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Achieving Symmetry in Synchronous Interaction in Hybrid Work is Impossible

PERNILLE BJØRN, University of Copenhagen, Department of Computer Science, Copenhagen, Denmark
JULIANE BUSBOOM, Roskilde University, Department of People and Technology, Roskilde, Denmark
MELANIE DUCKERT, IT University of Copenhagen, Department of Computer Science, Copenhagen, Denmark
SUSANNE BØDKER, Aarhus University, Department of Computer Science, Aarhus, Denmark
IRINA SHKLOVSKI, University of Copenhagen, Department of Computer Science, Copenhagen, Denmark
EVE HOGGAN, Aarhus University, Department of Computer Science, Aarhus, Denmark
KELLIE DUNN, University of Copenhagen, Department of Computer Science, Copenhagen, Denmark
QIANQIAN MU, Aarhus University, Department of Computer Science, Aarhus, Denmark
LOUISE BARKHUUS, IT University of Copenhagen, Department of Computer Science, Copenhagen, Denmark
NINA BOULUS-RØDJE, Roskilde University, Department of People and Technology, Roskilde, Denmark

Designing new technologies to support synchronous interaction across distances has for many years focused on creating symmetry for participation between geographically distributed actors. Symmetry in synchronous interaction has, to some extent, been achieved technologically (while multiple social, historical, political, and hierarchical concerns continue to exist) and proven empirically in the increased use of remote-work technologies that were used during the pandemic. However, synchronous interaction in hybrid work is achieved differently, since the asymmetry produced by some participants being collocated while others geographically distributed introduces increased complexities for such interactions. Focusing on this challenge, we ask: *To what extent can symmetry in cooperative work engagements be achieved in hybrid work contexts?* We explore this question by interrogating multiple different empirical examples of synchronous hybrid interaction collected across different organizations, activities, and events. We found that the effort required to accomplish hybrid work includes additional articulation work necessary for bounding multiple intertwined artefacts

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Authors' addresses: P. Bjørn (Corresponding author), I. Shklovski, and K. Dunn, Department of Computer Science, University of Copenhagen, Universitetsparken 5, 2100 Copenhagen, Denmark; e-mails: pernille.bjorn@di.ku.dk, ias@di.ku.dk, kedu@di.ku.dk; J. Busboom and N. Boulus-Rødje, Department of People and Technology, Roskilde University, Roskilde, Denmark; e-mails: busboom@ruc.dk, ninabr@ruc.dk; M. Duckert and L. Barkhuus, IT University of Copenhagen, Department of Computer Science, Copenhagen, Denmark; e-mails: mela@itu.dk, barkhuus@icloud.com; S. Bødker, E. Hoggan, and Q. Mu, Aarhus University, Department of Computer Science, Aarhus, Denmark; e-mails: bodker@cs.au.dk, eve.hoggan@cs.au.dk, qianqianmu@cs.au.dk.
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across sites, devices, and applications. Further, the multiple artefacts setup across sites, combined with asymmetric collocation across participants, produce incongruence in technological frames of reference for each participant. All participants in hybrid work have only partial access to the hybrid setup, and no single person has access to the complete setup. The incongruence in technological frames produces insurmountable gaps in collaboration, causing all hybrid work situations to be characterized fundamentally by asymmetric relationships. We argue that symmetry in hybrid synchronous interaction is impossible to attain in attempts to solve this problem through design. Instead, we propose that designers of cooperative technologies for hybrid work shift towards developing artefact-ecologies supporting hybrid work, focusing on asymmetry as a necessary feature. Fundamentally, the design strategy should explore novel ways of taking advantage of the multiple different artefact-ecologies which serve as the foundation for the hybrid collaboration. Instead of striving for symmetry, we propose to feature asymmetric conditions in future technology designs for hybrid interaction.

CCS Concepts: • **Human-centered computing → Computer supported cooperative work**;

Additional Key Words and Phrases: Distance, global software development, ethnography, comparative studies, incongruence, synchronous interaction, hybrid work, workshop, collaboration across distance, Covid

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1 INTRODUCTION

For decades **Human Computer Interaction (HCI)** and **Computer Supported Cooperative Work (CSCW)** research has explored the challenges of remote working with the aim of designing cooperative technology supporting remote cooperation [34, 49, 51, 67, 77], and examples of technologies for remote work emerging from this strand of research includes Hydra [78], T-Room [50, 93], Liveboard [38], and Clearboard [52]. A common core criterion explored across these technologies is the embedded challenge of designing for "equal participation" or "avoiding asymmetry" despite the geographical dispersion of participants. During the COVID-19 pandemic we witnessed how organizations were quick to adjust to the new situation, and by implementing laptop applications such as Zoom or MS Teams managed to successfully facilitate remote work with embedded symmetry as all participants had the same type of access to others while working from home on similar laptops using the same application. While COVID forced people to work in all-remote arrangements, the work situations after COVID opened up many different organizational structures for hybrid work providing flexibility for workers as well as organizations [62, 72, 83].

Hybrid work has even emerged as 'the new normal' for many professions because of COVID [27] such as software development [37, 59] and healthcare [46]. Hybrid work is a special type of cooperative work [73, 74] which inherits all the main challenges from cooperative work and distributed work, however, there are distinct differences. Where *cooperative work* emerges when at least two actors are involved in and dependent upon a common field of work [31, 75], *distributed work* builds upon the same definition, however it adds the complexities of actors being geographically located at different locations [13, 26, 61], potentially also increasing the complexities of discontinuities in the cooperative work [15, 91, 92]. Differently, *hybrid work* fundamentally takes place when some participants are geographically distributed, while others are collocated. Thus, the hybrid work arrangements we explore in this paper are cooperative situations where at *least three cooperative actors are geographically distributed across fewer locations than the number of actors*, while still being mutually dependent in a common field of work [36]. Hybrid teams thus consist of

multi-locations teams, where participants work from the office, from client's offices, from home, from a café, or any other location during the work week (and even during the same day) while their team members might do the same consequently being aligned or misaligned in locations at all times [82].

We collaborate with multiple organizations that are struggling in different ways to integrate hybrid work into their organizations after COVID. The COVID 'real life experiment' demonstrated that flexible working conditions are possible without increased costs or loss of productivity and are desired by workers, if such work arrangement does not disadvantage remote workers or negatively affect their wellbeing [44]. However, the cooperative technologies for distributed work implemented during COVID are not designed for hybrid work arrangements – and the old CSCW challenge of "providing equal access" to remote as well as collocated actors is yet again a burning platform for design. Interestingly, the "remote-work technologies" supporting working from home during the pandemic *have entered the office space without leaving the home office*. Thus, the use of remote-work technologies continues, however with the important difference that it is no longer "simply" to facilitate work where all participants are geographically distributed. Instead, the increased complexities in technology used now include supporting cooperative work where some participants are geographically distributed, while others are collocated. We refer to this as a hybrid cooperative work context. Our larger research interest is to interrogate how remote-work technologies designed for geographically distributed cooperation are challenged when entering a hybrid cooperative work context, and to see whether new design propositions for hybrid-work technologies can be identified.

We explore this research interest theoretically and empirically by guiding our explorations through literature and empirical observations, asking the research question: *To what extent can symmetry in cooperative work engagements be achieved in hybrid work contexts?* Through literature we identify that the challenges of symmetry in cooperative work in hybrid engagements arise from (1) the inherent limitations in providing consistent access to multi-modal information, increasing the efforts of relation work, and (2) the need to synchronize artefact-ecologies, multiple devices, and technologies. Using these theoretical insights as analytical sensitizing devices, we engage these theoretical conversations by allowing them to enter contemporary empirical situations of hybrid work. In this way, we build upon the past while adding concerns for future strategies and approaches in cooperative technology design in an empirically relevant work arrangement.

Based upon our research, we argue that hybrid work produces technological challenges which are distinctly different from distributed work, and thus require different sets of approaches for design. Further, we argue that striving to design technologies that produce symmetric engagements in hybrid work arrangements is not worth attempting. We acknowledge that this statement is potentially controversial, but all our empirical observations point out that hybrid work produces insurmountable gaps that increase the complexity of articulation work. These insurmountable gaps manifest themselves in hybrid activities and are produced by incongruences in the technological frames of reference creating unavoidable asymmetric relations between cooperative actors. While incongruence in frames of reference *might* manifest in all types of distributed work challenging common ground, *is it always* part of what characterizes hybrid work.

The paper is structured as follows: First, we unpack the literature on cooperative work, distributed work, and hybrid work. Then we dive into the relational challenges in hybrid work, followed by the artefact-ecologies challenge in hybrid work. We introduce our analytical approach and empirical data which stems from multiple different organizations and activities. In the results section we divide our empirical observations into three main Sections 4.1 From "Remote-work Technology" towards Artefact-Ecologies in Hybrid Work; 4.2 Incongruence in Individual Technology Opportunities for Hybrid Work; and 4.3 Unavoidable Asymmetric Relations in Hybrid Work.

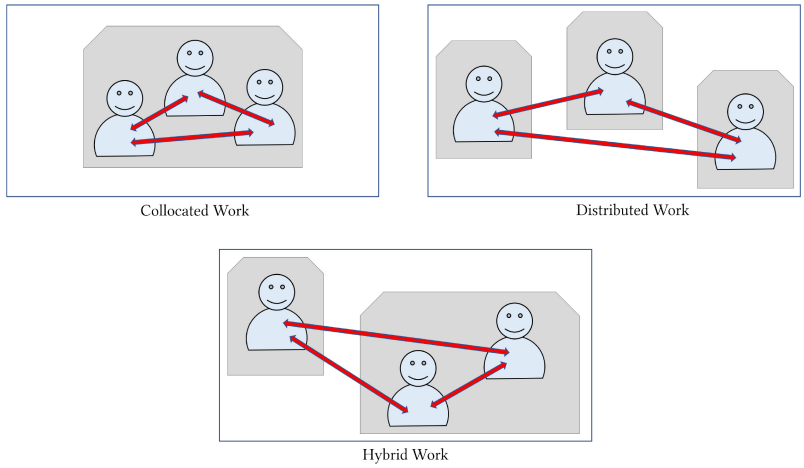

Fig. 1. Three participants collaborating in different configurations of collocated, distributed, and hybrid work. The grey boxes represent locations, and the red arrows represent the mutual engagement between participants.

Finally, we discuss our findings, by challenging existing design endeavours to create technologies that produce symmetry across actors in hybrid situations, producing the potentially controversial argument that achieving symmetry in hybrid synchronous interactions is impossible. On this basis, we need new directions for the design of hybrid technologies, and we put forward three propositions suggesting future design directions for hybrid technologies.

2 COOPERATIVE WORK, DISTRIBUTED WORK, AND HYBRID WORK

To explore how cooperative technologies influence cooperative work in hybrid workspaces and identify emerging design challenges, we must first conceptually unpack the nature of *cooperative work* as it takes place in collocated, distributed, or hybrid work settings (see Figure 1).

Collocated work refers to a situation where at least two participants are mutually dependent upon each other to achieve a cooperative task in a common field of work [31, 75]. The interdependence is crucial to the definition, since it is only through this interdependence that a task emerges as cooperative [86, 87]. The attribute of collocation refers to the physical location and manifestation of cooperative actors' bodies as being in proximity. Sharing proximity produces certain conditions which actors then can utilize in their interaction, such as gestures, artefacts, facial expressions, and so on which all actors have equal access to during the cooperative engagement [47, 48]. Proximity thus produces enabling conditions facilitating actors in developing common ground [32], if the collaboration setup is characterized by collaboration readiness [13, 67].

Distributed work is a situation where multiple participants (at least two) are mutually dependent in their work without collocation. The lack of proximity in distributed work reduces the access to, and availability of, using gestures, facial expressions, and artefacts as part of the interaction. Hence, technologies designed to support distributed interaction seek to create digital conditions mimicking what is lost through different modalities of video, audio, and digital artefacts [34, 45, 78, 93–96]. These technologies typically focus on creating facilitating conditions (e.g., awareness [4], social translucence [39], or coordination technologies [42]) allowing participants to develop common ground despite the lack of proximity. Distributed work relies on participants' *readiness for collaboration technology* [68]. When all actors in a cooperative setting are geographically distributed, technology is required *a priori*, since without technology, none of the participants have access

to interact with each other. Thus, the technology needs to be there, and participants need to be ready to use the technology. Being ready to engage in distributed work also includes being ready to collaborate which can be challenged by organizational practices [63, 84], geo-political circumstances [18, 80], **or** from potential disruptions from the participants' physical context [28]. Further, the challenge of creating common ground continues to exist in distributed work, and grounding activities are increasingly difficult in distributed work due to the perception of distance [26] that is influenced by how the coupling embedded within the work task shapes the collaboration [55].

Hybrid work is a situation where *at least three* actors are mutually dependent in their work, and where the actors are located in at least one fewer context than the number of actors [36]. Hybrid work increases the challenges of sub-group dynamics produced by the unequal access resulting from partial collocation [33]. Hierarchical structures risk being socially interrupted by partial collocation. For example, prior empirical data demonstrate how top management in a large organization choose to simply reach out to a collocated team member in a global strategic team *rather than* following the correct hierarchical procedure and calling up the team leader with a 6-hour time difference, producing unequal access to strategic knowledge relevant for the whole team but hidden from the team leader [15]. Hybrid work inherits all the challenges from collocated and distributed work but also has some special characteristics increasing the challenges of cooperative work in hybrid work situations.

In this paper, our interest is *hybrid work arrangements* and how hybrid work structure imposes specific challenges and thus specific requirements towards the design of cooperative technologies supporting hybrid work. Hybrid work activities can take different forms, utilize different technologies, and produce different outcomes. However, the temporal pattern of hybrid activities is critical for how we can comprehend hybrid interaction. The temporal nature of hybrid work interactions can on a broad scale be divided into *synchronous* and *asynchronous* activities. Hybrid synchronous activities occur across geographical sites but at the 'same time'. Here 'same time' signifies *simultaneous* activity, recognizing that hybrid work might span different time zones, thereby occurring "not at the same time" in a literal sense, but rather in a simultaneous fashion. The temporal nature of asynchronous hybrid work activities manifests in various forms, either as activities executed independently or organized consecutively. The temporal ordering of these activities is *disjoint* from other actors' activities. The special nature of hybrid work is more evident in synchronous activities since the simultaneous activities make the combined collocation/dislocation among hybrid team members pertinent in the moment, shaping the types of interaction that can take place. This does not mean that the hybrid element in the collaborative arrangement is not important in asynchronous work, even if it may be less pertinent and available for analytical scrutinizing. Being collocated with some participants and being dislocated from others affect the types of interaction possible. However, identifying the nuances of collocation/dislocation can be challenging, as the interactions in a hybrid work arrangement might closely resemble those in a distributed work arrangement. In our examination of different empirical cases of hybrid interaction, we analyze both synchronous and asynchronous activities. However, our findings indicate that the major design challenges arose from synchronous interaction, and thus we mainly focus on these in this paper.

2.1 Relational Challenges in Hybrid Work

When people engage in cooperative work, they always also engage in relation work. However, understanding what relation work entails and how it is accomplished, as part of cooperative work in general and hybrid work in particular, requires us to examine it theoretically. Studying hybrid work within global engineering, Bjørn and Christensen propose relation work as "a parallel to the concept of articulation work. Articulation work describes efforts of coordination necessary in cooperative work, but, arguably, focuses mainly on task-specific aspects of cooperative work. As

a supplement, the concept of relation work focuses on the fundamental relational aspect of cooperative work" [12, p. 1]. Later, in research exploring global software development, Christensen, Jensen, and Bjørn extend and nuance relation work by stating that:

> "[c]reating social ties are important for collaborative work [...] making social ties requires extra work: Relation work. We find that characteristics of relation work as based upon shared history and experiences, emergent in personal and often humorous situations. Relation work is intertwined with other activities such as articulation work and it is rhythmic by following the work patterns of the participants [...] Whereas collocated relation work is spontaneous, place-centric, and yet mobile, relation work in a distributed setting is semi-spontaneous, technology-mediated, and requires extra efforts" [30, p. 1]

While both conceptualizations above distinguish relation work as different from articulation work, the theoretical conceptualization needs more nuance to fully guide analyses of hybrid work situations. Therefore, we decided to follow theoretical strategies from Shklovski, Barkhuus, Bornoe, and Kaye [79] and investigate prior research on relationship and relational dialogues (e.g., [5, 6, 81]) as a starting point for theorizing about relation work in hybrid work.

Research on relationships is mostly based upon analysis of romantic partnerships or friendships, rather than being related to the work situation. Nevertheless, we can learn from these situations and connect conceptual understandings to the work situation. Personal relationship research reminds us that communication is a "means by which people construct and maintain relationships" [81, p. 331]. Thus, when we consider relation work in cooperative settings, it means that we are zooming in on the communication and dialogue that take place as part of creating the working relationship. Sillars and Vangelisti synthesize research on relationships into core properties of communication which are crucial for relationship building [81, p. 332]. One of these properties is interdependence, which is also important when we consider relations in hybrid work.

Interdependence in relationship building is different from how interdependence is considered in CSCW research, namely as task dependencies shaping how cooperative engagement emerges. Interdependence in relationships instead refers to how interaction, utterances, and messages "simultaneously influence and are influenced" by the context that precedes and follows the interaction [81, p. 332]. Relationships are thus co-constitutive of the very interaction which takes place. Relational dialogues are constitutive processes by which the interaction defines and constructs the social world of our relationships, "put simply, relationships are constituted in communication practices" [6, p. 3]. From this perspective, relationships cease to exist outside of dialogue and interaction. In CSCW research, the introduction of digital means for cooperative work has always been understood as shaped by temporal and spatial configurations [34, 88], and as such this understanding of relationship building as shaped and configured by the temporal-spatial circumstances aligns with current perspectives. So, while the interdependence in relationship building alerts us to consider how relationships are constituted by interaction configured by space and time, interdependence in cooperative work points to the fact that cooperative engagements are constituted by the work and only emerge when the task cannot be accomplished by the individual but requires at least two people. Thus, extending the current conceptual understanding of *relation work* in CSCW research by enfolding theoretical understandings from relationship literature, proposes to consider relationships as constituted by communication shaped by space and time when identifying design requirements for hybrid technologies.

Relational challenges in hybrid settings are thus co-constitutive and based upon interdependence in work tasks *as well as in personal relationships*. Relation work is impacted by communication and interaction *which take place outside the work dialogue*, and each interaction in the past

shapes interactions in the future. When investigating and designing for hybrid work, we must pay attention to the *social and personal relationships that are pertinent to the work arrangements*. This attention includes recognizing *when such a relationship does not exist* and thus risks shaping the interaction negatively.

Relational challenges are an important analytical lens when exploring potential challenges emerging when cooperative technologies enter the hybrid workspace. However, the challenges are not only about relations; we also need to examine how current technologies shape hybrid interaction.

2.2 From Artefact to Artefact-Ecologies in Hybrid Work

CSCW research has historically focused on the design of specific cooperative applications with the aim of developing general design guidelines for such technologies [43, 69, 70, 76]. Much of this work has centred around the design of 'a cooperative technology' supporting a specific practice. Still, the many detailed ethnographic studies documented within the research have multiple times pointed to how real-life practices are always using a set of multiple artefacts when accomplishing work in complex work arrangements e.g., hospitals [1, 2, 65] or architectural work [29, 64]. Thus, the focus on 'the singular technology' has always been challenged by empirical data, and researchers agree that studying only one technology at a time is too limited when considering cooperative practices. Further, we are witnessing the increase of multiple devices, software applications, and networked services emerging in our everyday life and work. Lyle et al. [60] point out that more and more empirical work has focused on *constellations* of artefacts rather than single applications. This work has often been framed as moving *from artefact to infrastructure* [9, 16, 66] or moving from *artefact to ecologies of artefacts* [19, 20, 23]. When moving from focusing on singular artefacts to multiple artefacts the complexities concerning the technological setup and thus the technology frames of reference also increase, making the analytical and design-oriented setup more complex. It becomes necessary to address both how individual participants explicitly or implicitly choose between e.g., devices and software applications for a particular activity, and consider the answers to these questions concerning participants' practices, how these practices develop, as well as how these practices and choices of technologies are shared with collaborators – or maybe differ depending on collaborators. We need to understand how specific technological setups of constellations of artefacts are used and negotiated by participants, and further re-negotiated over time [8, 89, 90].

CSCW researchers have studied the connection between artefacts as a web of coordinative artefacts [3] or as artefactual multiplicity comprising the multiple functionalities of heterogeneous artefacts and relations between embedded functionalities [14]. The characteristic of all these examples is that the multiple artefacts or the artefact-ecologies are somewhat fixed and taken for granted, and studied as is. However, artefact-ecologies *continuously develop over time*, in interplay with the dialectical development of the routines of the collaborative work [40, 41], and with extrinsic development and introduction of new technological possibilities [56].

Bødker and Bøgh Andersen [19] unfold a careful analysis of artefact-ecologies, and how the configurations of artefacts and people change and are transformed over time. The analyses also show how the very same artefacts have different roles in these shifting configurations. Thus, it is not only that there are multiple artefacts involved – the analytical moves also demonstrate how a concrete artefact can take on different roles and functionalities over time. The cases demonstrating the critical role of multiple artefacts are many [19]. When considering artefact-ecologies in hybrid work, we must explore the historical layers behind the artefacts. We need to analytically pay attention to the historic development of artefacts involved in cooperative work in the current hybrid work practices and explore the space for future practices.

Artefact ecologies consist of a dynamic constellation of multiple artefacts that are sometimes planned and negotiated, and other times more coincidental [22]. Since artefacts *activated in*, or *constructed for* a particular activity [21] are rooted in participants' past experiences and the availability of infrastructure (in terms of both devices, software and e.g., bandwidth) the conceptual understanding of artefact-ecologies has strong ties with the conceptual understanding of infrastructuring in CSCW and HCI research [11, 53, 54, 57]. The difference between the infrastructure work [7, 58] and the artefact-ecologies perspective can be debated as they have in the work of Star and Ruhleder [85], and Bowker and Star [25]. There is a tendency for an artefact-ecologies framework to move analytically from the grounded empirical cooperative situation, whereas infrastructures research tends to move across multiple interlinked sites of design [10] which to some extent can be removed from the concrete cooperative situation. We choose the conceptual framework artefact-ecologies over infrastructure because it aligns with our dedication to focus on the concrete work practices which emerge in hybrid work settings. Our interest is to understand and theorize how artefacts shape the opportunities for hybrid interaction – without focusing on only one type of technology in the situation. Instead, we follow and analyze all the technologies, applications, devices, and artefacts that comprise the ecology of artefacts and allow hybrid work to exist. By exploring artefact-ecologies in hybrid work, we are reminded to not only identify the 'main cooperative technologies' utilized (such as video conferencing tools) but also pay attention to and recognize the diverse range of other artefacts in use. This involves looking beyond the obvious devices and applications to acknowledge the various constellations of artefacts available across the geographical sites of hybrid work.

3 METHOD

Our research approach is a theoretically driven exploration grounded in empirical observations. To explore the intricacies of achieving symmetry in hybrid work arrangements, we began with theoretically informed discussions aimed at identifying the primary aspects contributing to these challenges. This resulted in three main aspects that emerged theoretically: First (1) the challenges caused by the use of multiple devices and technologies (artefact-ecologies) that must be synchronized for hybrid work to function effectively; second (2) the unique challenges caused by the fact that hybrid work can never provide the same type of access to different forms of multimodal information for all participants due to the incongruence in technology frames of reference; and third (3) how the incongruences in technology frames of reference produced by the diverse artefact-ecologies for each participant fundamentally create asymmetric relations in hybrid work. Having grounded these insights in the literature, we sought to explore how these challenges manifested in empirical examples, and thus see how the empirical insights might extend or challenge our conceptualization. Our collective analysis underwent multiple iterative processes spanning several months, while continuously adding diverse perspectives from multiple empirical cases we were (still are) studying in our project. With each analytical session, we took a deeper step into the empirical circumstances, refining our conceptual understandings. See Figure 2 for an overview. Below, delving into explaining this process in greater detail, we first present the empirical data that served as the foundation for our research.

3.1 Empirical Contexts

As part of a large research project exploring the future of work, the authors of this paper are researchers from four different universities who collaborate with 13 different empirical partners. The partners can be divided into four groups, depending on the type of collaboration. First, we have the industrial partners who want to reflect upon and develop their ways of working in the future.

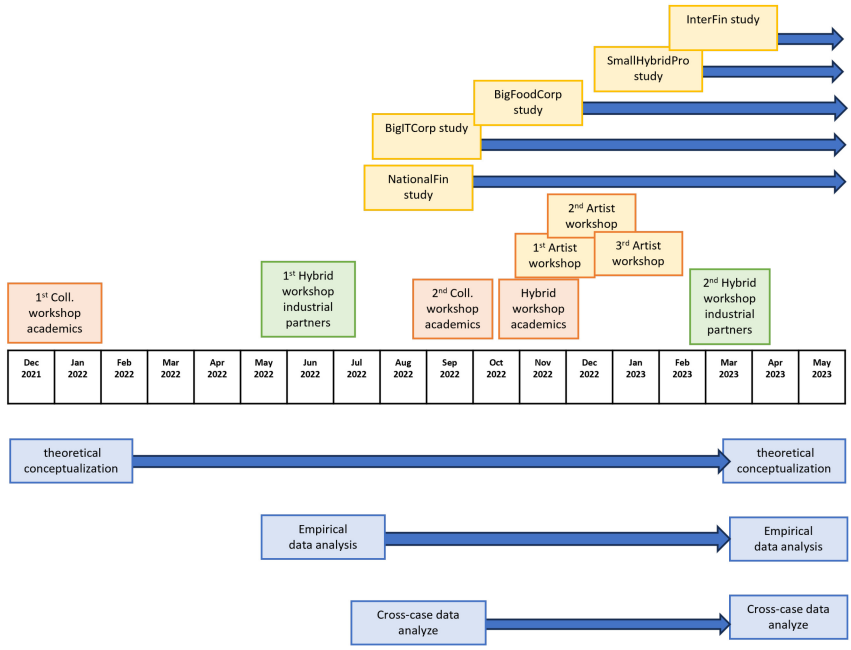

Fig. 2. Overview of the data collection (across empirical studies and activities) and iterative analysis comprising the theoretical conceptualization, empirical data analysis, and cross-case analysis.

Second, we have organizations focusing on supporting others in achieving success with hybrid and distributed work. Third, we have tech organizations that focus on new technology opportunities for new forms of work. Finally, we collaborate with artists, as a strategy to explore the future of work before the future arrives. What makes this diverse set of partners interesting, is that it allows us to explore multiple dimensions and details of hybrid work from various perspectives. Further, the organizational setup also allows us to challenge empirical insights from across settings. Table 1 provides an overview of the different empirical partners in the project, and while we do not report data from all these organizational settings, we report from workshops where participants from these different organizations joined.

3.2 Data Collection

We used different data collection strategies for each case, including workshops, observations, interviews, and the like. We conducted several workshops with different groups of partners, including industrial partners, artists, academics, participants outside the project, and participants inside the project. We used different kinds of data collection methods for each workshop including video and audio recordings, and we collected results of workshop activities such as posters or other types of shared paper-based artefacts. In most cases, we recorded (audio and video) the entire workshop and collected artefacts (posters, drawings, and other material), while in other cases we only collected artefacts and drawings. For all events, we also collected photos and reflections from multiple participants. With some organizations, we collected detailed ethnographic observations of work practices and conducted interviews with employees while spending time in their work settings to understand how they approach hybrid cooperative work. For these ethnographic studies, we collected data in terms of field notes, observations, and audio recordings of interviews. All data material has been transcribed for data analysis in the research project.

Table 1. Empirical Partners

	AnonPartner	Domain	Size	Locations Countries
1	BigFoodCorp	Foods production and resale	20,000+	+100 countries
2	BigITCorp	Technology consultancy and solutions	90,000+	+100 countries
3	InterFin	Fintech	1,700	2 locations in Europe
4	InnoStart	Support innovation processes of various kinds.	<10	Scandinavia
5	NationalFin	Fintech	1,000	3 locations in one country
6	SmallManageConsult	Leadership consultancy and training. Focus on new forms of working.	30	2 locations in Scandinavia
7	SmallVisual	3D visualization and digital communication solutions to a wide range of domains	10	Worldwide
8	SmallHybridPro	Facilitating hybrid meetings for big corporate companies in the medical sector	10	Worldwide
9	BigProdCorp	Big mechanical manufacturing corporation	20,000	+60 locations worldwide
10	BigToyCorp	Big toy manufacturing corporation	20,000+	+40 locations worldwide
11	SmallArts	Arts, design teaching and making	20	Danish city
12	SmallIT	Consultancy on information technology, with a focus on the automotive industry	2,000+	+40 locations worldwide
13	SmallVR	Virtual Reality production in different domains	20	Scandinavia

3.3 Data Sources

The data sources which serve as the foundation for this paper are based upon the empirical work across the cases, organizations, and researchers – however not all our data ended up as part of this paper, but all empirical insights from the different subprojects have shaped the analytical work of this paper through continuous discussions across the authors. The data sources reported upon in this paper comprise transcriptions of interviews, video recordings and transcriptions of workshops, online workshop recordings, photos, field notes, audio recordings of interviews, and so on. Table 2 below summarizes the data sources. In total, we conducted eight workshops and reported from five empirical studies in this paper. The ethnographic empirical studies were of various lengths between one month and four months.

3.4 Data Analysis

Our data analysis took the form of a collective analytical process where the authors met several times over several months and discussed the empirical observations from the different cases through theoretical interests in technology support for hybrid work. For each collective analysis, we have challenged current conceptualizations while extending our theoretical reasoning. While not all authors have been present at all of our collective analytical sessions, the first author has

Table 2. Data Sources

	Data types
Two (no. 1, 2) hybrid workshops with multiple industry partners from Table 1.	Video recordings, audio recordings, artefacts (flip overs), photos, and transcriptions, notes
One (no. 3) hybrid workshop with academics	Notes, photos
Two (no. 4, 5) collocated workshops with researchers	Notes, artefacts, photos
Three (no. 6, 7, 8) collocated workshops with artists from the Table 1.	Notes, artefacts, photos, audio recordings, transcriptions, interviews
Empirical study InterFin	In-situ observation, interviews, photos, and meetings Both remote and on-site observation
Empirical study BigITCorp	Interviews
Empirical study SmallHybridPro	Observations, interviews, photos Both remote and on-site observation
Empirical study BigFoodCorp	Onsite visit and interviews
Empirical study NationalFin	Onsite visit and interviews

been present at all sessions and has collected all the insight across all discussions. Further, the analytical categories have gone through several iterations, which in the end resulted in two main theoretical lenses which have been presented from the beginning namely: artefact-ecologies and relational challenges. So, while other theoretical perspectives have been tried out (e.g., technological frames [17, 71] and geopolitical circumstances [18, 24, 80]), these concepts showed less strength and resonance in our empirical data. This is not to say that such theoretical concepts are not relevant when researching hybrid work, but rather to state how the empirical data that served as the foundation for this analysis shaped the theoretical arguments in concrete ways. We continued to use the theoretical insights concerning technology frames of reference as analytical concerns in our data analysis inspired by Orlikowski and Gash [71] when exploring how relational asymmetry emerged in concrete examples.

The starting point of our data analysis was the data collected from a joint workshop where both the content and process of the workshop centred around the future of work and hybrid cooperative practices. We collected videos and audio from this workshop, where industry partners explained and discussed their challenges for hybrid work while participating in the workshop which was structured and executed as a hybrid workshop. We used the insights to start up the analytical process by unpacking and identifying the themes discussed by the participants and then simultaneously, did a bottom-up analysis of the entire data set from the same workshop to see how emerging themes would appear in how the workshop was structured. By combining these two sets of analyses we were able to test our initial theoretical perspectives on artefact-ecologies and relational challenges as well as technological frames and geo-politics to see if these could help to explain some of the challenges emerging during our workshop. What was interesting from this first iteration of our analysis was the production of the two types of data on hybrid work. First, it provided insights into the experiences of our industrial partners, and second, because the workshop itself was organized as hybrid, it produced challenges as part of the activity. After this initial classification of the empirical data, we left the theoretical conceptualization for a while and allowed a more open-ended approach in the analyses of the later workshop material as well as of the empirical cases explored ethnographically by different sets of researchers.

Interestingly, the different workshops conducted over the next year provided us with the opportunity to invite a varied set of participants from academia, industry, or art communities to discuss the future of work with us. These activities enabled us to explore further the challenges related to

artefact-ecologies, technological frames of reference, and relation work. Moreover, it became clear that we had to leave some of the initial theoretical concepts behind (e.g., technological frames of references) – and only two remained after the multiple iterations of data analysis. In some activities, we aimed to push participants' imaginations to challenge not only the existing conceptualization of hybrid work but also its future. In other workshops, we explored the difficulties in merging technological frames, as the technical setup of the hybrid work environment posed significant challenges to participants' ability to create symmetric interactions. Workshops no. 5–7 took the exploration into the artistic perspectives, and here we began to connect the original framework and categories into the imaginations of the artists. This allowed the artists to engage with the conceptualization as well as extend the empirical situations outside the ordinary office domain.

All the efforts and reflections came together after workshop no. 8 (which was 1.5 years into our project) where we not only reflected upon the workshops, but also matured our empirical understanding of hybrid work from the various ethnographic studies, interviews, and observations. This meant that we could re-visit prior analysis of the data considering the experiences and findings across all data material – and then compare this with insights from the field visits to organizations and ethnographic observations. This collective analytical approach turned out to be crucial for shaping our iterative analytical process. Based upon this reflective and comprehensive crosscase analysis (where most of the authors were present) we were able to identify, nuance, and structure the empirical material with the theoretical conceptualization – and then revise and create what is the final conceptualization presented in the results section.

4 RESULTS

The "remote-work technologies" mostly used by our empirical partners included various types of video conferencing applications, such as Zoom or MS Teams. Thus, we will begin our result Section (4.1) by unpacking how video conferencing tools are considered fundamental for hybrid work. However, a narrow focus on video conferencing tools does not capture the complex technology setup required for hybrid work. Thus, we demonstrate how artefact-ecologies as an analytical perspective emphasizes critical technologies, devices, and applications which are pertinent when facilitating hybrid work arrangements. Secondly (4.2), we will dive into the concrete circumstances that the artefact-ecologies perspective produces for hybrid work situations. Specifically, we will illustrate how the multiple diverse sets of technological opportunities available to individuals in hybrid arrangements produce incongruences in frames of reference across participants. In this part of the result, we will demonstrate how the diverse sets of technological opportunities across sites are unavoidable in hybrid work and thus must be considered *a priori* when we design technologies to support hybrid work. Finally, we will demonstrate how the artefact-ecologies shaping the technological opportunities produce hybrid work as unavoidably asymmetric without balanced relationships (4.3). This leads us to the discussion of our research question: To what extent can symmetry in cooperative work engagements be achieved in hybrid work contexts?

4.1 From "Remote-work Technology" Towards Artefact-Ecologies in Hybrid Work

In this first part of the results section, we will demonstrate how synchronous hybrid work depends not only on video conferencing software, but also on a bundle of different types of applications, artefacts, and connections. These different types of artefacts need to constantly be re-configured and re-arranged. In other words, there is a constant work of bounding artefacts together. It is not just one technology that makes a hybrid work technological setup; instead, it is a combination of multiple applications, artefacts, and devices. It involves connecting cables, internet, WIFI, video conferencing software, laptops, cameras, and projectors. And it involves sharing documents of various kinds through tools like Zoom, both in physical rooms and virtual spaces. It also entails

activating apps and applications across different devices (at the same time or across time), while ensuring that they are running on the latest update. Thus, we argue that it is crucial to pay attention to the complex work of bounding and coupling the hybrid ecology of artefacts. We present two different examples from our research: (4.1.1) A hybrid research workshop involving 22 participants from different organizations, and (4.1.2) An artistic Alternative Reality Experience for 78 students.

4.1.1 Hybrid Research Workshop for 22 Participants from Different Organizations. We organized a hybrid workshop in 2023 where participants from different universities, along with those from various organizations, spent half a day together presenting results, discussing concerns, and interacting about the challenges of hybrid work. Our hybrid workshop took place physically in Aarhus with remote participation from various locations in Denmark. Planning the technical setup of the workshop required considerations about how both remote and collocated participants could interact, not just in plenum sessions with questions and answers, but also in small workgroups where discussions were structured around different kinds of artefacts. These artefacts ranged from flip-overs and post-it notes to artistic cards and reflective prototypes challenging the notion of hybrid work. Analyzing the technological setup of the workshop reveals that technologies supporting hybrid interaction extend beyond just the video-conferencing tool, even if that is often the only tool that participants consider. For instance, during a prior workshop in Copenhagen, we chose Zoom as the videoconferencing platform for all remote participation, both during plenum and group work. However, upon reflection on the hybrid workshop, industrial participants mentioned their organizations used MS Teams, and they would prefer we change to that. As a result, we used Teams for the Aarhus workshop. However, the choice of Teams was merely a small component of the comprehensive setup, and while such a decision is critical, especially for participants from different organizations, it is far from the only technology that supported the hybrid workshop. Let us unpack this further.

In Aarhus, the physical part of the hybrid workshop comprised a plenum room and three group workspaces, as well as the physical locations of remote participants. These were planned to include one workshop facilitator, three spaces in Denmark where three participants from different organizations would join (SmallVR, InnoStart, and BigFoodCorp), and two spaces in India (two participants from two organizations in different places in India) (BigITCorp and SmallIT). Concretely, one of the participants from India was not able to join in the end due to other engagements and unstable internet access. Throughout the workshop, we had a total of 22 participants. This was divided into 17 participants (7 facilitators) in the same location in Aarhus, and 5 participants (1 facilitator) participating remotely from five different locations in Denmark and India. The workshop's structure consisted of plenum sessions of presentations and discussions, followed by three group work sessions where participants were expected to move between different themed workshops originally planned as hybrid sessions.

If we start to unpack the technological setup for the plenum situation of the hybrid workshop, the physical main space included tables (arranged in a 'horseshoe setup' – see Figures 3 and 4), as well as a podium for the computer to present slides projected onto a large screen. This setup is ordinary for any kind of plenum presentation. However, besides the ordinary setup, the presenting computer (laptop No. 1) also had the Teams meeting open to ensure that we could show slides not just locally but also remotely. Now for the cables and wires to be connected to the local projector, the presenting computer had to be standing on the right side of the room or else the wires were too short. This meant that the camera on the laptop was pointing at an empty wall rather than at the speaker. Thus, we placed a second laptop on the horseshoe setup with the camera pointing somewhat in the direction of the speaker. If the speaker walked too much around, they would leave the camera feed. The second laptop (laptop No. 2) also had a connected speakerphone for sound to ensure that the audio (questions and discussions from the local participants) was broadcast to all

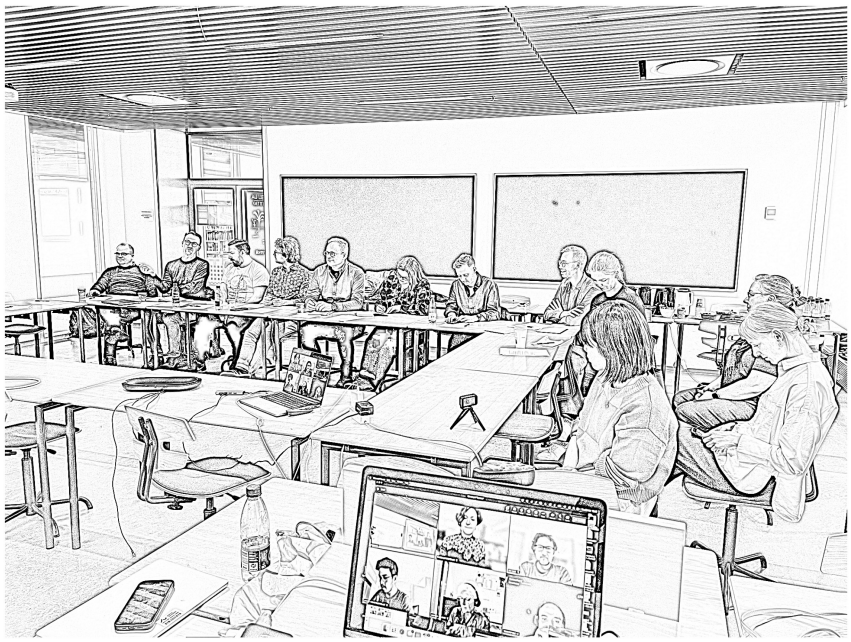

Fig. 3. A classroom with 7 tables in a house shoe setup. Around the table are 12 people, and on the table is a laptop with a zoom setup with six images of five remote participants and a video feed of the room. There is also an external camera and a room speaker microphone on the table. Next to the house shoe is another table (in front of the picture) where we see another laptop that mirrors the laptop in the house shoe setup with a zoom window with the video feed.

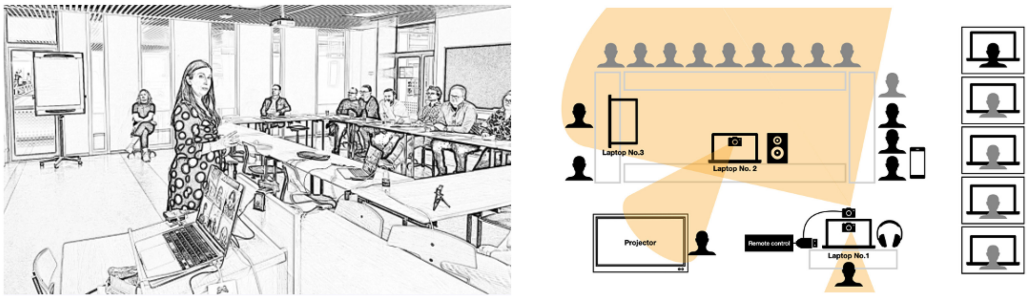

Fig. 4. Hybrid setup with collocated and online participants.

the remote participants while ensuring the local participants could hear the remote participants when they talked. The speakers and audio input for the presenting laptop were too far away to capture the audio properly.

However, it was not enough to consider how to display the video and audio feed for the speaker; we also had to find a way to project a separate video feed onto the local plenum space for the remote participants, so they could 'see' who was speaking and any bodily reactions they were displaying. As a result, we added a remote camera with extra wire from the presenting laptop pointing towards the horseshoe table and participants. This allowed us to have multiple video and audio feeds using a total of two laptops, three cameras (two laptop cameras and one extra camera), one speakerphone, and one projector screen.

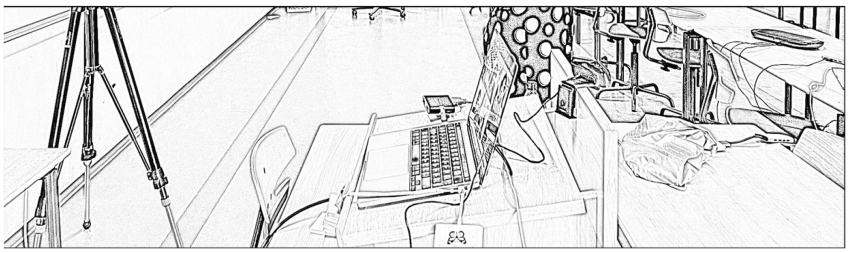

Fig. 5. Laptop with four adaptors for external artefacts.

We also had one more laptop (laptop No. 3) involved locally, namely the laptop which ran Teams. This laptop was the 'account' which created the whole Teams setup, including having access to send invites to people who had login difficulties, or to create additional access to the meeting. The laptop also recorded the session and was able to allow others to record the session. Interestingly, this 'back-end' laptop was not that directly visible in the setup, but at the same time, it had a hugely important task of ensuring the 'back-end' organization and monitoring the chat or messages – which neither of the other two laptops was able to do since participants were too far away from the actual laptop to monitor anything else which was taking place. The back-channel setup also included communication on phones (text messages, etc.) where the remote facilitator would inform the local facilitators about sound quality or other issues which needed to be addressed. We will provide two examples of this.

Firstly, the local facilitators did not have access to know about the audio quality produced remotely – since the local space included all sound – and the remote sound as heard in the collocated room would also be of good quality since remote participants would be placed close to their microphones. However, before we set up laptop No. 2 with speakerphone audio, the remote participants lacked access to the sound from the collocated space, and the remote facilitator informed us by SMS, and we got it set up. Consequently, to know about the remote audio quality – we added an audio headset to laptop No. 1 (Figure 5) — which allowed us to monitor remote sound. The presentations which took place in the hybrid setting were thus organized to share audio, video, and slide feed in the collocated setting of the 17 people as well as the five remote locations with one participant at each location. However, as the presentations and discussions went on, we experienced challenges with all three feeds. Starting with the video feed, even though we had carefully organized it so that remote participants had access to the video feed of the horseshoe setup with multiple participants and with one camera pointing in the direction of the presenter (despite the presenters moving around), there were times where remote participants (especially the remote facilitator) would explicitly ask the presenter to move into the camera frame and allow for video feed. In some situations, this was explicitly requested on the Teams audio link (voice coming from the speakerphone) and in other cases through text messages sent to collocated members from the remote facilitator. The presenters onsite were repeatedly leaving the camera frame visible to the remote participants. Further, the remote participants were not visible on the larger screen during presentations – and only visible on laptop screens pointing away from the larger audience. This in some situations let the remote participants experience the workshop as a remote stage they could watch, but not participate in.

The audio feed also created challenges. While the audio through the speakerphone worked generally well, one of the presentations had audio integrated within the slides. The presenter did not want to have the audio (music) but instead wanted to talk over the slides with video. In the collocated space, this was not a problem as the audio was simply muted. However, in the online space, the audio continued (and was audible in the headset attached to laptop No. 1) – so collocated

participants were aware of this, but they did not act, since it would disrupt the flow of the workshop and interaction. Concerns about the workshop flow locally impacted the experience of remote participants. Finally, the slides created issues. While the slides were shown from laptop No. 1, which was connected via cable to the wall and the projector, the laptop displayed the slides in presenter mode, meaning that the slides projected were slides, but the laptop displayed the flow and the next slide as well. However, since laptop No. 1 also displayed the slides remotely, it required the presenter to choose which 'display' to project remotely. It was not possible to choose the display of the projector, which meant that the choice was between showing the slides in presenter mode remotely or on the projector – and mirror screen was not an option either. So concretely, the presenter chose in the end to show presenter mode in the collocated settings, while the remote section had access to the correct display since remote participants had access to smaller screens than in the collocated setting, thus the trouble of having the presenter mode remotely would be more problematic.

Our point here is not whether specific applications like Teams or Zoom are best for hybrid settings. Instead, our point is that organizing and facilitating a hybrid workshop is not simply about choosing a videoconferencing application, but instead about choosing and navigating a bundle of both collocated and distributed artefacts. In our setup, our artefact-ecologies included three laptops, each connected digitally and materially using cables, internet, applications, external and built-in cameras, projectors, and audio devices, as well as remotely used laptops including remote screens shaping the choices in navigating.

Laptop No. 1 ended up having adapters for projection, an adapter for remote control of the slide, an adapter for external camera, and headphones for checking the remote sound – on top of being connected to Teams, Google slides, and PowerPoint depending upon the stability of the internet. The complete artefact-ecologies thus included seven laptops (five remote) with internet access, an external camera, built-in cameras, a projector, headphones, a speakerphone, cell phones for backchannel texting, and multiple wires and cables. There was also a digital infrastructure of Teams, slide applications, and emails for sending slides to the projecting computer. Finally, there was a back-end channeling where laptop No. 3 provided access through passwords and invitations.

Summarizing, this empirical example demonstrates how hybrid technology is not about choosing a videoconferencing tool, but fundamentally about binding together the technological setup of multiple artefacts and digital applications.

4.1.2 Artistic Alternative Reality Experience for 78 Students. Collaborating with artists, we were introduced to a detailed example of artefact-ecologies used in a hybrid class on alternate reality experiences in games. The class had 78 students, 48 of whom were collocated with the teacher in the classroom site, while the other 30 were attending remotely via video conferencing on MS Teams. The classroom site consisted of a main classroom plus two auxiliary rooms connected by a hallway. The main classroom had a projector screen, hardwired speakers, one stationary computer on a table, one laptop computer with a dedicated table, three webcams (the third of which was built into the laptop), additional tables strategically located in the hallway and auxiliary rooms for placing the same laptop, a chair in a certain location by the projection screen for hybrid interactive activities, and a Bluetooth headset with directional mic for the teacher to wear. The software used in this case included Teams, Miro, and Google Docs, as well as whatever software the students were using to make and demo their individual projects and prototypes.

This artefact-ecology was used in various flexible ways throughout the class. At times, the teacher presented content on the projection screen, as in a traditional classroom setup. At other times, students worked on their projects in the space, and the teacher would hold the laptop with one arm, as you would hold a baby, and carry it throughout the rooms and hallway, to give the

remote students a point of view of moving throughout the site via the laptop's built-in webcam and speakers. He could then use the laptop screen while moving around to see the remote participants and allow them to interact directly with him and with other people in the room. He developed different scenarios for the interaction. In one scenario, the students engaged in hybrid prototyping demonstrations through the projection screen, where a remote student could see and give instructions to an onsite student seated in a particular chair in the field of view of one of the webcams. Choosing the technological setup was:

> "A really wild thing to experience... with the technology giving almost like superpowers of handling so many people from different places. And also, still having really an engaging environment where they really felt that they were creative and doing something." (artist workshop 1)

It also required a considerable amount of coordination (bounding work) to make this complex artefact-ecology function in the ways it needed to. Due to the flexible style of teaching, spontaneous hot swapping between camera views, audio outputs/inputs, projection sources, software, and both wired and wireless connections, with minimal hassle in the moment, needed to be accounted for. Due to the technological complexity of this ecology, it would be easy to overlook the use of non-technological artefacts in this case. However, the teacher was also very clear about the importance of the placement of specific tables and chairs when describing how the system as a collective functioned. Throughout the class, the teacher acted as the primary director or manager of the system while he was using it, choosing when to move, change, connect, and disconnect multiple artefacts.

Not only was the artefact-ecology challenging from an organizational perspective, but it was also at times physically challenging for the teacher, who carried some of the artefacts on his body for parts of the class. Carrying the laptop around the space with one arm left him temporarily with only one other arm to use to control the rest of the technology and do other teaching tasks. However, he felt that this trade-off was worth it, and made this choice intentionally, instead of opting for a hands-free body-mounted camera and headset or placing a phone camera in his shirt pocket. He wanted to carry the laptop screen with him so he could see and interact with the remote participants directly while moving around the space, ensuring that their hybrid interactions were 2-way instead of unidirectional.

This teacher is a professional artist whose work involves both performance and technology, so he is exceptionally skilled at the exact kinds of effort this hybrid teaching scenario demanded of him. However, he still noted the amount of work this required:

> "I don't mind that it's exhausting if it's just controlled within a clear frame. Yeah. Because it's like a performance. I mean, yeah, it becomes exhausting. When you teach 90 students at the same time, it's like, it is exhausting. But it's, it's also effective. It feels it's nice that you have so many people engage with something. And I feel that this setup could be done for 500 people if you just organize it the right way. And everyone would actually feel excited about it if you, again, organize it the right way." (Interview with Artist)

Highlighting the importance and challenge of bounding work, when asked if he would change anything about this system in a future hybrid teaching situation, he said that the choices he made in how to use the artefact-ecology were just as important as the artefacts themselves. Making the hybrid teaching experience possible was far more than simply choosing a video-conferencing application. In summary, the above empirical example demonstrates how hybrid work in a complex cooperative setup with increased complexities is possible. Interestingly, the artist teaching activity

is a much more complex hybrid work arrangement than the hybrid workshop with industry partners mentioned in 4.1.1 – yet the artist's dedicated attention in planning and considering moving bodies, and so on, in the actual technological setup allowed for more flexibility and support of the hybrid work. Organizing and executing hybrid cooperation requires a lot of articulation work, and the success of the event is highly linked to how the artist's conceptual approach to hybrid work considers it as an artistic performance rather than a teaching or meeting situation.

Summarizing, our point here is that across all the empirical work we have done in this project so far, hybrid work is not about using one video conferencing application, but about bounding the artefact-ecologies which constitute the hybrid interaction. Thus, a crucial part of the efforts involved in hybrid work is how participants can synchronize and be bound together using artefact-ecologies to provide a sustainable hybrid infrastructure.

4.2 Incongruence in Individual Technology Opportunities for Hybrid Work

We have demonstrated that hybrid work is shaped by artefact-ecologies which shape the opportunities for interactions in certain ways. Another important aspect is that the multiple different technological setups impact the opportunities for interaction since none of the participants can know what is available for other participants. We label this phenomenon incongruence in technological frames of reference. In this part of the result section, we will demonstrate how the incongruence in technological frames of reference matters and shapes what type of hybrid interaction can take place concerning multi-modal interaction patterns such as video, audio, and touch. We have three empirical examples: (4.2.1) When non-verbal communication is not displayed in the hybrid setting, (4.2.2) Mismatches in visuality displayed across multiple inputs and outputs, and (4.3.3) When soundscapes interfere.

4.2.1 When Bodily Gestures are Not Displayed in the Hybrid Setting. As part of the empirical work, we saw several examples of incongruence in the technological frame of reference – however one stood out regarding non-verbal communication. The InterFin company has multiple hybrid meetings each day. Our empirical example is a meeting the InterFin company hosts with external and internal participants to review customer feedback on product development. The meeting includes 24 participants from several different locations, where some are collocated at the company office. The main technological application is MS Teams, and all participants have joined. In their use of Teams, the typical layout for their meetings is that one person shares their screen with slides, while a camera feed from each participant is displayed on a sidebar allowing each other to monitor remote colleagues via their video-camera feed. Due to the lack of digital real estate on a typical laptop screen, participants must scroll to see all of the other participants in the video feed. In the specific example we refer to here, the video feed of participants is displayed across three 'scrolls' in the Teams application and thus it is not possible to monitor all the video feeds simultaneously.

When observing the hybrid meeting, the researcher was physically located in the office and thus collocated with participants who were also in the office. At the same time, the researcher was online in the Teams meeting. Being both collocated at the office, while digitally located in the online meeting allowed us to identify aspects from the office which were lost in the digital part of the meeting. From the researcher's position, it is – due to the collocation – visible to see that one of the meeting participants in the office makes bodily gesticulations to acknowledge what other participants are saying during the meeting. This includes giving thumbs up, nodding, applauding, and the like. These gestures are possible to monitor due to the collocation, but completely invisible for any remote participants since that specific person's video feed is not displayed on that part of the sidebar. Because the sidebar reacts to sound, participants mute themselves when not speaking, and therefore bodily gestures are not detected.

To monitor and acknowledge bodily gestures, remote participants would need to browse through the sidebar pages regularly during the hybrid meeting. Teams has an in-built feature where users can react to what is being said by sending emojis, such as thumbs up, which will show up on the screen in the Teams call. These feature options were also used by some of the participants in the meeting, but when they chose to gesture using their body (bringing in the physical aspects of the hybrid meeting) – these gestures disappeared and were lost.

This example demonstrates a consequence caused by the incongruence in frames of reference. What participants assume to be visible is not available remotely. The participants who do the bodily gestures can monitor themselves and how they appear on the video feed on their computer and continually ensure that gestures are within the camera input. However, what cannot be controlled is what others can see and monitor. Because the collocated workers' bodily gestures are within the camera frame, they assume that it is displayed to the other participants in the meeting. Yet, it is not visible to them what the others are seeing on their screen due to the Teams function of selecting what is shown to the users. Therefore, they do not know that their bodily gestures are not received by some of the other actors – unless remote participants have modified their Teams settings to show different content than what Teams by default deems relevant to display.

In this way the incongruence in frames of reference matters for what kind of interaction is shared and what remains invisible in hybrid interactions. Further, participants might not even be aware that their bodily gestures are not being monitored, and thus there is a risk of misunderstanding. Where one participant perceives and expects the use of the Teams application to be an application to display bodily gestures during hybrid meetings; other participants can have very different perceptions shaping how they use the technology – and whether they choose to browse the video feed regularly or not during hybrid meetings. The incongruence in frames of reference, shaped by the lack of social translucence in the setup increases the risk of misinterpretations and communication mismatches.

4.2.2 Mismatches in Visuality Displayed Across Multiple Inputs and Outputs. Considering the incongruence in technological frames of reference we also saw how various hybrid activities produce mismatches between expected and realized visuality – mismatches between the various visual inputs and visual outputs produced in hybrid settings. A hybrid setting offers unique characteristics that differ from fully collocated and/or fully remote settings. Our ability to be seen and heard in hybrid settings fully depends on technology's capability to produce multi-modal inputs and outputs simultaneously. Unlike a completely collocated setting, where bodies and voices have a physical manifestation, hybrid interactions are never detached from the technology. The specific technical setups utilizing the chosen artefact-ecologies have a direct impact upon which parts of participants' bodies are made in/visible, influencing the types and forms of interactions that are made available or lost.

To illustrate this phenomenon, we present an example from an academic hybrid workshop, where the majority were physically collocated with only a few presenters being remote. The technology setup was configured to include Zoom videoconferencing running on one laptop with a built-in camera which connected to the remote speaker's laptop. The video feed was projected on a giant screen on the wall in the physical space, while the collocated participants' faces were captured on the same camera feed and projected as tiny on the screen. These differences in the projections of the remote vs. collocated participants led to incongruences in frames of reference. While all participants could see very clearly the remote participant's face on the screen, remote speakers could only see many small bodies, predominantly those who sat closest to the laptop camera. Those who happened to sit further away, or outside the angle of the camera, were not visible, and thereby non-existent, to the remote participants.

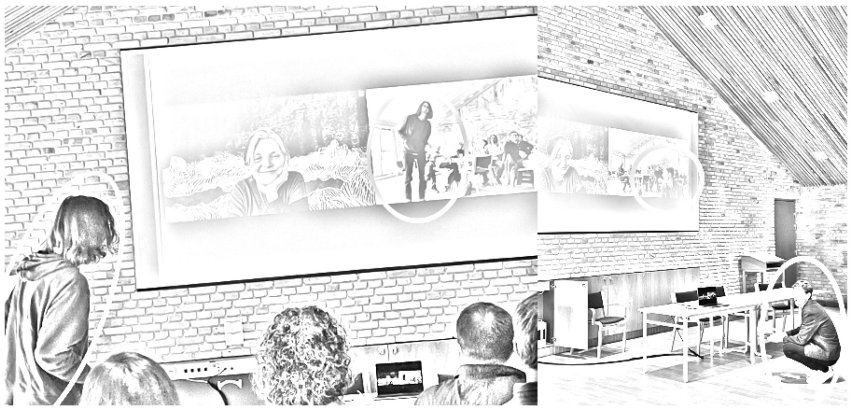

Fig. 6. Hybrid interaction, where co-located participants fold their bodies to accommodate the technology.

To minimize these incongruences experienced in the hybrid situation, collocated participants began to display themselves and their bodies in new ways. Collocated participants were asked to stand in front of the laptop's camera (and microphone) when interacting with the remote participant. This was assumed to help in establishing a common frame of reference between the remote and collocated participants. While this certainly helped to ensure that the collocated participants raising a question were visible to the remote participants, there were still insurmountable incongruences in terms of the size of the physical bodies of collocated participants. As can be seen in the illustrations in Figure 6, collocated participants had to 'fold their body' to make it compatible with the small size of the camera and its low position, as well as the projector.

The type of configuration of the hybrid session thus may result in increasing the size of some physical bodies and project disproportionally large sizes of faces and/or bodies. The specific configuration used in this example resulted in projecting both digital and physical bodies in disproportionally different sizes.

In summary, the multi-modal constraints in visually displaying peoples' bodies in hybrid work impact the interaction opportunities and shape hybrid work in certain ways by producing very different frames of reference across participants.

4.2.3 When Soundscapes Interfere. While the previous section focused on incongruences related to visual input/output, we also identified another type of incongruence in hybrid work: namely, incongruence in soundscapes or audio frames of reference. To provide examples, we will report from a hybrid research workshop we organized in Copenhagen in June 2022. Participants in the workshop included 20 participants from various organizations and research institutions. This workshop comprised a plenum session and then group work sessions. We will focus on the group work part of the workshop, where participants discuss questions and concerns about hybrid work. Each sub-group was tasked with creating a flip-over to present the main discussion items to the rest of the team when returning to the plenum. Participants were divided into three sub-groups, and two of the groups had both remote participants and collocated participants.

The partial access we have to information about the interaction within a hybrid setup requires participants to constantly be aware and make interpretations about what is available and address what is missing. Thus, the hand or lip movements of remote participants might easily be misinterpreted. We saw examples where the collocated facilitator of the workshop was confused because she noticed the remote participant moving his lips, thus assuming he wanted to say something but had forgotten to unmute his microphone. It turns out that he was just talking to someone at his office in Aarhus, but this was not visible to the collocated participants. As expressed by the facilitator:

> "[the remote participant], are you trying to say something? Oh, no. Oh...Sorry. It's very difficult to know." (Facilitator, Workshop with industry partners no. 1)

The soundscape of a hybrid setting includes sounds at all locations taking part in the interaction but is restricted to what sounds are allowed by participants to be included through muting or not muting local sounds. However, the soundscape is not completely controlled by participants. We saw examples where sounds became amplified due to the technological setup counter to how participants wanted. The amplified sounds disrupted the hybrid interactions for remote participants but were undetected locally. For example, the collocated facilitator was sitting very close to the computer (and the microphone) and writing notes. The sound of the facilitator's pen was amplified and constituted a considerably large part of the soundscape for the remote participant. This was not noticed until the remote participant explicitly articulated his experienced soundscape and explained how it was disruptive, which was different from the collocated soundscape.

> "I can hear your pen, [facilitator name]", commenting that he had a hard time hearing and participating in our discussion as the noise of writing fieldnotes was disrupting the sound quality (NationalFin, Workshop with Industry partners no. 1).

Incongruence in the soundscape in hybrid interaction shaped by the ecology of artefacts matters. In other words, the sound across hybrid-connected spaces is often not identical since the local soundscape "sneaks" in, and often cannot be controlled fully by participants. Thus, while sounds produced in hybrid situations are critically important for participants to make interpretations of activities – since hybrid settings with no audio feed also disrupt the interaction, as is also portrayed in the ubiquitous meme from COVID-19 "You are muted". Nevertheless, the artefact-ecologies (including microphones and speakers) shape the collective hybrid soundscape, and no participant has complete access to knowing how the soundscape is experienced in the other sites.

> "The sound becomes an issue very quickly. In physical meetings, people think it's okay to whisper to each other. And [in hybrid setups] it is so difficult for the sound equipment to figure out what is just two people small talking and who is the presenter." (BigFoodCorp, Workshop with Industry partners no. 1)

The technological systems used to facilitate hybrid collaboration do not allow participants access to configure how the tools are processing audio and designing their soundscape for the situation. The lack of control for the soundscape also impacts what participants choose not to do. One example of this is in collaborative situations where the distinction between 'interrupting' or 'participating' becomes blurred in the hybrid setting due to the incongruence in access and control of the produced soundscape.

> "There are some technical limitations to the whole interrupting thing as well. Because of the audio processes that these computers do when somebody says something and somebody interrupts, we lose both of the audio because of the cancellation routines that are there. So, it's not only not really possible. You destroy what's coming out from other participants as well. So, it means that in the end, we are very, very careful. We never interrupt." (Workshop with Industry partners no. 1)

The incongruence in technology frames of reference, shaped by the artefact-ecologies, together produces both the view-scape (the collective visual scape across all participants), and the soundscape in hybrid situations where everybody only has partial access to the complete audio-visual scape. No one has access to the complete soundscape and view-scape of the hybrid situation.

Summarizing, the uniqueness of hybrid cooperative situations includes the fact that participants do not have full control over the situation, but instead depend upon the artefact-ecology that produces the foundational infrastructure of the hybrid interaction. Furthermore, what is fascinating about this setup is that the remote participants can't know what the collocated participants have access to and vice versa. The hybrid interaction inevitably introduces many different types of asymmetries. These asymmetries produce unequal access for participants and thus risk producing situations of insecurity while challenging the building of relationships and trust.

4.3 Unavoidable Asymmetric Relations in Hybrid Work

We have now demonstrated that hybrid work is characterized by the challenge of curating and connecting an artefact-ecology that supports the hybrid work. This artefact-ecology requires participants to be engaged in additional forms of articulation work, which involves bringing together and creating a coherent set of physical and digital artefacts, applications, and devices that act as the foundational structure of the hybrid work. We have also demonstrated that the plurality of artefacts in combination with different geographical locations also produces a situation characterized by incongruences in frames of reference. No one person has complete access to the full hybrid experience, since the technological setup only partially unfolds for each participant and is always incomplete. This incongruence produces asymmetric audio-visual scapes, which risk disrupting the interaction. We will now turn to the final empirical observations across our empirical data to demonstrate how the incongruences across technological frames, produced by the artefact-ecologies, impact the collaborative practices that can take place in hybrid interaction. We will demonstrate the insurmountable asymmetric relations that are pertinent to hybrid work arrangements with two types of examples illustrating different aspects of hybrid relations: (4.3.1) Asymmetric relations in synchronous collaboration and (4.3.2) Exclusion in hybrid work.

4.3.1 Asymmetric Relations in Synchronous Collaboration. From our empirical data, it is evident that hybrid configurations produce work arrangements characterized by inescapable asymmetric relations, leading to an increase in the effort of relation work in terms of emotional labor required for making synchronous hybrid work function.

Past shared experiences strongly influence hybrid interactions, as prior engagement impacts the building of relationships and trust. During our first workshop in Copenhagen, participants discussed how the capability to engage in hybrid conversations including, for instance, interrupting each other requires safety and trust within the hybrid setup:

> "If you know each other [in person] and have already built psychological safety (trust) with the people you collaborate with, then it is okay to meet online because you feel safe. The more it [the collaboration] becomes only digital, the more you wear on this psychological safety, and it becomes harder and harder to have these open conversations and interrupt." (BigFoodCorp, Workshop with Industry partners no. 1)

In the conversation, our participants discussed how difficulties in developing trust increase in digitally mediated interactions, and how the audio and visual limitations reduce the possibilities for 'reading the room', including having access to monitor the participants' body language.

> "Once it [collaboration] gets online, it becomes more formal. Everything that happens in the office physically is more informal, the informal way of reading each other generates other kinds of ideas or other kinds of social functions." (BigFoodCorp, Workshop with Industry partners no. 1)

Additionally, the positioning of the remote participants caused insecurities among the collocated participants. The way the remote participant ends up being talked about in the third person emphasizes the asymmetries in the visual presence and inclusion of all actors:

> "Where do you want Thomas (the remote participant) to sit? [...] He gets his own chair. [...] Oh, but he can't see. [...]Yes, he can see the board." While the collocated participants are discussing his position, the remote participant is answering visually by nodding or shaking his head which generates even more insecurities: "Can you not see? You can't see that? Yes, you can see! Okay!" (Workshop with Industry partners no. 1)

Adding to the complexities are those hybrid situations where participants are not only geographically distributed but also work across time zones. This is expressed by BigITCorp which has employees working in Copenhagen and India. Despite the locations' different time zones, the employees work at the same time to "be more productive". Working out of sync with one's time zone is identified as problematic, as expressed by BigITCorp:

> "It is completely difficult and disturbing to your sleep-wake-cycle [...] but still ok because they (the employees in India) start at 11:30 and work until 20:30 or 21:00 in the evening." (BigITCorp, Workshop with Industry partners no. 1)

Furthermore, these observations illustrate the unequal relationships that exist in translocal work where asymmetric relations are also affected by the global south/north economic relations:

> "So, the majority of the team who is doing the groundwork, [..] they are all in India, whereas only the critical people are sitting here [in Copenhagen]. Only the leadership or the management layer sits here." (BigITCorp, Workshop with Industry partners no. 1)

The affective, emotional labor which is important for cooperative work in hybrid settings stood out as pertinent for the participants in our workshop. They were all able to discuss and bring examples of the challenges related to handling emotional labor – the relation work required to create and maintain the relationships within the cooperation.

To summarize, a hybrid setting requires people to invest greater efforts to establish interactions and maintain relations. This impacts people's conditions for engaging successfully in cooperative tasks. The work of creating relations can be seen as an investment from the participants; people are investing in each other's relations which can benefit their long-term interactions. Such investments can take many different forms, but eventually, they become a fundamental part of the social infrastructure within which hybrid work can function.

4.3.2 Exclusion in Hybrid Work. We have now demonstrated that the diverse nature of the asymmetric relations produced in hybrid work matters for the type of interaction which happens in hybrid work. The major challenge in hybrid work, despite efforts to mitigate the challenges, is the risk of exclusion in hybrid work. We will demonstrate an empirical example of exclusion from our NationalFin empirical case. The situation was that Carl, a team leader at NationalFin, spent 1 year working remotely from France while the rest of his team remained collocated in Denmark. The team leader made an effort to explicitly include relational interactions during the team's hybrid meetings, as he explains:

> "I set aside a lot of time for small talk during the video calls, and we always discuss what you have done. What have you been doing this weekend? What's going on in the family? Are we working on the right things? Anything outside work, that

> requires your attention for this week, because then we sort of adjust the work." (Interview, NationalFin)

Despite these efforts to introduce and maintain relations with remote colleagues, in addition to Carl being the leader of the team with the responsibility and power to set the tone of the interaction, Carl later learned that he had missed out on a lot of informal communication. Interestingly, Carl was not aware that he was missing out while being in the remote location. Besides sharing stories as part of a hybrid meeting, he missed out on many funny stories, shared jokes, and was isolated from the rest of his team. This asymmetry became apparent when he returned to Denmark.

> "I could tell that they had a lot of small interactions and small talks that I wasn't a part of. So now was my turn to sort of get back into the team when I got home. And the funny thing is to realize I am an outsider." (Interview NationalFin)

One thing is to be aware and know about a potential disconnect within a hybrid work setting, but it is a much more complicated issue when participants lack knowledge and awareness about remote participants' exclusion, even if all people involved are doing their best not to exclude anyone. The companies which are part of our project all express how collocation is important for their organizations. As a manager from NationalFin expressed:

> "So, historically, we haven't hired people that work fully remotely, the closest thing was the India Development Center, and they had to come into an office (from India). It's a big way of the way we work and treat people. If people don't come in and sort of be part of the way we work and the way we treat people, we're afraid that it will eradicate our culture. So, we've been reluctant to do that." (NationalFin, Interview)

NationalFin had a strategy to only hire people who came to the office on regular intervals, as was the case with BigITCorp, InterFin and BigFoodCorp. In general, this strategy has been challenged by COVID-19, where it was demonstrated that much of the work could take place remotely, not requiring employees to come to the office. This situation has caused the workforce to re-evaluate where they lived, and multiple remote employees in India and Poland, as well as in Denmark have moved to the countryside, and thus are not interested in coming to the office to work. Thus, there exists a conflict in what the flexible workplace emerging after COVID-19 should look like. Who is being flexible, and for whom? Is it the employees who are flexible for the company, or is it the companies being flexible for the employees? This is an ongoing debate across our empirical partners and organizations. Embracing hybrid work and flexibility in work arrangements, how can organizations reduce the risks of breaking culture?

> "Culture - it happens when you're in a room together when you're in a company together. But when you're not in a company together, when you just meet on screen, how does this happen? How does my behavior affect you? Or you? How do you be a role model? Is that the same thing? Or is it a different thing? So, there's a lot of unknowns." (BigFoodCorp, Interview)

Sharing a common time zone and physical space plays a fundamental role in building relationships; however, since these are absent in hybrid settings, we need to rethink how to support relation work. We also witnessed this during our workshop, where collocated participants would network and interact before the workshop, during coffee breaks, as well as after the workshop – all situations not available for remote participants. All remote participants were disconnected and excluded from these social interactions, which was also highlighted by one of the remote participants during one of our workshops:

> "When we started one o'clock, us– online [participants]– were sitting [and] waiting. And there were a lot of talks between you [the collocated participants]and coffee [..] but we were not included." (NationalFin, Workshop with Industry partners no. 1)

Hybrid work is *a priori* asymmetric since collocated participants have different conditions to engage in relational activities compared to remote participants. Relational activities are thus the emotional labor that participants engaged in to establish the connections vital for the cooperation to even take place. Such activities might be conducted by both collocated and remote participants, and these both shape and are shaped by how relation work is performed within the hybrid setup.

Summarizing, the asymmetric relations evident in hybrid work foregrounds the need for paying explicit attention to relation work, since the lack of space and time proximity requires actual work in 'being included' or 'including others' to balance the physical spaces with the digital spaces. Relation work is thus part of developing collaboration readiness in hybrid work and is thus a prerequisite for participants in hybrid settings to even start developing common ground. The hybrid setup has a critical impact upon the organizations, and especially the relationships created, and is tremendously important for companies. Hybrid work stands on the artefact-ecologies, creating incongruences in technological frames producing insurmountable gaps and asymmetric relations.

5 DISCUSSION

Across all our empirical examples, the technological setup supporting hybrid collaboration was always a multiplicity of artefacts, which participants brought in *incidentally or with planned purpose* to accommodate the needs of the hybrid interaction. We saw how different devices, screens, laptops, audio-visual equipment, digital applications, and the like entered the hybrid interaction. These *artefact-ecologies* [19, 20] influenced the interaction in certain ways by allowing for specific forms of multi-modal interaction while disrupting other types of interactions. We saw in our empirical examples how the audio-scape of hybrid interaction takes different forms depending on access or lack of access to the collective artefact-ecologies. Participants in hybrid interaction might have access to audio; however, this soundscape can interrupt interaction (sound from a pen or noise from a slide show) for remote participants, which collocated participants are not aware of and thus do not act upon. Further, our empirical examples show how participants in hybrid interaction accommodate technological shortcomings by 'folding their bodies', extending the view-scape of remote participants. Our empirical examples demonstrated how understanding the challenges of artefact-ecologies for hybrid work is not just about the choices of selected artefacts but includes the extra work of bounding the artefacts together, which sets the scene for the hybrid interaction. Bounding artefacts in practice is the effort involved in connecting and linking artefacts [9, 16], producing the boundary around what is included or excluded in the hybrid interaction. This extra work is important since without producing the boundaries for the specific hybrid interaction, participants will have increased work maintaining and adjusting their technological frames towards the interaction. Even when the boundaries for what is included and excluded in the artefact-ecology for specific practices are set, the work of continuing negotiation and accommodating cooperation will remain.

As far back as the 1990s, researchers working on media spaces [34, 35] pointed to the problem of what to display across distance – the face view or the activities – and what would it mean to display activities. As Heath, Luff, and Sellen phrased it: "media space tends to provide (mediated) face-to-face views, but rather that it is assumed that access between participants does not need to vary with respect to ongoing and shifting demands of a particular task or activity. It is this static and inflexible notion of collaborative activity which has inadvertently hindered media space

research, and undermined its ability to provide a useful environment to enable people to work, or even socialise with each other" [49, p. 88]. Similarly today, the digital technologies for distributed and hybrid work focus on the 'face', in a static notion, where participants are required to 'fit into the frame of the technology' rather than being able to move and act. This causes the current hybrid technologies to freeze the participants into a static frame of reference. To counter the static nature, hybrid participants might then choose to carry on their bodies the laptop and audio equipment, to push the boundaries of the technologies to allow movement – as we saw in the example of the artist teaching. Current technologies are not purposefully designed to include the physical surroundings of participants in the hybrid work arrangements. Instead, rephrasing Heath et al. from 1995 for our 2023 observations, technologies in hybrid work produce a "poor and inadequate approximation" of remote distributed work making it very difficult to utilize physical artefacts and location "even for the most simple collaborative tasks" of co-presences [49].

The use of individual artefacts in the artefact-ecology changes with time (within the day, week, month, etc.) when participants move between the office, home office, client, and so on. Such flexible work arrangement requires participants to continuously engage in articulation work depending upon individual concrete situations. Each time the artefact-ecology is changed, the complete bounding of the foundational infrastructure [16] facilitating the hybrid interaction is impacted. We argue that the effort of articulation work in the cooperative work [31] is extended in hybrid engagements to include the work of bounding artefact ecologies, which are produced asymmetrically across participants and sites. Hybrid work inherits the challenges from both collocated and distributed work [36], but has increased effort required for engaging with an artefact-ecology that no participant has a comprehensive perspective on, since no one has access to the complete artefact-ecology. If a remote participant collaborates with a collocated group of four people, the remote person does not know what the group has access to, and similarly, the four people do not know what the individual can see or hear. This often leads to several breakdowns in interactions and constant repair or realignment attempts, as is evident in the ubiquity of expressions such as "You are muted" and "Can you see this".

We suggest considering the *coupling of work* not just as a feature of the cooperative practices [13, 55, 67], but instead as an activity to mitigate disruptions caused by artefact-ecologies that participants in hybrid work need to use, to bound the artefact-ecologies to support the concrete hybrid activity. The coupling of work then becomes an underlying activity shared by hybrid participants in connecting or disconnecting artefacts, devices, and applications. It is shaped by the nature of the interdependence in work (closely or loosely coupled), and it is more than just a characteristic; instead, coupling of work emerges as an activity. The coupling of work as an activity refers to *binding together while setting boundaries* for what is part of the sociomaterial nature of the hybrid work situation, thus bounding technologies in practice [16]. In this way we nuance the concept of coupling of work in distributed work from primarily being a debate about whether distributed work functions best in loosely coupled work situations [67] or in tightly coupled work situations [13].

> Proposition no. 1: We propose that a design challenge for hybrid work technologies is to reduce the effort of articulation work required to continuously 'bound' artefact-ecologies, and suggest coupling of work as an activity, where hybrid participants negotiate how to bring together multiple devices, applications, artefacts, and work practices.

Technological frames of reference remind us that the ways people think about technology matter for how they use it [69, 71]. We extend this understanding to state that technological frames of reference in hybrid work are *shaped by our experiences or lack of experiences*. What we cannot see or do not have access to remains difficult for hybrid participants to consider. Interestingly, the early

studies of remote conversations demonstrated that there was no difference between video/audio feed conversations and audio-only conversations, as they produced similar support for remote collaboration [78]. In this work, Sellen shows that it was only in the face-to-face condition that the conversation changed [78]. Considering this insight in terms of hybrid work, our data demonstrated that both video/audio and audio-only feed in hybrid work arrangements matter, *but* this may *be because* hybrid work always combines digital and face-to-face interaction, hence the impact by which the digital feed provides/constrains interaction directly matters for the complete hybrid engagements. As our data demonstrate, there is an insurmountable gap between what participants have access to and what they do not have access to in terms of the complete artefact-ecology for the hybrid interaction. There is a complete lack of **What-You-See-Is-What-I-See (WYSIWIS)** capabilities in hybrid artefact-ecologies. Hybrid work participants' perspectives and access to the "complete" hybrid artefact-ecology is never possible, since cooperative partners do not have access to other cooperative partners' perspectives – only their own. Frames of reference are individual by nature, and the incongruence between technological frames can be disruptive to cooperative technologies [71]. Designing for congruence in frames of reference has been a challenge for many years. Already back in 1992, when Sellen, Buxton, and Arnott's Hydra system provided each participant with a unique view of the complete setup, no one had a complete view and access to the system [77]. Similar to the 2023 hybrid setup, participants only have access to an individual partial perspective of the complete setup. However, while the distributed work arrangement embeds the risk of a mismatch in perspectives and views, the hybrid work situation extends this challenge. Not only do participants experience the constraints of *incongruence in frames of reference for the artefact-ecology*, but further, the repair work of resolving issues related to the incongruence in frames of reference is jeopardized, because participants cannot adjust themselves (their bodies and cognitive attention) in such a way that they can have access to remote participants' point of view. There is immediately and always an inequality in access to, and resolution of, modalities of interaction for remote participants. Attempting to use a WYSIWIS approach, strict or relaxed, remains a design challenge. Furthermore, given the visual and audio asymmetries (especially for remote participants), it is crucial to support reconfigurable audio and visual feedback in hybrid artefact-ecologies. For example, by enabling audio routing to allow sounds to flow across remote and collocated sites, or to individual people. Additionally, in terms of audio feedback, it is also important to consider the distributed challenge of 'interpreting silence' as it emerged in the hybrid work [15].

> Proposition no. 2: We propose that a design challenge for hybrid work technologies is to find new ways to compensate for audio, visual, and other non-verbal asymmetries in technological frames by considering new potentials for multimodal interaction, whilst acknowledging that paradigms such as strict WYSIWIS are not possible, nor necessarily desirable.

Relationships in hybrid work are ephemeral and transitory, depending on the artefact-ecology that immediately shapes and is shaped by the bounding activities of the participants and the internet stability. The insurmountable gaps in hybrid work caused by the incongruence in frames of reference will always be evident in hybrid settings and produce asymmetric relations. These asymmetric relations risk being pertinent for the cooperation due to the constrained possibilities for *relation work* [12, 30], particularly upon disruptive breakdowns. Hybrid work requires an increased need for relation work to produce the foundation for developing common ground and collaboration readiness [13, 28, 67]. Relation work is the work of constructing and maintaining relations, including technical connections as well as human relationships. Relation work is co-constitutive of the practice by which it is produced and is based on the interdependence in interaction, where hybrid

interaction is simultaneously influenced by and influences the preceding context [81]. When people engage in hybrid interaction, they simultaneously engage in relation work. When a breakdown occurs (e.g., internet instability) the connection to remote participants disappears, breaking the coherence in the collocated group, while disrupting the hybrid cooperative setting. Relation work requires flexibility since dialogue is generative; however, the artefact-ecology acts and creates the boundaries for what types of communicative moves are included and excluded. The asymmetric nature further produces potential differences in communicative moves among hybrid participants, exacerbating communication challenges.

We speculate that achieving relational symmetry in hybrid work is potentially impossible. Asymmetric relations are at the core of hybrid work. However, we question whether initiatives to balance out the asymmetric relations that exist *a priori* in hybrid work would be possible. Relational symmetry, understood as an equal balance between all participants during interaction, can thus not be the aim for technology design for hybrid work as this risks being a futile effort. Further, asymmetries can also emerge from the social and cultural contexts of the participants, and Saatci et al. argue that managing these asymmetries is critical for the success of hybrid meetings [74]. However, we can still try to improve the conditions for hybrid work through technology design. Inspired by Sillars and Vangelisti [81, p. 338], we suggest exploring *relational complementarity* as an approach to support hybrid work. Relational complementarity refers to the relative dominance across participants and considers how participants might complement each other in the concrete interaction rather than balance out. An excellent example of relational complementarity as a strategy for distributed work is Malhotra and Majchrzak's work on farflung teams [61]. They provide empirical data regarding how highly qualified experts collaborate remotely on designing a new rocket engine.

Participants complement each other in terms of knowledge and expertise, but also by always having access to local specialized equipment, reducing the time to 'test' ideas and move forward. Thus, considering the multiple physical local contexts which complicate the hybrid work can also produce enabling potentials in terms of access to artefacts, resources, people, and places that can support the hybrid work. Thus, considering *relational complementarity* as a design strategy can be a way forward when designing technologies for hybrid work considering relation work.

> Proposition no. 3: We propose that a design challenge for hybrid work is to find ways to enable participants in the emotional labor of relation work directly linked to the cooperative activity. The design challenge is about finding ways to allow participants to compensate for the asymmetric relations produced in hybrid work situations, considering 'being included' while 'including others', potentially considering relational complementarity.

We propose these three propositions as core design challenges for hybrid work technologies. Fundamentally, the design challenges for hybrid technologies are about (1) reducing the effort of articulation work required to continuously 'bound' artefact-ecologies; (2) compensating for the multimodal asymmetries produced in the interaction; and (3) enabling emotional labour of relation work. While each of these design challenges are difficult to achieve and require future research to obtain, they are interlinked as a set of challenges and thus we argue that future hybrid technologies need to address all three challenges. However, the design challenges are also different in nature and potentially require very different types of design activities to explore various potential design solutions and opportunities. While finding design solutions is beyond the scope of this paper, we offer an overview of the design challenges and potential design research questions in Table 3, which hopefully can serve as an actionable cross-referencing framework for the fundamental design challenges for hybrid work technologies.

Table 3. Design Challenges for Hybrid Work Technologies

Design challenges based on propositions	Research questions for future design research
Reducing the effort of articulation work required to continuously 'bound' artefacts-ecologies (prop. 1).	How can we support hybrid participants in negotiating and bounding their use of multiple devices, applications, and artefacts as part of their everyday work practices.
Compensating for audio, visual, and other non-verbal asymmetries in technological frames (prop. 2).	How can we develop new multimodal interaction paradigms, which are based upon fundamental asymmetry between cooperative actors.
Enabling participants in the emotional labor of relation work directly linked to the cooperative activity (prop. 3).	How can we create modes of inclusion supporting the emotional labor of 'being included' while 'including others', potentially taking advantage of relational complementarity.

6 CONCLUSION

We set out to interrogate which new challenges for design of cooperative technologies emerge with the introduction of hybrid work. We did this by considering one of the major design challenges for cooperative work technologies, namely, how to create symmetry across participants by asking: To what extent can symmetry in cooperative work engagements be achieved in hybrid work contexts?

Through theoretical reasoning, we identified two sets of conceptual exploration we wanted to interrogate through our empirical observations. These were (1) relational challenges in hybrid work, and (2) what happens when we think about technology support for hybrid work not as a single digital application, but as an ecology of artefacts. First, we extend the concept of relation work [12, 30] to include the work of constructing and maintaining relationships interdependent upon preceding contexts as well as simultaneously being produced within interactions. We argue that relation work is generative for relationship constructions, and thus the constraints produced by artefact-ecologies [21, 23] influence the opportunities for hybrid collaborators in developing relations. We explored how these two streams of research (relation work and artefact-ecologies) would change the ways in which we think about the design challenges for hybrid work through analytical work across empirical cases and activities.

Empirically we found that artefact-ecologies for hybrid work produce incongruence across individual technological opportunities and frames of reference. These incongruences produce unavoidable asymmetric relations in hybrid work arrangements. Extending recent research on hybrid work, we support prior work showing that asymmetries complicate the conditions for cooperative work in hybrid situations [36, 73, 82]; however, we also challenge previous design approaches for cooperative technologies dedicated to reducing asymmetry [72], by arguing that the multiple artefact-ecologies which are fundamental for hybrid work produce incongruence across individual technological perspectives. We argue that achieving symmetry in hybrid work is unattainable (and maybe even impossible) and thus argue that HCI and CSCW designers should reconsider symmetry as the golden standard for the design of cooperative technologies. Instead, we suggest that we need a new and different design strategy and approach (considering relational complementarity) for how to develop hybrid technologies, and we bring forward three propositions which can be the first step in creating this design approach.

Consequentially, we bring forward the potentially controversial statement that rather than trying to establish symmetry in hybrid work arrangements supporting the development of common ground [13, 67] and reduce the risks of sub-group dynamics [33, 36] – we should face the challenges of asymmetry as it is produced in hybrid work arrangements and find ways to use this productively in the design of cooperative technologies.

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