

Micro-Practices for Facilitating Participation in Informal Group Activities via Telepresence Robot in Higher Education

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Abstract

Telepresence Robots (TRs) offer remote students a mobile and embodied way to join in-person group activities, yet their role in informal, peer-driven collaboration, such as brainstorming, small-group discussion, and socializing, remains understudied. We conducted a small exploratory study with five groups of university students, in which one member joined each activity remotely via a Telepresence Robot (TR). Using questionnaires, interviews, and video observations, we identified recurring interactional challenges, including limited opportunities for initiating turns and difficulties maintaining shared visibility of physical artifacts due to visual and navigational constraints. We also identified micro-practices employed by on-site and remote participants to routinely support collaboration. These preliminary findings suggest that participation and social connectedness in informal collaboration are co-constructed, rather than solely being provided by the robot's technological features. We outline early implications for educators, students and designers to support shared awareness and smoother interactional coordination in group work mediated by TRs, as well as directions for future research in this space.

CCS Concepts

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

Keywords

telepresence robot, social presence, informal collaboration, higher education, human-computer interaction

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1 Motivation and Background

Videoconferencing techniques are frequently utilised in higher education, but have difficulties in promoting physical engagement and active involvement. In contrast, TRs provide remote users with a mobile, embodied way to navigate physical space and engage in

peer-to-peer interaction in addition to videoconferencing. These robots have the potential to enhance accessibility, such as for students with disabilities or conditions that prevent them from attending in person. Prior work has examined TRs mainly in formal classroom contexts, such as lectures, seminars, labs, and campus life [12, 15, 19]. However, informal peer-driven collaboration, such as brainstorming, small-group discussion, and socializing, has received less attention, even though it plays an important role in student learning and sense of belonging [20]. These dynamic settings introduce interactional challenges for remote participants, including difficulties in turn-taking, interpreting limited non-verbal cues, and managing robot movement [16]. As hybrid education becomes more common, understanding how TRs support informal collaboration is increasingly important. Empirical studies of TRs in formal classroom contexts have found associated benefits in visibility, participation, and belonging, with mobility and self-presentation seen as critical [12, 13]. Barriers such as limited directional cues, low resolution, and ambiguous social signals that can interfere with how others react to the remote person [13, 18]; however, little is known about how remote and on-site students interact with each other and around shared artifacts in informal settings.

In this paper, we present results from an exploratory mixed-methods study with 15 university students across five groups, with one member from each group joining the other two on-site peers remotely through a Double 3 TR. Questionnaire data (TAM, NARS, QUIS and social presence) was complemented by semi-structured interviews and video-based analysis. This study examines university students' experiences of using TRs in informal, non-classroom group work to identify key challenges and considerations for future design. The following research questions guide the research conducted:

RQ1: How do university students perceive the usefulness, ease of use, and sense of social presence of TRs during group activities?

RQ2: What challenges and opportunities do remote participants experience during informal collaboration?

RQ3: How do remote operators' roles and experiences differ from on-site peers?

RQ4: What design and facilitation strategies can improve support for remote participation outside the classroom?

By focusing on informal collaboration, this work contributes empirical insights into the affordances and constraints of TRs for educational contexts, highlights the importance of designing for informal contexts, and provides implications for educational practice, research, and interface design.



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2 User Study Methods

We conducted a mixed-methods study to examine how remote students participate in informal group work using a TR, drawing on questionnaires, interviews, and video observations. Attitudinal and behavioral data were triangulated to interpret patterns in remote participation, following mixed-methods principles for cross-validation and credibility [7, 9]. The study received ethical approval by the University of Nottingham’s School of Computer Science, and all participants provided informed consent.

Fifteen university students (aged 20–30) formed five groups of three; in each group, one member joined remotely via the robot while two worked on site. Ten students had HCI/CS backgrounds and five were from other disciplines, and most had little prior experience with TRs. Each 60–75 min session included a pre-study questionnaire, the activity sequence, a post-study questionnaire and interview. The remote participant operated the robot from a separate room for the entire session. All sessions were video-recorded.

A Double 3 TR with mobile navigation and two-way audio–video communication was used. Groups completed three informal activities: idea generation with printed ideation cards, a synthesis task involving organizing materials while narrating actions to the remote peer, and a short socializing interaction. The study took place in a university lab arranged with four activity stations requiring light robot navigation.

Questionnaires measured perceived usefulness and ease of use using TAM [8], baseline attitudes toward robots using NARS [17], usability via QUIS [6], and social presence using items adapted from prior work [2]. These were complemented by brief open-ended questions. Quantitative responses were summarized with descriptive statistics and paired comparisons between pre–post scores and between remote and on-site roles. Interview data was analyzed using reflexive thematic analysis [4, 5], employing iterative coding and results refinement. Video data were examined using multimodal interaction analysis [11], focusing on turn-taking, spatial positioning, robot responsiveness, and role asymmetry. Multimodal findings were triangulated with attitude and interview data to identify convergences and discrepancies across sources, and reveal how interaction was sustained or disrupted.

3 Results

We report three themes derived through triangulation of post-study questionnaires, semi-structured interviews, and fine-grained video analysis, allowing us to relate reported perceptions to observed interactional dynamics. These themes correspond to our research questions regarding perceptions of the TR (RQ1), the interactional challenges and role asymmetries that shaped remote participation (RQ2–RQ3), and the design and facilitation strategies needed to support more stable collaboration (RQ4).

3.1 Usefulness, Usability, Social Presence (RQ1)

Overall attitudes toward the TR were moderately positive. Questionnaire scores showed small changes from pre- to post-study (TAM: 3.36 to 3.20), suggesting stable but cautious perceptions of usefulness and ease of use. As shown in Table 1, social presence received the highest ratings (post $M = 3.80$), indicating that participants felt meaningfully connected when interaction conditions

were favourable. Interviews reinforced this view: several remote operators described the experience as “fun” or “refreshing”, noting they “felt part of the group” when they could follow the activity and contribute to decisions.

Table 1: Summary of key questionnaire results (Likert 1–5).

Construct	Pre (M)	Post (M)	Note
TAM (overall)	3.36	3.20	$\Delta = -0.16$, $t = -0.568$, $p = .579$ (n.s.)
Social presence	—	3.80	$\alpha = .797$
QUIS (usability)	—	3.40	moderate satisfaction
NARS (neg. attitude)	low	—	positive predisposition

Video analysis revealed the moments that supported these positive impressions. For instance, remote operators produced timely suggestions and engaged in turn-by-turn talk when materials were clearly visible, when on-site peers oriented their bodies and artifacts toward the robot, and when roles were well paced (e.g., confirming card placements, narrating actions). These converging findings suggest that the robot supported social presence and participation, but that this sense of presence was contingent on visibility, timing, and the interactional work of peers.

3.2 Remote Issues, Role Asymmetry (RQ2, RQ3)

Across all groups, remote participation was shaped by three recurring challenges. First, *limited visual access* made it difficult to view small printed text or subtle gestures at table distance. Remote students frequently requested that cards be lifted closer to the camera or read aloud. On-site peers often compensated by repositioning chairs, holding materials up to the lens, or narrating the action—behaviours that restored shared visibility but reinforced a helper–recipient dynamic.

Second, *navigation and latency* disrupted conversational flow during station transitions. Video evidence showed lateral drift while moving “straight”, overshoot during turns, and occasional freezes or delays. These issues pulled the camera away from the shared focus and temporarily removed the remote participant from the conversation. Remote operators often verbalised uncertainty (“It’s drifting right”, “I didn’t touch anything”), while on-site peers paused the task or briefly took over navigation.

Third, *interactional timing* contributed to role asymmetry. Remote participants spoke less frequently and typically after explicit nomination (“What do you think about this idea?”). When no invitation was offered, they waited through long stretches of silence and described feeling “just like observing”. On-site peers similarly reported confusion about what the remote operator could see, asking “Can you see this?” before moving materials or making decisions. Groups that developed simple practices—checking visibility, pausing before moving materials, and explicitly inviting remote input—showed more balanced participation.

Together, these challenges indicate that remote operators had the willingness to contribute but depended on peers for access to

Table 2: Video-coded interaction patterns observed in groups

Observed patterns	G
Peers support (moving chairs, holding cards to camera, reading aloud)	5/5
Remote user asking for task status or entry point	2/5
Viewpoint confusion when guiding robot (e.g., remote vs on-site left and right)	3/5
Robot drifts/veers while remote user "moving straight"	4/5
Latency affecting turn-taking or movement timing	5/5
UI glitches / unintended moves (e.g., controls vanish, zoom triggers move)	3/5
Connectivity loss / temporary disconnect	1/5
Remote user disengaged (prolonged silence)	3/5

visual information, turn opportunities, and coordination signals. The resulting interaction patterns were uneven and sensitive to moment-to-moment conditions. The recurrence of video-coded interaction patterns across groups (Table 2) provides a lightweight quantitative grounding for the observed role asymmetries.

3.3 Strategies for Remote Participation (RQ4)

Across all data sources, social presence emerged as a co-constructed achievement rather than a stable outcome of the TR alone. Presence was strongest when on-site peers actively shaped the interactional ecology: orienting their bodies and artifacts toward the robot, lifting cards to the camera, timing invitations before transitions, and repeating missed contributions after delays. These practices stabilized remote involvement by making turn-entry opportunities visible and signalling that the remote participant's perspective mattered. Conversely, when such practices were absent—during rapid table transitions, periods of drift or freeze, or when roles were ambiguous—remote students were easily sidelined. Network interruptions or UI glitches further disrupted participation, with remote users temporarily "falling out" of the activity and requiring reintegration when they reconnected.

Participants proposed improvements that mapped directly onto these breakdowns. For visibility, they requested higher resolution, reliable zoom or magnification for small artifacts, and multiple camera views. For control, they suggested joystick-like input, clearer feedback about movement, and lightweight navigation assistance such as a mini-map. For interaction, participants recommended features such as request-to-speak signals, confirm-before-move prompts, and simple annotation tools (e.g., a pointer or highlight overlay). Several also proposed designating an on-site "remote liaison" to monitor inclusion during fast-paced moments.

Taken together, these findings show that supporting remote participation in informal, artifact-centered collaboration requires a combination of technological enhancements and low-effort social scaffolds. Robust visual access, responsive movement, and explicit turn-taking cues collectively contributed to sustaining social presence, reducing role asymmetry, and enabling remote students to contribute more fully.

Across all data sources, a consistent pattern emerged: remote participation was neither uniformly positive nor uniformly constrained

but fluctuated depending on visibility, timing, and interactional support from peers. Questionnaire results showed moderate usefulness and high social presence, yet interviews revealed that these impressions were contingent on moments when remote operators could clearly see artifacts and were explicitly invited to contribute. Video analysis further illustrated how breakdowns in perspective or control often removed the remote member from the conversational floor, requiring peers to re-establish common ground. When technology, task structure, and peer facilitation aligned, participation was smooth and balanced; when any component faltered, the remote participant shifted toward a peripheral role. This triangulation highlights that effective telepresence in informal collaboration depends on the dynamic interplay of technical reliability, spatial access, and social-scaffolding practices.

These findings also extend prior work by demonstrating that social presence becomes particularly fragile in informal, fast-paced, artifact-centered tasks, where limited perspectives and latency restrict remote members' access to turn-taking and shared materials [1, 14, 16, 20]. Furthermore, they build on existing accounts of embodiment by showing that mobility and height-adjustability alone cannot sustain interactional visibility; social practices are required to make turn transitions, artifact movement, and group decisions publicly accessible to the remote participant [1, 18, 20].

4 Discussion

Our preliminary findings show that TRs can support remote students' participation in informal collaboration, but this participation remains highly sensitive to moment-by-moment interactional conditions. Notably, while post-test questionnaire results indicated relatively high levels of social presence ($M = 3.80$), qualitative accounts revealed that some remote participants nonetheless experienced themselves as observers rather than active contributors. Drawing on video analysis, we show that this tension reflects fluctuating interactional access: remote participants felt socially present when visibility, timing, and peer orientation were maintained, but drifted into observational roles during moments of camera instability, navigation delays, or unscaffolded turn-taking. This suggests that social presence alone is insufficient to guarantee meaningful participation, particularly in fast-paced, informal group activities. This study contributes an empirically grounded description of the micro-practices that sustain or erode remote involvement in informal group work. Prior research has highlighted general benefits and challenges of telepresence [12, 14, 15], but has comparatively little fine-grained evidence of moment-by-moment coordination around shared artifacts [3]. By triangulating our data, we identify the strategies (e.g. visibility scaffolding, explicit invitations, timing repairs, and peer-assisted navigation) that shape participation asymmetry. These strategies explain why remote users sometimes feel included and at other times drift into observational roles, offering conceptual clarity that can inform the design of both robot interfaces and hybrid learning practices.

4.1 Practical Implications

Inspired by the practical implications by [10] for students attending class through TRs, we recommend some *preliminary guidelines* for

educators (E), robot users (U), and designers/developers (D) aiming to support participation in collaborative activities.

E1. Plan for inclusion through verbal prompting. Make turn-taking explicit (periodic, named invitations) and have a rotating *liaison* who watches the robot's view, cues the remote member, and summarizes decisions. Following a move or short dropout, issue a one-sentence summary (e.g., “*You’re back; we were discussing whether to retain X.*”) to reestablish common ground and conversational floor rights. Likewise, consider explicitly re-opening the floor (e.g., “*Remote first on this round*”). Lastly, it may be necessary to retain a second audio or text messaging channel for cues such as “want to speak”, “repeat” or “out of sight”.

E2. Arrangement of space, objects, and people. Leave an empty “robot slot” at every table, as well as clearing aisles and spots with good camera angles for the robot. Share digital copies in advance. During activities using physical materials, follow the steps announce–hold–read–confirm, so the remote member can see and decide with the group. Distribute role support by e.g. rotating readers, artifacts holders, and path clearers, so that particular persons are not always the helpers or the assisted.

U1. Become familiar with the robot and robot norms. Remote users should practice navigation and camera angles, while on-site peers should be aware of the required actions for accommodating the remote person using the robot, such as making room for it and orienting the artifacts relative to camera. On-site peers should be aware as well of the distribution of the labor of reading/holding/clearing amongst themselves, particularly when there are no educators or facilitators assigning these roles. Remote users could self-select into proposing and summarizing to even out the distribution. Remote users should also try to signal that they are moving to a new table (“*Moving to X, hold on*”) and everyone should consider suspending the discussion until the robot is repositioned.

U2. Use inclusion micro-habits. On-site peers should tell what they will show, hold to camera, read only briefly, and check; remote users should request zoom/hold when necessary. Remote people can be proactive if they wish (“*Can I take this one?* ”), ask for repetition after an interruption, and indicate that they wish to talk.

D1. Visual access, control and navigation. TRs should provide reliable zoom/magnifier that works at table distance, and multi-view (wide room + close-up) to aid reading. Joystick-like navigation control and clear status feedback for both remote and on-site users (e.g. “*navigating.../ movement completed*”) are technical functions that can make a great difference for direct and indirect users. In addition, more complex features can be implemented, such as a mini-map, with room waypoints, and allowing on-site peers to drop visual beacons that the remote user can target.

D2. Turn-taking cues, reconnection support and liaison role functionality. Features such as a request-to-speak sign, prompts to confirm actions before moving items, and visual indicators displaying the current speaker can facilitate clearer communication and foster a more comfortable and efficient collaboration environment for both in-person and remote team members. Exploring the use of emerging AI and Large Language Model technologies to summarize the most recent points following brief disruptions

can facilitate the remote user to reconnect efficiently. Assigning a rotating “remote liaison” role or embedding a checklist of simple facilitation cues may help on-site peers sustain inclusive practices.

5 Conclusion and Future Work

This paper presented a mixed-methods study of informal, student-led group work involving a TR. By integrating questionnaires, interviews, and fine-grained video analysis, we provide evidence that remote students can meaningfully participate in collaborative tasks, but that their involvement remains fragile and highly dependent on visibility, timing, and peer facilitation.

The study contributes an in-depth account of how social presence is established, disrupted, and repaired in fast-paced, artifact-centered collaboration. Remote participants’ reduced access to non-verbal cues and shared materials led to asymmetries that were only partially mitigated by compensatory actions from on-site peers. These findings reveal latent coordination challenges that are less visible in structured classroom contexts. The primary contribution of this paper is the identification of initial micro-practices that facilitate participation in collaborative group activities that involve a remote person via a TR.

However, the small sample size and single-session encounters limit the generalizability of the findings and do not capture how participation and coordination might evolve over time. Insights were also derived from only one telepresence platform (Double 3), restricting our ability to compare how different embodiments, control interfaces, or sensing capabilities affect collaboration. The participant group lacked diversity in terms of learning needs and accessibility requirements, leaving open questions about how TRs may support students with disabilities or those who rely on alternative modes of communication, and that already experience different forms of exclusion in everyday life.

Future work should explore longer-term deployments (e.g. multi-week or semester-long use) to understand how groups develop routines, repair practices, and shared norms for remote participation. Comparative studies across robot types (e.g. with variations in mobility, field of view, controls, or augmented interaction features) would further clarify which design characteristics most effectively support equal participation. Broader participant samples, including individuals with different accessibility needs or cultural communication styles, would provide deeper insight into how telepresence systems can be designed and integrated to support more inclusive hybrid learning environments. Likewise, the target group of this study was university students; future work should investigate contexts beyond higher education.

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