation? *Harvard Business Review*. https://hbr.org/2021/09/who-is-driving-the-great-resignation

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research & Evaluation*, *10*(7), 1–9. https://doi.org/10.7275/jyj1-4868

Cousins, K. C., Robey, D., & Zigurs, I. (2007). Managing strategic contradictions in hybrid teams. *European Journal of Information Systems*, *16*(4), 460–478. https://doi.org/10.1057/palgrave.ejis.3000692

Cramton, C. D., & Hinds, P. J. (2004). Subgroup dynamics in internationally distributed teams: Ethnocentrism or cross-national learning? *Research in Organizational Behavior*, *26*, 231–263. https://doi.org/10.1016/S0191-3085(04)26006-3

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*, 319. https://doi.org/10.2307/249008

de Souza Santos, R. E., & Ralph, P. (2022). A grounded theory of coordination in remote-first and hybrid software teams. *Proceedings of the 44th International Conference on Software Engineering*, 25–35. https://doi.org/10.1145/3510003.3510105

DeVellis, R. F. (2017). *Scale development: Theory and applications. Fourth edition*. Sage.

Dey, A. K., & de Guzman, E. (2006). From awareness to connectedness: The design and deployment of presence displays. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 899–908. https://doi.org/10.1145/1124772.1124905

DiStefano, C., Zhu, M., & Mîndrila, D. (2009). Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation*, *14*(20), 1–11.

Dourish, P., & Bly, S. (1992). Portholes: Supporting awareness in a distributed work group. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 541–547. https://doi.org/10.1145/142750.142982

Duckert, M., Barkhuus, L., & Bjørn, P. (2023). Collocated Distance: A Fundamental Challenge for the Design of Hybrid Work Technologies. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–16. https://doi.org/10.1145/3544548.3580899

Duckert, M., & Bjørn, P. (2024). Revisiting Grudin's eight challenges for developers of groupware technologies 30 years later. *I-Com*. https://doi.org/10.1515/icom-2023-0039

Duckert, M., & Bjørn, P. (2025). Location Multiplicity: Lost Space in the Hybrid Office. *Proceedings of the 2025 ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '25)*.

Fang, Y., Neufeld, D., & Zhang, X. (2022). Knowledge coordination via digital artefacts in highly dispersed teams. *Information Systems Journal*, *32*(3), 520–543. https://doi.org/10.1111/isj.12358

Flex Index. (2024). *Flex Report Q3 2024: Hybrid and Remote Work by the Numbers* (Q3 2024; p. 30). FlexOS. https://www.flexindex.com/stats

Gibson, C. B., & Cohen, S. G. (Eds.). (2003). *Virtual teams that work: Creating conditions for virtual team effectiveness* (1st ed). Jossey-Bass.

Griva, A., Chandra Kruse, L., Hattinger, M., Högberg, K., Pappas, I. O., & Conboy, K. (2024). Making space for time: Strategies for the design of time-aware hybrid work. *Information Systems Journal*. https://doi.org/10.1111/isj.12552

Gutwin, C., Penner, R., & Schneider, K. (2004). Group awareness in distributed software development. *Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work*, 72–81. https://doi.org/10.1145/1031607.1031621

Hacker, J., vom Brocke, J., Handali, J., Otto, M., & Schneider, J. (2020). Virtually in this together – how web-conferencing systems enabled a new virtual togetherness during the COVID-19 crisis. *European Journal of Information Systems*, *29*(5), 563–584. https://doi.org/10.1080/0960085X.2020.1814680

Hirata, K., Harada, Y., Takada, T., Aoyagi, S., Shirai, Y., Yamashita, N., Kaji, K., Yamato, J., & Nakazawa, K. (2008). t-Room: Next Generation Video Communication System. *IEEE GLOBECOM 2008 - 2008 IEEE Global Telecommunications Conference*, 1–4. https://doi.org/10.1109/GLOCOM.2008.ECP.1058

Kiesler, S., & Cummings, J. N. (2002). What do we know about proximity and distance in work groups? A legacy of research. In *Distributed work* (pp. 57–80). Boston Review. https://doi.org/10.7551/mitpress/2464.001.0001

Lamovšek, A., Radević, I., Mohammed, S. S., & Černe, M. (2024). Beyond the office walls: Work design configurations for task performance across on-site, hybrid and remote forms of work. *Information Systems Journal*. https://doi.org/10.1111/isj.12542

Macdonald, S., & Maclntyre, P. (1997). The generic job satisfaction scale: Scale development and its correlates. *Employee Assistance Quarterly*, *13*(2), 1–16. https://doi.org/10.1300/J022v13n02_01

Madsen, S., Haslan, C. R., & Nielsen, J. A. (2020). *Accelerated Digital Transformation: The Case of The Online University Caused By Covid-19*. 16.

Mark, G., Abrams, S., & Nassif, N. (2003). Group-to-Group Distance Collaboration: Examining the 'Space Between'. *Proceedings of the Eights European Conference on Computer.Supported Cooperative Work, 14-18 Septemcer 2003, Helsinki, Finland*.

Martin, L., Hauret, L., & Fuhrer, C. (2022). Digitally transformed home office impacts on job satisfaction, job stress and job productivity. COVID-19 findings. *PLOS ONE*, *17*(3), e0265131. https://doi.org/10.1371/journal.pone.0265131

Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual Teams: What Do We Know and Where Do We Go From Here? *Journal of Management*, *30*(6), 805–835. https://doi.org/10.1016/j.jm.2004.05.002

Matthiesen, S., & Bjørn, P. (2016). Let's Look Outside the Office: Analytical Lens Unpacking Collaborative Relationships in Global Work. In A. De Angeli, L. J. Bannon, P. Marti, & S. Bordin (Eds.), *COOP 2016: Proceedings of the 12th*

International Conference on the Design of Cooperative Systems, 23-27 May 2016, Trento, Italy (pp. 107–122). Springer International Publishing. https://doi.org/10.1007/978-3-319-33464-6_7

Olson, G. M., & Olson, J. S. (2000). Distance matters. *Human-Computer Interaction*, *15*(2–3), 139–178. https://doi.org/10.1207/S15327051HCI1523_4

Olson, J. S., & Olson, G. M. (2014). Working Together Apart: Collaboration over the Internet. *Synthesis Lectures on Human-Centered Informatics*, *6*(5), 1–151. https://doi.org/10.2200/S00542ED1V01Y201310HCI020

Orešković, T., Milošević, M., Košir, B. K., Horvat, D., Glavaš, T., Sadarić, A., Knoop, C.-I., & Orešković, S. (2024). *Associations of working from home with job satisfaction, work-life balance, and working-model preferences*. https://doi.org/10.3389/fpsyg.2023.1258750

Sako, M. (2021). From remote work to working from anywhere. *Communications of the ACM*, *64*(4), 20–22. https://doi.org/10.1145/3451223

Schmidt, K., & Bannon, L. J. (1992). Taking CSCW Seriously Supporting Articulation Work. *Computer Supported Cooperative Work*, *1*, 7–40.

Schoch, M., Gimpel, H., Maier, A., & Neumeier, K. (2023). From broken habits to new intentions: How COVID-19 expands our knowledge on post-adoptive use behaviour of digital communication and collaboration. *European Journal of Information Systems*, *32*(6), 989–1010. https://doi.org/10.1080/0960085X.2022.2096489

Sheikh, K., Baptista, J., & Albuquerque, J. P. de. (2019, January 8). Spatial practices in digital work: Calling for a spatial turn in information systems research. *Proceedings of the 52nd Hawaii International Conference on System Sciences*. 52nd Hawaii International Conference on System Sciences, Hawaii. https://doi.org/10.24251/HICSS.2019.725

Smite, D., Christensen, E., Tell, P., & Russo, D. (2023). The Future Workplace: Characterizing the Spectrum of Hybrid Work Arrangements for Software Teams. *IEEE Software*, *40*, 34–41. https://doi.org/10.1109/MS.2022.3230289

Smite, D., Moe, N. B., Tkalich, A., Hanssen, G. K., Nydal, K., Sandbæk, J. N., Aamo, H. W., Hagaseth, A. O., Bekke, S. A., & Holte, M. (2022). *Half-Empty Offices in Flexible Work Arrangements: Why are Employees Not Returning?* (arXiv:2208.12797). arXiv. https://doi.org/10.48550/arXiv.2208.12797

Smite, D., Moe, N., Klotins, E., & Gonzalez-Huerta, J. (2022). From forced Working-From-Home to voluntary working-from-anywhere: Two revolutions in telework. *Journal of Systems and Software*, *195*, 111509. https://doi.org/10.1016/j.jss.2022.111509

Smite, D., Tkalich, A., Moe, N., Papatheocharous, E., Klotins, E., & Buvik, M. (2021). Changes in perceived productivity of software engineers during COVID-19 pandemic: The voice of evidence. *Journal of Systems and Software*, *186*, 111197. https://doi.org/10.1016/j.jss.2021.111197

Stevens, J. P. (2009). *Applied multivariate statistics for the social sciences* (5th ed.). Routledge.

Sull, D., Sull, C., & Zweig, B. (2022). Toxic culture is driving the great resignation. *MIT Sloan Management Review*.

Taser, D., Aydin, E., Torgaloz, A. O., & Rofcanin, Y. (2022). An examination of remote e-working and flow experience: The role of technostress and loneliness. *Computers in Human Behavior*, *127*, 107020. https://doi.org/10.1016/j.chb.2021.107020

Venolia, G., Tang, J., Cervantes, R., Bly, S., Robertson, G., Lee, B., & Inkpen, K. (2010). Embodied Social Proxy: Mediating Interpersonal Connection in Hub-and-Satellite Teams. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1049–1058. https://doi.org/10.1145/1753326.1753482

Waizenegger, L., McKenna, B., Cai, W., & Bendz, T. (2020). An affordance perspective of team collaboration and enforced working from home during COVID-19. *European Journal of Information Systems*, *29*(4), 429–442. https://doi.org/10.1080/0960085X.2020.1800417

Wiatr, A., & Skowron-Mielnik, B. (2023). Hybrid team management: The long and winding road. *Organizational Dynamics*, *52*(1), 100936. https://doi.org/10.1016/j.orgdyn.2022.100936

Williams, S., & Shaw, N. (2024). Hybrid working – Benefits and challenges for productivity and performance. *International Journal of Productivity and Performance Management*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/IJPPM-05-2023-0230

Winkler, K., König, S., & Heß, C. (2022). *Managing and Leading Hybrid Teams*. https://opus4.kobv.de/opus4-hs-kempten/frontdoor/index/index/docId/1313

Yang, L., Holtz, D., Jaffe, S., Suri, S., Sinha, S., Weston, J., Joyce, C., Shah, N., Sherman, K., Hecht, B., & Teevan, J. (2022). The effects of remote work on collaboration among information workers. *Nature Human Behaviour*, *6*(1), Article 1. https://doi.org/10.1038/s41562-021-01196-4

Zamani, E. D., Watson-Manheim, M. B., Abbott, P., & Lin, A. (2024). The new wave of 'hybrid' work: An opportunity to revise assumptions and build theory. *Information Systems Journal*. https://doi.org/10.1111/isj.12558