

Co-Designing Multimodal Tools for Radically Mobile Hybrid Meetings

Julia Kleinau
Aarhus University
Aarhus, Denmark
julia.kleinau@cs.au.dk

Jens Emil Grøn­bæk
Aarhus University
Aarhus, Denmark
jensemil@cs.au.dk

Eve Hoggan
Aarhus University
Aarhus, Denmark
eve.hoggan@cs.au.dk

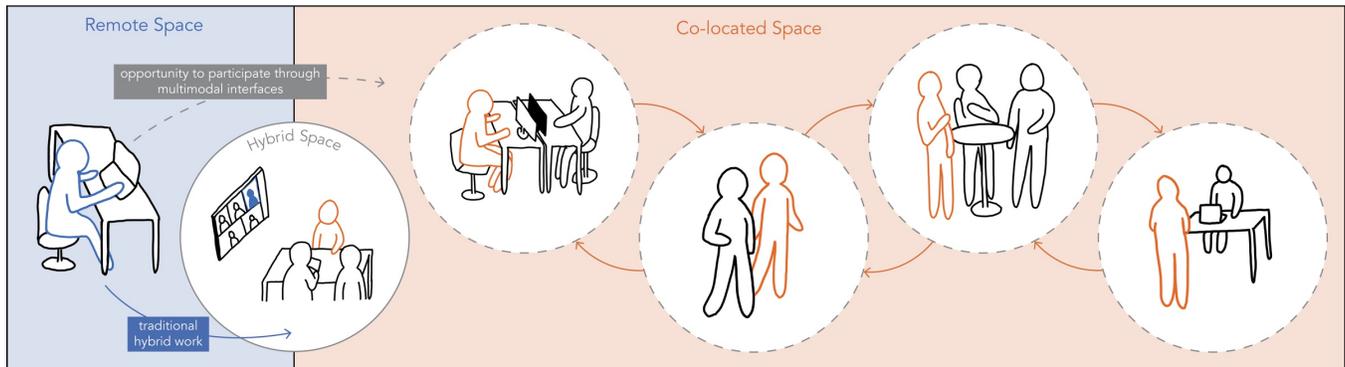


Figure 1: We investigate the contrast between how hybrid meetings are practised and studied and how meetings are carried out in co-located collaboration. While co-located workers engage in a variety of dynamic, mobile meetings, remote workers have no access to these spontaneous interactions that happen in the co-located space. Traditional hybrid meetings through video-conferencing require fixed arrangements to include remote participants. With multimodal interfaces, we can create mobile alternatives for hybrid participation in flexible, ad-hoc collaboration. Our research explores ways to enable remote workers to join radically mobile meetings, expanding the design space for more inclusive and flexible hybrid collaboration.

Abstract

Hybrid meetings have become common practice in collaborative work environments. However, they are constrained by the fixed spatial configurations of videoconferencing technology. This limits opportunities for mobile and spontaneous interactions; qualities that are critical to successful collaboration. In this paper, we explore the concept of radically mobile hybrid meetings. Our work investigates the design space of multimodal devices as mobile alternatives to traditional videoconferencing. We conducted three group co-design sessions, where participants prototyped mobile hybrid meeting technologies to explore how such meetings could be supported. From these workshops, we derive design fictions envisioning future uses of these technologies, which we evaluate with a questionnaire to spark reflections on future mobile hybrid collaboration tools and practices. We contribute an initial exploration of the design space for radically mobile hybrid meetings, laying the groundwork for developing tools that enable spontaneous, effective, and inclusive collaboration in hybrid mobile settings.

CCS Concepts

• **Human-centered computing** → **Empirical studies in collaborative and social computing.**

Keywords

hybrid meetings, co-design, design fiction, mobile meetings, Computer Supported Cooperative Work (CSCW)

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1 Introduction

In organisational contexts, meetings often occur spontaneously and in various locations, reflecting the dynamic and ad-hoc nature of modern work environments. Research in Computer Supported Cooperative Work (CSCW) has shown that meetings frequently take place outside of regular meeting rooms, allowing participants to collaborate flexibly where and when needed [5, 15, 22, 32]. These meetings, which are referred to as mobile meetings [6, 51], enable higher adaptability to the immediate needs of the participants.

Hybrid meetings, where co-located and remote participants collaborate synchronously, have become standard practice in knowledge work [36, 44, 45]. However, these meetings often face significant challenges in ensuring equal participation and engagement.



Hybrid meeting setups typically rely on fixed spatial configurations, constrained to meeting rooms equipped with videoconferencing technology, while research on hybrid work often focuses on structured meeting setups [31]. This conflicts with the flexible nature of mobile meetings in actual workplace settings. As a result, when mobile meetings are necessary, distributed colleagues are often excluded, or the meetings are cancelled altogether, as coordinating them becomes too complicated [31]. This issue was also raised in our field visits to companies who engage in hybrid work practices. A central problem thus is that current hybrid setups – and the way these are studied – assume a spatial rigidity that is incompatible with the fluid, often chaotic nature of real-world work scenarios [16, 31, 35, 45]. Due to the dynamic and individual settings of mobile meetings, co-located spaces often lack the capacity to effectively use videoconferencing tools, as participants in mobile settings are unable to face a fixed screen or be adequately captured by video cameras. The use of video in hybrid meetings limits mobility, as it requires spatially fixed technologies and is anchored to specific physical setups [30]. Fixed cameras and screens constrain mobility, requiring participants to be in specific locations, thus limiting their ability to engage in dynamic, ad-hoc interactions [7], while the absence of video amplifies challenges like turn-taking and interpreting peripheral cues [26].

In this research, we explore how multimodal technologies can support *radically mobile hybrid meetings*, where remote and co-located participants collaborate dynamically and spontaneously across multiple settings outside the traditional meeting room, depending on the needs of the meeting (as illustrated in Figure 1). This concept focuses on including remote users in flexible, informal meetings by addressing the unique challenges of mobility in hybrid collaboration, where participants must interact seamlessly in flexible, dynamic settings. Unlike traditional hybrid setups, radically mobile hybrid meetings require technology solutions that do not constrain mobility, like video tends to do. This necessitates a more radical approach that moves away from using video to better balance the demands of both hybrid collaboration and mobility requirements. We address the Research Question: *What are the challenges and requirements for designing technologies that support users in conducting radically mobile hybrid meetings?*

To do so, we employ a mixed method approach. Based on initial motivating examples from field visits to industry companies, we conducted three co-design sessions with a total of 14 participants, where they prototyped tools for mobile hybrid meetings to explore the challenges and opportunities. Informed by the findings from the co-design sessions, we created three design fictions of future technologies supporting mobile hybrid meetings, which we evaluate in an online questionnaire to elicit feedback from potential users.

We provide an initial exploration of the challenges and requirements of mobile hybrid meetings. Our research aims to offer researchers in HCI an understanding of factors involved in the design of technologies that support collaboration in these mobile hybrid settings. In particular, we contribute: (1) Three co-design sessions which identify key challenges in supporting mobile hybrid meetings (2) Three design fictions envisioning potential future technology for radically mobile hybrid meetings, evaluated in a questionnaire (3) Considerations for the design of future systems that support radically mobile hybrid meetings.

2 Background and Related Work

Our work is situated at the intersection of hybrid meetings and mobile collaboration (see Table 1). Unlike traditional hybrid meeting setups bound to fixed locations, radically mobile hybrid meetings require flexibility and dynamic reconfiguration across diverse contexts. While hybrid meetings have been studied extensively in conventional fixed setups (e.g., [20, 35, 37, 39]), tools for mobile collaboration have primarily been explored in exclusively co-located [22, 51] or remote settings [32]. Although some of these tools could potentially be adapted for hybrid scenarios, the distinct challenges of mobile hybrid collaboration remain largely unexplored.

2.1 Hybrid Meetings

The hybrid work model has become a common work arrangement for knowledge workers [36]. This flexible work setting allows employees to work at the workplace as well as remotely [25]. As a result to this, hybrid settings become more and more present in work and especially in meetings, where the engagement of several co-located participants in coordinated work with at least one remote participant in video- and audio-based meetings is defined as a hybrid meeting [44, 45]. The asymmetrical setup of hybrid meetings, which offers different access to the meeting to remote and co-located participants, creates challenges for enabling inclusive participation [7, 17, 20].

Hybrid meetings are typically studied in fixed spatial configurations, such as meeting rooms equipped with videoconferencing software [16, 20, 31, 44]. This rigid setup limits flexibility, as most hybrid systems are designed for structured environments rather than the dynamic nature of real-world collaboration.

In hybrid meetings, remote participants often lack access to the multimodal communicative cues available to co-located participants, such as nonverbal cues and peripheral awareness. Recent work in HCI has explored multimodal feedback and tangible systems to bridge this gap, enhancing awareness and interaction between distributed participants [3, 49]. These approaches suggest that multimodal systems, such as tactile or thermal feedback, can aim to complement missing nonverbal cues in hybrid settings and support social sense-making and interpersonal awareness [19, 23, 48].

The use of mobile remote telepresence robots in hybrid meetings is examined in research to provide remote participants with spatial interaction possibilities [10, 18]. While these systems can enhance engagement, presence, and autonomy for remote users [27, 40], their size, weight, and manoeuvrability often make them cumbersome for co-located participants [11]. This limits their effectiveness in mobile hybrid meetings in diverse, unstructured environments, particularly in ad-hoc settings where multiple remote participants may join or the meeting space may be constantly shifting.

Meeting technology should not only support participants in their individual settings, but also be flexible enough to adapt to the unique demands of each meeting [45]. This highlights the need for exploring how hybrid meetings can be made more adaptable to the fluid and dynamic nature of real-world work environments, rather than being confined to rigid, predefined setups, as they especially can be found in research on hybrid meetings. As our work explores

| | Co-located | Remote | Hybrid |
|---|---|---|---|
| Fixed fixed spatial configurations, bound to meeting room infrastructure | Traditional Co-located Meetings | Fixed Remote Meetings | Traditional Hybrid Meetings Blended Interaction Spaces [37], Domino [35], MirrorBlender [20], Hybridge [39] |
| Mobile on the go, anytime and anywhere | Mobile Meetings The Walking Talking Stick [22], RoamWare [51] | Mobile Remote Meetings EasyMeet [32], mobile remote meetings through tools like zoom or microsoft teams on mobile devices | Radically Mobile Hybrid Meetings |

Table 1: Mapping meeting configurations across mobility and collaboration contexts. The horizontal axis represents the collaboration context, differentiating between co-located, remote, and hybrid settings. The vertical axis indicates the mobility spectrum, ranging from fixed spatial configurations to fully mobile setups, enabling on-the-go, dynamic meetings. Our work focuses on the bottom-right corner, which combines the flexibility of mobile setups with the collaborative challenges of hybrid spaces.

a specific type of hybrid setting, where traditional video calls are not always feasible due to the mobile and individual setup, we build on the findings above by considering feedback across multiple sensory modalities to support communication in radically mobile hybrid meetings.

2.2 Mobile Meetings

Early research in CSCW acknowledges that people often are mobile to meet, and investigates mobile meetings as held outside of regular meeting rooms, often without any pre-scheduled agenda [5, 6]. A study by Bergqvist et al. [6] on mobile meetings explores challenges of mobility in collaboration, highlighting that mobility can increase social interaction, but also complexity. They emphasise the need for meeting support beyond the traditional meeting room, underlining the difficulty of conducting mobile face-to-face meetings using conventional tools. Similarly, Bellotti and Bly [5] highlight the importance of portable technologies that move beyond workstation-centric CSCW applications.

Luff and Heath [33] underscore the role of physical mobility in shaping collaborative activities, arguing that collaborative technology often restricts the mobility of its users. This research highlights the mobile dynamics in collaborative settings, suggesting that technologies supporting such mobility must account for the ways in which participants adapt their actions. Their findings are highly relevant to the design of mobile hybrid meeting technologies, as they point to the need for tools that can support fluid, ad-hoc collaboration across distributed environments.

Wiberg [50] further extends this work, emphasising the importance of considering spaces outside of conventional meeting rooms for collaboration, as informal face-to-face meetings often occur in places like corridors. He developed *RoamWare*, a system designed to support spontaneous mobile meetings through personal digital assistants, primarily for co-located or virtually mobile interactions [51].

Ciolfi et al. [15] examine the significance of place in spatial mobility, showing how the location of meetings can shape collaborative practices and interactions. Similarly, Rossitto and Eklundh [43] study how students manage their collaborative activities across different locations, using various artefacts and technologies to support their work, and find that locations are tightly connected with practices and interactions in terms of possibilities for collaboration. These studies underscore the tight connection between location and collaboration, suggesting that mobile meeting support should consider the diverse spaces where work takes place.

Several projects have explored mobile meeting technologies. For instance, *EasyMeet* explores enabling mobile meetings "anywhere and anytime" through mobile phones, identifying the need for simultaneous voice and data sharing, as well as remote content access [32]. Additionally, research in technology-supported walking meetings, such as *The Walking Talking Stick* [22], provides insights into how physical mobility can be integrated into physical meetings through novel technologies. Haliburton et al. [24] explore technology-supported walking meetings in HCI through design fictions illustrating possible future scenarios. While some of these examples date back several decades, more recent work on mobile meetings has been limited and predominantly focuses on either co-located or virtual mobile settings, with little attention to hybrid configurations.

Our research aims to extend this understanding by exploring the possibility of hybrid collaboration in mobile meetings. By combining mobile and hybrid setups, we investigate how technologies can facilitate ad-hoc collaboration in hybrid contexts, enabling remote participants to be more seamlessly included in mobile meetings.

3 Method

To examine our research questions, we employ a mixed method approach. Based on initial motivating examples from interviews with industry companies, we conducted three co-design sessions (see section 5). Informed by the findings of the co-design sessions, we

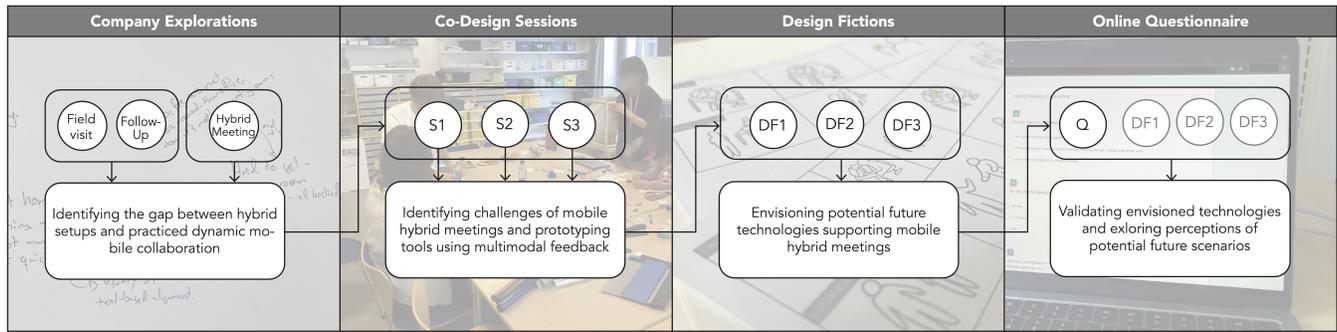


Figure 2: Overview of the research process. We follow a mixed method approach, basing subsequent research methods on the findings of each previous method. Explorations with two companies motivate our concept of radically mobile hybrid meetings, which we further examine through co-design sessions, design fictions, and an online questionnaire.

created three design fictions of potential future technologies supporting radically mobile hybrid meetings (see section 6). To evaluate the design fictions and gain a deeper understanding of considerations for mobile hybrid meeting technologies, we conduct an online questionnaire (see section 7). Figure 2 illustrates our methodology in detail, showing how the insights from each step inform the next stage of our project.

4 Preliminary Exploration of Hybrid Work Practices

As part of our research, we conducted initial explorations with companies to investigate their hybrid work practices. These were informal sessions, with the agenda focused on discussing the companies' hybrid meeting routines and practices. Over a three-month period, we visited *company1* (a large production company), held a hybrid meeting with *company2* (a large manufacturing company), and invited two employees of *company1* to join us at the university for a follow-up conversation. The sessions involved open discussions with office knowledge workers, as well as small activities designed to engage participants in reflecting on their hybrid collaboration experiences. These exploratory engagements provided us with a preliminary understanding of the challenges and opportunities within their hybrid work environments and serve as a motivation for this research.

In the hybrid meeting with three employees of *company2*, employees discussed the different rooms with various purposes in their office space, emphasising how they move between spaces to find the most suitable environment for specific activities or meetings.

In conversations with two office workers employed at *company1*, challenges regarding the use of office spaces for hybrid practices were discussed. A key concern was the "one-size-fits-all" setup of meeting rooms, which is introduced to accommodate hybrid meetings, but does not support the diverse needs of various forms of hybrid collaboration, particularly for spontaneous or creative work.

Employees shared a perceived lack of informal, spontaneous interactions in hybrid collaboration. Before a shift to the hybrid work model, meetings were often held spontaneously in different spaces of the office. Since hybrid participation in meetings became more common, these types of meetings exclude colleagues who are

not physically co-located. All meetings have to be held in designated meeting rooms, and are often dropped due to difficulties in booking rooms on short notice and a higher effort in making spontaneous collaboration work.

In a post-it activity with employees of *company1*, participants further highlighted the contrast between how meetings are carried out in the office space and the setup a hybrid meeting imposes on them. As one employee writes, in the office, most interactions take place in formal meeting rooms rather than in informal office corners, as was the case previously. A problem related to this as stated by one participant, is that it is "Hard to get a meeting room last minute, all booked". They further note that this leads to them "not joining many meetings. Not many 'catch-ups' or quick alignments" when working remotely.

This shift from spontaneous, on-the-go collaboration to a more structured, planned approach underscores the challenges posed by current hybrid setups. Hybrid practices can often not be combined with the mobile way of working and meeting throughout office spaces. Rigid meeting room structures contrast with the dynamic, often spontaneous nature of work. These insights from our initial explorations with industry companies motivate our aim to make hybrid meetings radically mobile to better accommodate the fluid and dynamic nature of real-world collaboration.

5 Study 1: Co-Designing Radically Mobile Hybrid Meetings

To explore the challenges and technological approaches for radically mobile hybrid meetings, we conducted participatory co-design sessions. Co-design, as an approach to joint creativity, involves end-users in the design process and empowers users to actively participate in shaping future scenarios and tools, ensuring their specific needs of their work environments are met [46, 52]. Using co-design as a means of collaborative creative exploration allowed us to engage potential users directly in the ideation and creation process, uncovering insights into the design requirements for multimodal technologies that facilitate mobile hybrid meetings. Particularly in work settings, participatory approaches are crucial for understanding the context and enabling users to actively consider future use situations [14].

| Session | Location | Duration | Participants | Age Group | Gender | Occupation Type | Initial meeting task role |
|---------|----------|----------|--------------|-----------|--------|---------------------|---------------------------|
| S1 | Denmark | 97min | S1P1 | 25-34 | Male | PhD Student | Remote |
| | | | S1P2 | 18-24 | Male | CS Student | Co-located |
| | | | S1P3 | 25-34 | Male | Electrical Engineer | Co-located |
| | | | S1P4 | 25-34 | Female | PhD Student | Co-located |
| S2 | Denmark | 101min | S2P1 | 25-34 | Female | CS Student | Co-located |
| | | | S2P2 | 18-24 | Male | PhD Student | Remote |
| | | | S2P3 | 25-34 | Female | PhD Student | Co-located |
| | | | S2P4 | 25-34 | Female | PhD Student | Co-located |
| | | | S2P5 | 18-24 | Male | Engineering Student | Co-located |
| S3 | Germany | 109min | S3P1 | 25-34 | Female | Software Developer | Remote |
| | | | S3P2 | 25-34 | Female | Project Manager | Remote |
| | | | S3P3 | 25-34 | Male | UX Designer | Co-located |
| | | | S3P4 | 25-34 | Female | Software Developer | Co-located |
| | | | S3P5 | 18-24 | Male | Software Developer | Co-located |

Table 2: Co-Design participants' backgrounds.

We conducted three co-design workshops, which aimed to identify the challenges associated with mobile hybrid meetings and explore how multimodal technologies could facilitate mobile hybrid collaboration. Through hands-on prototyping activities, participants collectively developed and discussed speculative prototype designs, which offer insights into future possibilities for mobile hybrid meetings.

5.1 Participants

In total, N=14 participants took part in the three co-design sessions (7 female, 7 male). The mean age was 26.3 (min=21, max=29). Our study recruited participants from six countries in Asia, Europe and Northern America, working in Denmark and Germany. Details of the participants' background are given in Table 2. All participants had attended hybrid meetings before.

5.2 Apparatus

The study sessions were conducted in a university environment. The room was equipped with *LittleBits*¹, which are modular electronics kits that allow users to create simple circuits and prototypes without prior technical expertise. These kits include various input and output modules (e.g., sensors, LEDs, vibration motors) that can be magnetically connected, enabling rapid prototyping. In addition to the *LittleBits*, participants had access to a variety of creative materials, such as paper, markers, scissors, and adhesives, to aid in

the design process and to facilitate the creation of physical representations of their concepts. The setup of the workshop room can be seen in Figure 3.

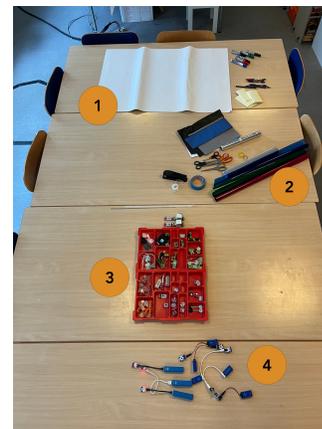


Figure 3: Setup of the study lab. (1) Poster sheets for group prototype descriptions. (2) Creative materials including paper, tape and tools. (3) Assortment of *LittleBits*. (4) Power supplies for prototypes.

¹<https://sphero.com/pages/littlebits>, retrieved 01.09.2024

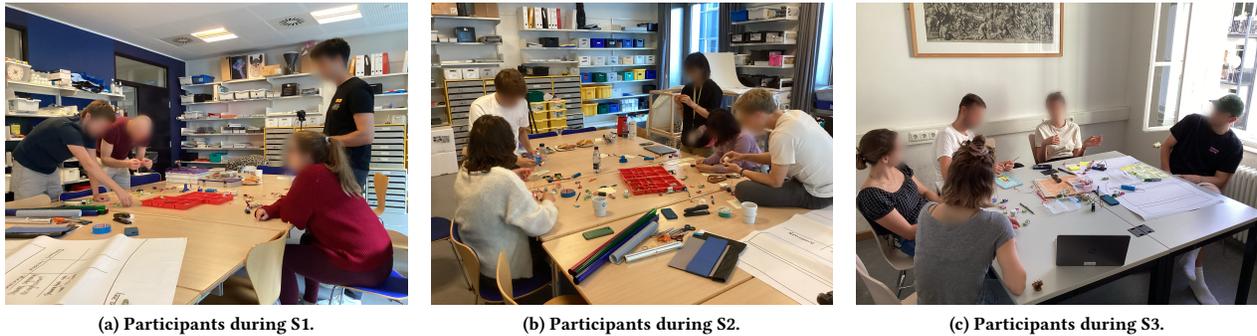


Figure 4: Photographs of the participants engaging in the co-design sessions, collaborating on building prototypes with various electronic components and tools to explore multimodal feedback for mobile hybrid meetings. Faces are blurred for anonymity.

5.3 Procedure

Upon arrival at the lab, participants were provided with an overview of the study. After obtaining informed consent, they were introduced to the concept of mobile hybrid meetings. To explore challenges connected to mobile hybrid setups, each group was divided into a remote and a co-located subgroup of minimum one remote participant, to conduct a mobile hybrid meeting. The co-located group conducted the meeting using a tablet, while the remote participant(s) connected via a smartphone without video connection. This setup was intended to simulate the challenges commonly encountered in hybrid mobile meetings. The initial task thus was to conduct a mobile hybrid meeting focused on a predefined topic. It served as a way to elicit participants' natural responses to the challenges of such meetings. Following the meeting, the remote participant(s) rejoined the co-located group in person.

Subsequently, participants were introduced to the co-design task, which aimed to explore potential technological solutions to the challenges identified during the mobile hybrid meeting. Participants were asked to discuss the challenges and to brainstorm possible technological approaches. They were provided with *LittleBits* modules to prototype their ideas, allowing for hands-on exploration of different interaction modalities. Photographs of the participants during the prototyping process can be seen in Figure 4.

The task concluded with participants developing a use case scenario, designing a prototype, and creating a poster that summarised their design. The poster included key aspects of their proposed solution, such as the identified challenges, the envisioned modality use, and the role of their design in addressing the challenges of hybrid mobile meetings (see Figure 5).

5.4 Data Collection and Analysis

During the co-design sessions, we recorded participants with a videocamera and a voice recorder, and took pictures. We further collected the artefacts produced by the participants throughout the workshops, which consisted of post-it notes, posters summarising their process, and the final prototypes.

For the analysis of the data, an approach based on thematic analysis [12] was followed. All artefacts created by the participants were analysed, and the audio recording of the workshops was transcribed, coded, and annotated in the NVivo software. This

process was led by one of the authors with regular reviews with the co-authors. The research team examined the data in detail and facilitated the identification of key themes and patterns, which are discussed below.

5.5 Findings

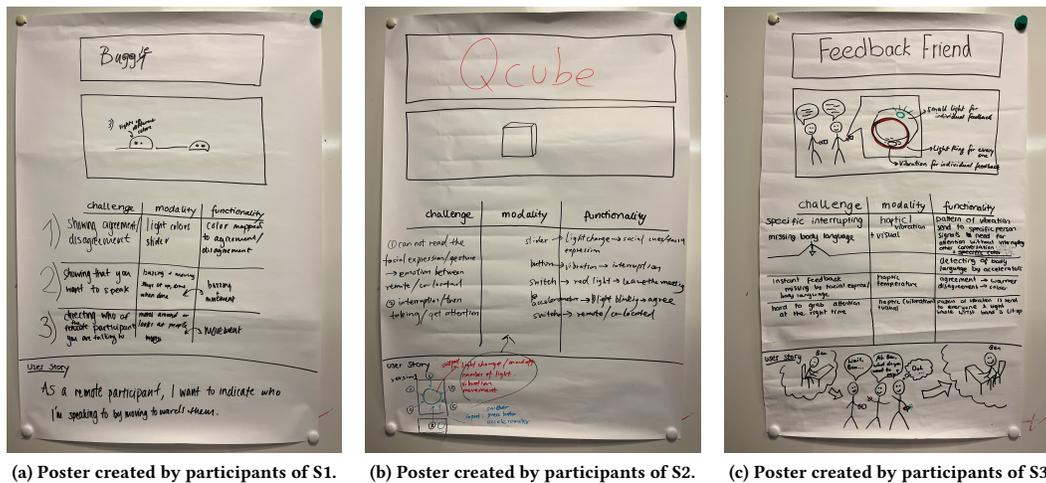
Our findings are organised around key themes that emerged during the co-design sessions, focusing on the challenges of mobile hybrid meetings identified and the prototype solutions developed by participants. Each group's prototype reflected their approach to these challenges through multimodal devices.

The prototypes, along with participants' discussions and posters, offer valuable insights into how different sensory modalities can facilitate interaction in mobile hybrid meeting settings. We analyse the rationale behind the use of these modalities, showing how participants envisioned them to signal key dynamics like interruptions and turn-taking, social cues, and directing conversation.

Across all sessions, participants identified turn-taking and interruptions as significant challenges in mobile hybrid meetings, particularly without visual cues through video feeds. Each group approached this challenge through the prototypes they built, using haptic vibrotactile (S1, S2, S3) and visual (S1, S3) feedback. Social cues and instant feedback were also central concerns, with the groups exploring visual (S1, S2) and haptic temperature (S3) modalities to address these. Each of these issues, turn-taking, social cues, and directing conversation, are elaborated in the sections below.

The group in S1 created a device transmitting the audio of the meeting call (see Figure 6a). The device uses light colours to identify the speaker and to indicate agreement and disagreement. Interruptions are signalled through vibrotactile feedback, while conversation can be directed towards specific participants through movement.

Participants of S2 prototyped two artefacts, one of them showing their concept and modality use (see Figure 6c), while the other visualises the imagined design as a cube (see Figure 6b). Their device is a small cube held in the hand of all participants, who can interact with the sides of the cube to indicate different social cues on the other participants' cubes. They focus on transmitting facial expressions or gestures as indicators of emotions and social cues



(a) Poster created by participants of S1. (b) Poster created by participants of S2. (c) Poster created by participants of S3.

Figure 5: Posters created by the participants in the co-design sessions. The posters describe their prototypes for radically mobile hybrid meetings following a pre-defined structure, including a title, sketch, challenges approached and a user story.

through visual feedback in the form of coloured lights. Interruptions and turn-taking were mapped to vibrotactile feedback.

In S3, the group designed a wearable wristband (see Figure 6d). The device can give feedback both privately to individual meeting participants as well as publicly to the whole meeting. It uses vibrotactile feedback for interruptions and attention grabbing, while the body language of the user can be tracked as an input. Instant feedback and social cues are transmitted via temperature feedback.

5.5.1 Missing Visual Social Cues. In all three co-design sessions, group members discussed possibilities for social cues when visual information about facial expressions or body language is missing. These often subconscious cues can be used to obtain information about participants’ status, agreement, or opinion visually. S2P3 notes the importance of social cues for decision-making, emphasizing that “when we’re making decisions, I’m looking at each other’s emotions to see if they agree or not. But now I cannot see the people who are remote.” Understanding other participants’ comprehension is often bound to their visual representation in a hybrid meeting. S3P2 reports from experience, in a mobile hybrid meeting without possibility for a video feed, “I don’t know if they’re understanding me.” Instant feedback in the form of reactions conveyed visually through facial expressions or body language was described as lacking in radically mobile hybrid settings, whereas these information are not completely lost in traditional hybrid settings with a video call connection.

S1P3 reflects on the absence of instant visual feedback in hybrid meetings where video transmission is unavailable: “How many times you’re in a meeting and [...] there’s no feedback that you’re not understood, like - why are you ignoring me?” This lack of visual reactions disrupts awareness of participant status and meeting dynamics. All three groups discussed challenges connected to this missing visual instant feedback about the meeting status. Participants in S3 made this a central theme of their discussion, noting the importance reading reactions in a meeting, “like nodding, but not having to say something” (S3P4).

In their prototype, participants of S1 focus on missing social cues for indicating agreement and disagreement through facial expressions and body language. They map this to visual light feedback, changing colour depending on the level of agreement of the remote participants. Similarly, participants of S3 discuss the possibility of indicating agreement when cues like nodding are not possible. They use temperature feedback to indicate agreement (warm) and disagreement (cold).

The group of S3 further uses accelerometers in their collaborative wristband device to capture body language. In meeting settings without video, participants would have to verbalise otherwise subconscious social cues, as S2P2 notes: “it’s very hard to convey that for me unless you’re very explicit.” To make these interactions more natural and seamless, participants in S3 envision a scenario for their design in which facial expressions and gestures are automatically recognized and shared as feedback about during a meeting.

The group of S2 designed their prototype around the challenge of social cues, including input- and output modalities to convey these. Their device for instance uses movement to turn a representation of a head, changing the displayed emotion from a smile to a frown. Colour changes in the light emitted by their device are supposed to illustrate facial expressions as social cues, while blinking lights are used to show agreement.

From the co-design session prototypes, it becomes clear that participants value the potential of multimodal feedback to give instant feedback in radically mobile hybrid meetings, describing this form of social cues as subconscious, informal and uninterrupted.

5.5.2 Indicating Interruptions and Turn-Taking. In our co-design sessions, participants frequently emphasised the difficulty of indicating the wish to interrupt, especially in settings where video feeds are unavailable. The absence of visual cues, such as facial expressions or hand-raising, was highlighted as a key challenge in coordinating turn-taking. As S2P1 noted, “the remote person can’t really read the social cues, so they always interrupt conversations because they can’t know when to speak.” They mention a wish for

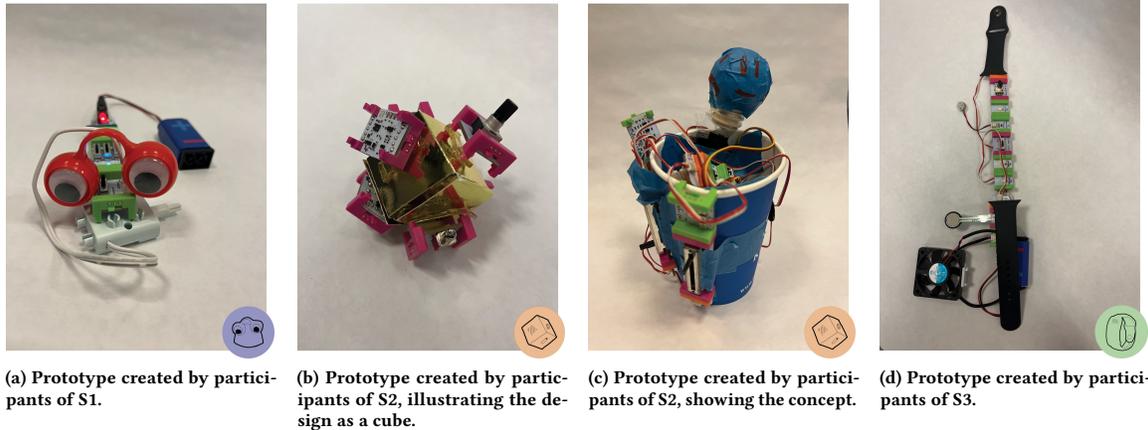


Figure 6: Prototypes created by the participants in the co-design sessions. The images are coded with a corresponding icon representing the concept for visual continuity throughout the paper. It links the co-design prototypes to the following stages and studies.

representations for whenever someone is about to speak. In traditional hybrid meetings, intentions to interrupt could be perceived via visual cues through video feeds, as S3P3 states: *"If you're changing your face expression, it's not necessarily interrupting, it's more like a small hint to other people."* This lack of feedback leads to remote participants feeling hesitant or invasive when contributing, as S1P3 shares their experience as a remote meeting participant: *"when you speak, you think about it a lot more because you feel more invasive, so you wait until you have something that's important to say. You're not as spontaneous."*

The difficulty of knowing when to contribute heightens the risk of accidental exclusion. The group of S3 discusses this challenge connected to managing interruptions and turn-taking:

S3P5: *"Sometimes it could happen that people forget you, and then it's hard to get back on track again, you know, like jump into the conversation again. Sometimes you just don't feel part of the meeting because everyone is sitting there and talking, and you don't see the others. [...] Then it is also hard to jump in and say something."*
 S3P3: *"If you're remote, you will probably not do it, the chance is high at least. And if you're in person, you're probably way more motivated to raise your hand."*

Participants across the sessions explored how multimodal feedback could mitigate these challenges in their prototype designs. S1 integrated vibration and visual cues to manage interruptions and turn-taking. Their device uses vibrotactile feedback in the form of short buzzes, *"so when you want to talk you buzz to draw attention"* (S1P2). Lights in assigned colours indicate active speakers, dimming once they finish, indicating the participant leaving the speaker role. Participants of S2 also use vibrations to indicate interruptions. These are activated by a button on the cube device, and can be activated for as long as the button is pushed down, allowing for indicating an interruption until getting noticed.

In S3, the group combines both haptic and visual feedback for grabbing attention. They ideate their wristband prototype to send

patterns of vibrations to all meeting participants, while the wristbands light up to be perceived publicly. However, participants of S3 noted that haptic feedback could be perceived as harsh or disruptive and suggested it should be used sparingly to avoid desensitisation. Visual cues, such as dimming lights or subtle expressions, were seen as less intrusive and more effective in signalling intent without breaking the flow of conversation.

5.5.3 Directing Conversation. A recurring theme in the group discussions was the challenge of directing conversation in hybrid meetings, a problem that becomes even more pronounced in mobile settings. In co-located meetings, participants can use body language and eye contact to signal who they are addressing. However, in hybrid meetings, where remote participants are often represented by a single audio-visual source, it becomes difficult to indicate who is speaking to whom. This challenge is further amplified in mobile hybrid meetings, where co-located participants are not facing a screen, limiting their view of remote colleagues, and may not be visible on camera, making it difficult for remote participants to see them.

Participants noted the frustration of not knowing who is speaking or being addressed. As S1P3 explained, *"if somebody's saying something out of the speaker to the people who are in the the physical room you don't know who said that, [...] like who am I speaking to right now"*. This issue is intensified when there is no visual indication of speakers through a video feed, making it harder to distinguish between participants. S1P2 highlighted how this differs from the natural perception of the flow of conversation: *"it's a group conversation, but I'm talking to you. I look at you. It's obvious to everybody I'm answering to you but now that doesn't work."*

Participants also suggested potential solutions to address this issue in mobile hybrid meetings. For instance, S3P5 pointed out that cues such as a vibration or visual indication could help address the specific person being spoken to. Participants of S1 focus their prototype on directing conversation towards specific colleagues by making the device move towards the person that should be

addressed. S1P2 describes the prototype's functions further: "*if you want to talk to somebody specific you have the googly eyes and as long as you're talking the light stays on and googly eyes stays on if you're still relevant.*". Thus, after a meeting participant shows the directing of the conversation through moving the device, it lights as long as the remote participant is speaking, and keeps directing its 'eyes' at the approached colleague.

5.5.4 Designing for Mobile Hybrid Collaboration. Our findings suggest several key considerations for designing future tools to support mobile hybrid meetings. The co-design sessions suggest potential for facilitating and supporting mobile hybrid meetings through feedback across multiple modalities, with technology supporting communication by complementing verbal conversation with further subtle cues in these settings.

Participants across all sessions agreed that audio feedback can be disruptive, favouring more subtle modalities like vibrations and temperature to provide non-intrusive cues. When discussing the possibility to involve the auditory modality, it was described as "*interrupting*" (S1P4), "*aggressive*" (S2P1) or "*distracting*" (S1P3). This is due to "*the audio channels already being taken up by people speaking*" (S1P3) and thus acting as the main channel for communication in mobile hybrid settings.

Across the prototypes created in the co-design sessions, modalities were consistently mapped in similar ways. Vibrotactile feedback was used primarily for managing turn-taking and interruptions, while social cues were conveyed through visual or temperature feedback. This was based on vibration being perceived as "*nudging*" (S1P3), "*indirect*" (S3P3), "*subconscious*" (S3P3), and attracting attention (S1P2). S3P4 mentions the possibility to design vibrotactile feedback in unobtrusive and intrusive ways, while S1P3 describes it as easy to interpret. S3P3 adds, "*It's not too disrupting but still at that moment you will recognise it for sure.*" Temperature was seen as a subtle and subconscious feedback opportunity, as "*the heat is less attention grabbing, but heat is more like communicating general agreement*" (S3P2).

However, some form of visual feedback remains necessary, potentially in a low-bandwidth and unobtrusive format, such as light colours or brightness to transmit information. As research shows, even this kind of minimal communication can create awareness of distributed participants [28]. All three groups' prototypes employ the visual modality by using lights, colours or movement for speaker identification or information on intentions.

The findings of our co-design study indicate a need to design for subtle, multimodal interactions that facilitate seamless communication without overwhelming users. These multimodal systems can enable and facilitate communication and collaboration in radically mobile and ad-hoc hybrid meeting scenarios.

6 Design Fictions

The co-design sessions provide us with an initial understanding of challenges in radically mobile hybrid meetings and a set of key themes that need to be approached within technologies that are developed for this setting. Building on the groups' inspirations and ideas about possible technologies built in their prototypes, we created design fictions.

Design fictions are increasingly employed in HCI research to envision potential technological futures and explore their implications, and have been applied in numerous publications [2, 9, 24, 34, 41, 42, 47]. Through storytelling, design fictions create contexts that allow researchers to envision and speculate on the use and impact of emerging technologies [8]. Baumer et al. [4] argue that the evaluation of design fictions should be context-specific, tailored to the particular goals and the type of knowledge the fiction is intended to generate.

Our approach draws inspiration from previous design fiction research on work and meeting practices. For instance, Busboom and Boulus-Rødje [13] re-imagine planning for hybrid cooperation using speculative artefacts, while Haliburton et al. [24] explore the hypothetical implications of supporting walking meetings with technology and evaluate their fictions with users. Further, Somanath et al. [47] illustrate how future work technologies could foster happiness through design fiction scenarios. These works demonstrate the potential of design fictions in exploring the impact of future technologies in work environments and have informed and inspired our exploration of mobile hybrid meetings by this method.

We developed three design fictions based on themes from the co-design sessions. The prototypes developed by the groups as well as the findings from the sessions' analysis guided the design of the technology scenarios. Each design fiction is directly informed by the challenges approached by respectively one of the groups in the co-design sessions. The groups' imagined mapping of modalities to feedback mechanisms was integrated in the scenarios, ensuring that the fictional technologies align with the themes that emerged during the first phase. Every design fiction presents an imaginary technology aiming to facilitate mobile hybrid meetings, and includes a description of the tool as well as an accompanying user story. We provide full descriptions of each design fiction in the following.

6.1 Buggie - Initiating and Directing Informal Hybrid Conversation

Buggie is a small, mobile device designed to facilitate spontaneous, informal meetings for remote workers. It approaches the challenge of directing conversation in radically mobile hybrid meetings. The device, equipped with visual cues and movement, allows remote colleagues to simulate stopping by the office of co-located colleagues and thus initiating spontaneous informal meetings. Through the Buggie's physical presence and movements, remote workers can nudge their co-located colleagues into casual, hybrid meetings without relying on formal scheduling. During mobile hybrid meetings, the movement functionality of the Buggie can be used to direct the conversation between remote and co-located spaces. A user scenario for the tool can be seen in Figure 7.

6.2 QCube - Multimodal Social Cues in Mobile Hybrid Meetings

The QCube is a portable device that supports mobile, hybrid meetings by enabling real-time transmission of social cues across remote and co-located participants. Each participant carries their own QCube, which provides both visual and haptic feedback. When QCubes are brought into proximity, they automatically connect,

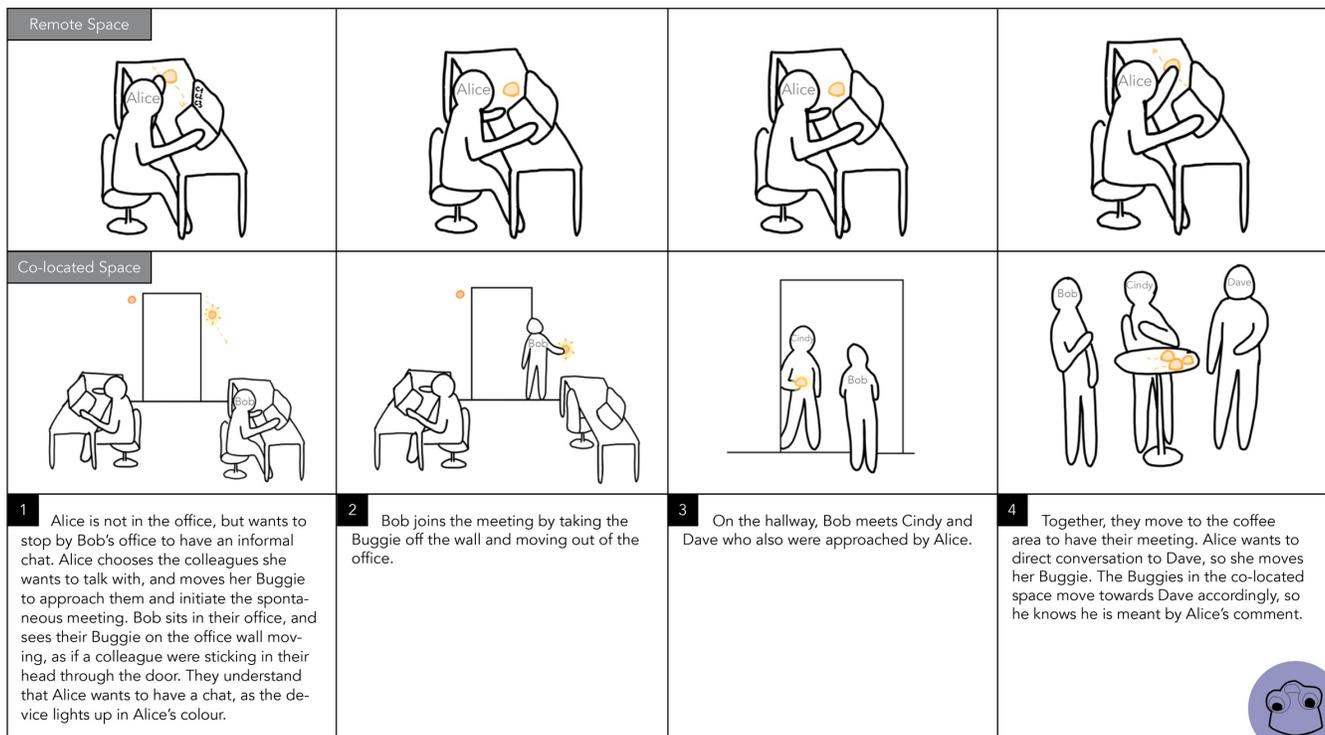


Figure 7: Story board visualising design fiction 1. The Buggie is used in a hybrid work setting, where a remote colleague initiates a mobile hybrid meeting.

forming an instant hybrid meeting. Remote participants can join seamlessly with their QCube and interact with others through vibrations, lights, and audio connection features. The use of the device and how it aims to approach the challenge of social cues is specified in a user story in Figure 8.

6.3 The Feedback Friend - Instant Feedback

The Feedback Friend is a wearable wristband designed to enhance mobile meetings between remote and co-located colleagues by transmitting instant feedback through multimodal cues. Through input such as shaking the hand or performing gestures, the wristband provides haptic and visual feedback to participants, allowing them to give or receive cues during meetings. Whether co-located or remote, colleagues can communicate approval and disagreement, and be present with one another in hybrid mobile settings through the Feedback Friend. Figure 9 illustrates the application of the device in a user scenario.

7 Study 2: Feedback on the Design Fictions

To evaluate our design fictions, we conducted an online questionnaire aimed at gathering feedback and reactions to the speculative technologies we proposed. The primary goal was to investigate how technologies supporting mobile hybrid meetings are perceived by potential users. Our aim was to provoke participants' thoughts and emotions, prompting them to reflect on challenges of mobile hybrid meeting technologies. This aligns with literature recommendations on evaluating design fictions, where the goal is not merely

validation, but rather to spark critical reflection on the technologies and their implications [4].

7.1 Participants

We recruited $N=22$ participants (10 male, 12 female) to complete our questionnaire. Participants for the questionnaire were recruited through convenience sampling, initially reaching out to individuals within the researchers' network. These contacts were then asked to further distribute the questionnaire, facilitating a broader reach across different backgrounds and experiences.

The participants' age ranged from 21 to 58 ($M=28.1$, $SD=7.2$), and they are currently working in three different European countries. Participants report working in IT ($N=10$), research ($N=2$), administration ($N=3$), engineering ($N=1$), as a student ($N=3$) or being unemployed ($N=1$). All participants stated they had attended hybrid meetings before.

7.2 Procedure

After a brief introduction to the study, participants were asked for demographic data and their hybrid and mobile meeting experience. Each participant was then presented with all three design fictions one at a time subsequently, in the same order, each being followed by questions regarding the scenario. We asked about potential positive and negative aspects connected to the fictional scenario, as well as possible use of the presented technology in their own hybrid meeting practices. Each set of questions contained an open

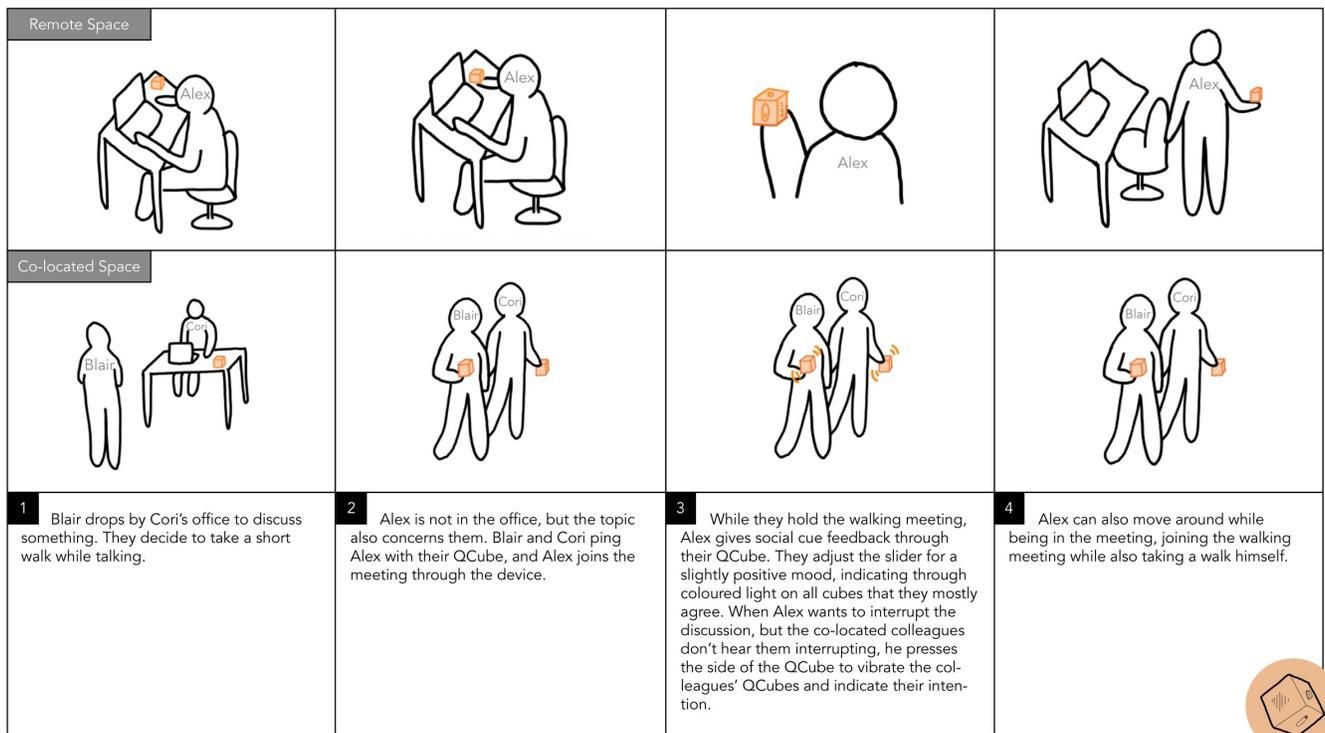


Figure 8: Story board visualising design fiction 2. A remote colleague is integrated in a spontaneous mobile meeting through the QCube.

text-field providing the participants with the opportunity to express additional thoughts about the fictional scenario.

7.3 Analysis

For the analysis of the data, answers to the questionnaire were clustered by question and design fiction scenario, and imported as text files into the NVivo software for coding and thematic analysis [12]. Similar to the analysis of the co-design sessions, we followed an iterative, collaborative approach to reflect on the material. The initial coding process was led by one of the authors, with codes generated inductively from the data. These codes were then grouped into potential themes, which were iteratively discussed and refined by all authors.

7.4 Results

We present the findings of our questionnaire study, highlighting key insights into participants' perceptions and reactions to the scenarios described in the design fictions. Out of the respondents, 14 (63.6%) reported that hybrid meetings are a regular part of their work, while 8 (36.4%) participate in hybrid meetings less frequently. When attending these meetings, 5 (22.7%) typically join remotely, 7 (31.8%) co-located, and 10 (45.5%) participate from both sides. While 45.5% (10) of respondents have never participated in mobile meetings, 54.5% (12) have engaged in meetings that take place in informal settings, such as walking meetings or conversations in hallways and other spaces. These participants report experience

with walking meetings (3), meetings in office hallways (7), and meetings in other spaces such as office kitchens or coffee corners (10). From the responses, we identified several key themes, which mainly focus on the spatial and contextual flexibility of meetings, social factors, as well as inclusion of remote participants. These will be described in detail in the following sections.

7.4.1 Flexibility. A key theme that emerged in the answers to our questionnaire is the positive perception of the flexibility of the proposed meeting technologies, particularly in terms of how meeting spaces and formats can shift dynamically. Participants highlighted the importance of free location choice for hybrid meetings in the co-located space, where meetings often start in one place and move to another as needed. One participant noted, "Often I find myself meeting in new or informal places. Rarely, however, are these meetings hybrid. Maybe it would be easier to include remote colleagues if they could be notified more easily" (Q4 DF 1). This adaptability, including impromptu hallway discussions transitioning to other environments, was seen as crucial but rarely extended to hybrid meetings. Q14 notes they would like to use a system such as the device described in DF1 "when the meetings change location. E.g. starts as a talk in the hallway and changes to a lab." Participants frequently described the ability to relocate as desired in their work practices, indicating a wish for hybrid meetings to support similar flexibility.

In addition to spatial adaptability, the flexibility to adapt to meeting types in mobile hybrid setups was discussed. For example, respondent Q11 describes the idea to use different collaboration tools

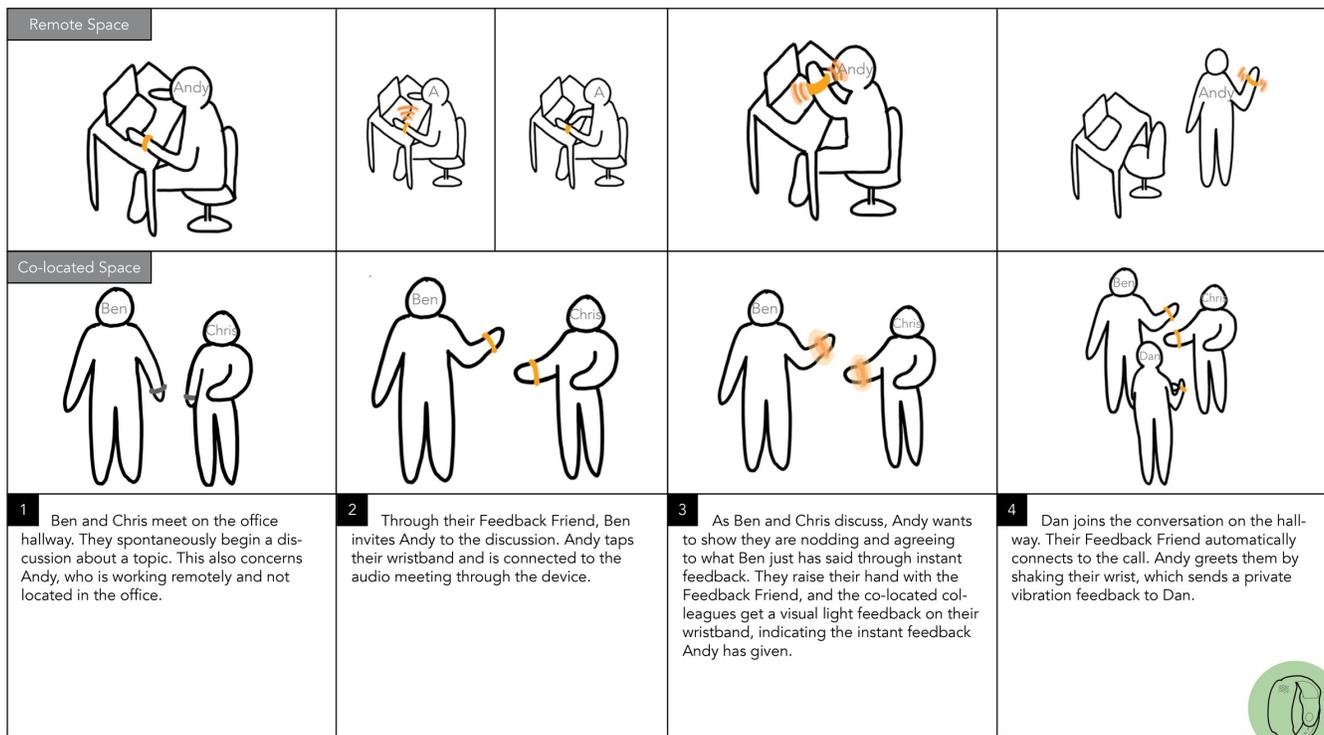


Figure 9: Story board for design fiction 3. The Feedback Friend enables remote and co-located colleagues to exchange instant feedback in mobile hybrid meetings.

for various meeting purposes; a videoconferencing tool for more formal meetings, and a device as illustrated in scenario 1 for informal meetings. Participants mentioned how the technology could be "simulating the spontaneity of informal physical meetings" (Q18 DF1) matching "immediate and unforeseen needs to have a chat and talk about questions or concerns" (Q15 DF1). Participants further appreciated the informality and playful nature of mobile interactions, describing the potential for these devices as "fun" (Q5 DF1, Q14 DF1), "cute" (Q6 DF1), and making it "easier to have a quick chat" (Q9 DF2).

However, several participants raised concerns about the extra effort involved in carrying or remembering to use the device. One participant for example expressed the concern that "it would be too much of a hassle for me if I had to carry around a device just to be able to have informal conversations with a remote person" (Q2 DF2). This suggests that while the potential for adaptivity is appreciated, its implementation must minimise effort for co-located participants.

7.4.2 Social. Answers to our questionnaire indicate the positive perception of the fictitious technologies' ability to replicate social interactions in mobile hybrid meeting environments. Some participants viewed the tools in the scenarios as a means to bridge these gaps in social interaction. In scenario 1, a participant noted, it "makes me feel legitimate to replicate the 'stand up in the open space and grab colleagues for a coffee break' behaviour when I'm remote working" (Q11 DF1), suggesting that mobile hybrid meeting technologies could empower remote workers to engage more naturally

in spontaneous, informal interactions. Similarly, in scenario 2, another participant linked the technology to the 'raise hand' feature in Microsoft Teams, stating that it allowed remote participants to express themselves through subtle social cues without the need for constant verbal input.

However, the replication of social interactions in hybrid meetings also presents potential negative social implications. Participants expressed concerns about the social dynamics of ignoring or dismissing the remote. One participant asked, "Will the Buggie be taken as seriously as a real person? Will the co-located people ignore or focus more on the co-located people?" (Q14 DF1). These answers suggest that while mobile hybrid technologies have the potential to replicate social dynamics, they may also introduce new complexities in power relations and social interactions that need careful consideration in design.

7.4.3 Inclusion. Another key theme emerging from our questionnaire study is improved inclusion of remote participants in co-located work practices. Mobile hybrid meetings could increase the possibility for remote workers to join informal, spontaneous interactions, which are often restricted to co-located participants.

The concept of physical presence also played a key role in how participants viewed the inclusivity of these tools. Several participants appreciated the physicality of the devices, with one noting, "I like that it is a physical approach rather than just a message on e.g. teams. It brings you into action, you need to get up and react" (Q3 DF1). Another participant remarked that in scenario 1 "Alice is also in the

meeting, even she is remote" (Q7 DF1). This physical representation of remote participants adds a level of presence that is often missing in traditional software-based solutions.

Remote participants are often disadvantaged in hybrid settings, as they are unable to initiate or join spontaneous mobile meetings. One participant explained, that with mobile hybrid meeting technology as depicted in scenario 2, *"the remote person gets more power. Normally they can just join when someone thinks of telling them that something is going on in the co-located space"* (Q1 DF1). However, another participant reflected on the still limited control for remote participants, stating in scenario 2, *"They have to carry Alex, and Alex cannot choose where to go"* (Q6 DF2). This tension between being present but lacking agency was a recurring challenge, as remote participants may still feel excluded despite having access to the meeting space. Participants noted that remote participants as a result might face power imbalances, as they rely on co-located colleagues to be noticed or included in conversations.

7.4.4 Use of Mobile Hybrid Meeting Tools. Participants were asked to reflect on how the envisioned technologies could be integrated into their existing hybrid work practices, noting both the opportunities and limitations they perceived. Some participants saw the potential for these tools to act as a small conferencing system for quick and spontaneous meetings. Others emphasised the benefit of these technologies for informal and impromptu conversations, particularly for remote workers: *"If I would work remote for a longer time and feel the need to have informal chat with people I would use it"* (Q2 DF1).

Participants also saw the value in using the technology for meetings that do not require a formal setting, especially when visual information is not a priority. As one participant put it, *"For more informal meetings where general topics might need to be discussed I could imagine using it exactly for the reason that it does not force you to sit in a meeting room"* (Q3 DF1). Another shared this perspective, suggesting that the technology could facilitate spontaneous, mobile meetings without the need for extensive planning: *"I see this as a chance for spontaneous mobile meetings that I otherwise wouldn't have or would only with planning overhead"* (Q19 DF1).

However, participants also pointed out that the experience is not fully equivalent to in-person meetings. One participant remarked that *"it still doesn't completely matches the in-person meeting and the remote person is still a little bit out of the current context, for example when [something] spontaneous is happening, and people in the office are talking about it"* (Q8 DF1). This highlights the ongoing challenges in ensuring remote participants feel fully included in the dynamic and often spontaneous mobile hybrid meetings.

8 Discussion

In this paper, we set out to answer the research question: *What are the challenges and requirements for designing technologies that support users in conducting radically mobile hybrid meetings?* In the following, we discuss how our findings position radically mobile hybrid meetings as an area for further research, and how the insights gained from our approach can serve as a foundation for the continued investigation and design of technologies to support radically mobile hybrid settings.

8.1 Making Hybrid Meetings Radically Mobile

Hybrid work environments require ongoing negotiations of workspace composition, where workers engage in a broad variety of work arrangements [31]. One of the main challenges in making hybrid meetings radically mobile is the difficulty of including remote participants in mobile collaboration, as communication channels cannot be used in the same ways as in co-located collaboration. Landowski et al. [31] point out that hybrid configurations are often avoided, as remote participants lack the implicit information and awareness needed to fully engage in a meeting's social dynamics. This points to the need for creating a more inclusive setting for hybrid collaboration, where remote users can participate in dynamic, mobile meetings to foster more informal, unstructured settings. Yet, existing hybrid technologies fail to support such scenarios.

Multimodal technologies, which leverage different sensory modalities beyond visual and auditory channels, hold potential for addressing this gap.

Our findings extend prior work by highlighting the heightened complexity introduced by mobility in hybrid collaboration and underscore the need for lightweight design of multimodal tools. Table 3 provides a synthesized summary and comparison of challenges in traditional hybrid meetings and radically mobile hybrid meetings, highlighting the amplified complexities introduced by mobility. It demonstrates how our work extends prior research by exploring these challenges and addressing mobility in hybrid collaboration through the use of multimodality. We further map specific modalities explored during the co-design sessions to address these challenges effectively, thus introducing multimodality as a critical dimension for enabling radically mobile hybrid collaboration.

In radically mobile hybrid meetings, the absence of high-bandwidth visual communication significantly intensifies challenges such as conveying social cues, managing turn-taking and interruptions, and directing conversation without spatial or visual context (Table 3, leftmost column). We found that these issues, while present in traditional hybrid meetings [29, 38, 45], are amplified in radically mobile contexts. For instance, traditional videoconferencing features used in hybrid meetings, like the common 'raise hand' function, rely on screen-based interactions that are impractical in mobile settings, necessitating mechanisms based on alternative modalities. Our work shows that multimodal feedback – particularly through subtle haptic and visual cues (Table 3, two rightmost columns) – has potential to address challenges of radically mobile hybrid meetings. These cues offer a low-bandwidth, non-intrusive way of maintaining engagement and interaction without relying on traditional videoconferencing tools.

There remains an important balance to strike between attempting to 'fix' the inherent imbalances of hybrid collaboration and designing systems that acknowledge and design with these asymmetries, as Bjørn et al. [7] suggest. Further research is needed to explore how hybrid meetings can become radically mobile and cater to more informal aspects of collaboration.

8.2 Considerations for Design

Unlike traditional hybrid meetings restricted to meeting rooms, radically mobile hybrid meetings require solutions that accommodate

| Challenge | Traditional Hybrid Meetings | Radically Mobile Hybrid Meetings | Explored Modalities |
|-------------------------------|--|--|--|
| Social Cues | Limited, but partially supported via video [26, 44] | Missing visual cues through video due to mobility | visual light colour   haptic temperature  |
| Turn-Taking and Interruptions | Video allows for visual cues, such as hand-raising or nodding [26, 45] | Lack of high-bandwidth visual cues, necessity for alternative modalities | visual light   haptic vibration    |
| Directing Conversation | Limited spatial awareness and gaze direction through video [7, 30] | Amplified limitations without fixed positions or visual indicators | movement  visual light colour  haptic vibration  |

Table 3: Comparison of challenges in traditional hybrid meetings vs. radically mobile hybrid meetings. Our findings extend existing knowledge by emphasizing the amplified complexities introduced by mobility and the need for multimodal tools. In the two rightmost columns, examples of modalities explored in the co-design sessions illustrate potential solutions to address the challenges.

spontaneity, flexibility, and location independence. These considerations are essential for enabling more ad-hoc, informal collaboration between remote and co-located participants.

Participants expressed a strong desire for systems that enable more flexible, location-independent meetings, particularly for situations where formal, structured videoconferencing is impractical. This aligns with prior research which highlights how dynamic and flexible systems are essential for addressing the challenges of distributed collaboration [38], particularly in enabling lightweight, low-bandwidth tools to support awareness and facilitate informal, ad-hoc interactions [21]. Systems designed to support radically hybrid meetings must be easy to use and seamlessly integrated into participants' workflows, which was e.g. discussed as a main advantage of our fictional tool *Feedback Friend*, enabling spontaneous meetings anywhere at any time without carrying cumbersome and inconvenient devices.

Figure 10 outlines the design dimensions explored in our studies and positions the co-design prototypes and design fictions within these. Design considerations for tools for radically mobile hybrid meetings go beyond modalities of interactions, and are connected in an interplay of various design aspects. This overview over the key dimensions emphasizes how modalities work in conjunction with other factors to address the unique challenges of radically mobile hybrid meetings. The prototypes from our co-design sessions, which further inform our design fictions, occupy distinct positions within the design space, showcasing varied approaches to achieving flexibility, mobility, and multimodal interactions. This mapping provides a comprehensive overview of our explored concept and underscores the potential for lightweight, dynamic tools that integrate seamlessly into radically mobile hybrid meeting contexts. We provide this overview of key design dimensions to inspire future research on multimodal alternatives to enable mobility in hybrid

meetings and invite for expansion of the aspects currently explored in our research.

Our findings emphasise the need for non-intrusive modalities that support mobile hybrid collaboration without overwhelming participants or adding complexity. This suggests that future designs should focus on creating tools that are intuitive and low-bandwidth, allowing participants to connect effortlessly in informal, spontaneous settings.

However, multimodal interaction tools for radically mobile hybrid meetings may also require explicit actions for behaviours that are typically negotiated unconsciously [26]. It is crucial to balance the benefits of meeting tools with their potential cognitive and social challenges and explore how they can be effectively integrated into real-world hybrid work scenarios.

Despite these promising directions, there are still challenges in designing technologies that can fully support the diverse needs of hybrid collaboration. One of the key concerns is how to create flexible systems that can adapt to a variety of meeting formats [45]. Our findings point to the need for tools that are not only adaptable but also able to seamlessly integrate into existing workflows without adding complexity to the co-located practice of being mobile for meetings. The social acceptability of multimodal tools also varies across these various contexts and meeting formats, where feedback cues may be perceived differently. Participants of our questionnaire highlighted potential social implications, which points towards a need for future designs to consider the interpretation and acceptance of multimodal feedback.

8.3 Limitations and Future Work

While this study provides valuable insights into the design space of radically mobile hybrid meetings, certain limitations must be acknowledged. Our research generated findings through co-design

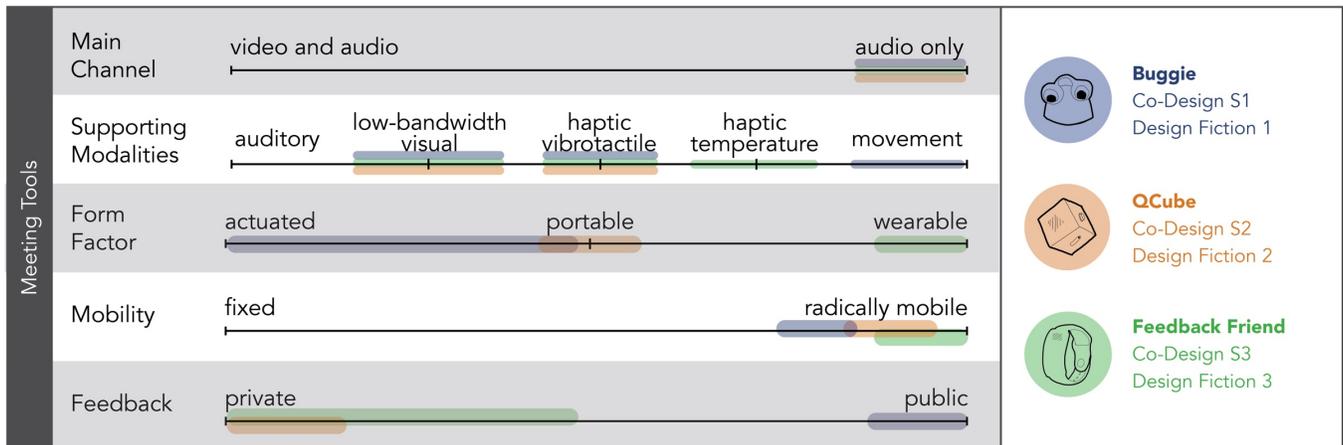


Figure 10: Overview of the key design dimensions for radically mobile hybrid meeting tools explored in this research. We summarise dimensions beyond the modalities explored, highlighting the interplay of further tools design aspects. The placement of the co-design prototypes and design fictions reflects their exploration of these dimensions and demonstrates how different factors connect to address challenges unique to mobile hybrid collaboration.

sessions and design fictions, yet we have not implemented fully functional prototypes based on these insights. Field studies could offer additional perspectives by testing these ideas in real-world environments. Our findings are intended as a basis for future research and design, and must be implemented in practice to confirm and expand the knowledge generated.

Additionally, the participants in our co-design sessions and questionnaire study were drawn from a relatively narrow demographic, primarily involving knowledge workers in flexible work environments. Future research should broaden the scope to include participants from various industries and organisational structures where different collaborative dynamics may arise, potentially extending beyond challenges found in knowledge work, which was the focus of this study due to the companies explored and the target group of participants.

Design fictions are an effective method in sparking discussions and engaging users with potential future scenarios, yet they introduce narrative biases. Future work could explore more diverse methods to evaluate the feasibility and user experience of mobile hybrid meeting technologies in practice.

Moreover, multimodal approaches, by leveraging multiple sensory modalities, hold significant potential for enhancing accessibility in mobile hybrid meetings [1]. Future research should investigate how such approaches could address diverse accessibility and inclusion needs.

9 Conclusion

In this paper, we explored radically mobile hybrid meetings, focusing on the potential to extend the flexibility and spontaneity of co-located meeting practices to hybrid work settings. Through our industry explorations and related work, we identified that meetings in co-located settings are often dynamic, spontaneous, and mobile. However, current hybrid meeting technologies fail to accommodate these needs, leaving remote participants excluded from informal, mobile collaboration. We explore the potential of making

hybrid meetings radically mobile, enabling improved inclusion for distributed colleagues.

In three co-design sessions, we engage participants in prototyping multimodal tools for radically mobile hybrid meetings, addressing both challenges and opportunities, as well as technological approaches. Key issues commonly encountered in hybrid meetings were found to be further amplified in radically mobile settings, with identified challenges focusing around turn-taking and interruptions, social cues, and directing conversation. Our findings highlight the importance of developing technologies that can effectively manage these complexities in dynamic environments.

Through our design fictions, we extended this exploration, envisioning future technologies to support radically mobile hybrid meetings. We conducted an online questionnaire study to evaluate these scenarios, revealing that tools for radically mobile hybrid meetings need to provide seamless support for managing social interactions and flexibly configuring to ad-hoc needs.

We open up the design space for radically mobile hybrid meetings and emphasise the need for future research in this area. To ensure inclusivity and effectiveness, hybrid meetings must become more mobile and adaptive to the fluid contexts of real-world work collaboration. In summary, our research demonstrates the importance of multimodal support and flexibility in designing hybrid meeting tools that can adapt to the dynamic nature of real-world collaboration. By addressing the unique challenges of mobile hybrid meetings, we open up new possibilities for more inclusive and spontaneous interactions between remote and co-located participants.

Acknowledgments

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