

# Design Heuristics for XR Tools to Support Social Presence in Hybrid Teams

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## ABSTRACT

Our study employs Design Based Research (DBR) to produce a set of design heuristics for Mixed Reality (XR) tools that can support distributed teamwork. Our current design cycle explores students' views relating to their experiences of engaging in hybrid based transdisciplinary teamwork via the MS Teams platform, within the context of the CHARM-EU MSc in Global Challenges for Sustainability.

## Concepts

• Information systems→Information Systems Applications.

## Keywords

Mixed Reality; Social Presence; Design Based Research; Design Heuristics; Distributed Teamwork; Distributed Cognition.

## 1. INTRODUCTION

Online distributed teamwork has been popular since the arrival of cheap domestic broadband and has unsurprisingly become more common in recent years. However distributed teams are more prone to lack cohesion than co-located teams due to their reduced capacity for communication when it is mediated via technology (Bubaš, 2001). Mixed or extended reality (XR) is proposed as a technology that can overcome some of the challenges that teams face when communicating online. We describe XR as a continuum of experiences ranging from augmented reality (AR), through inter-realities (IR) such as live feeds into virtual spaces, and ultimately fully virtual reality (VR). XR represents a significant improvement in our ability to communicate. Such tools and environments are claimed to promote a sense of shared presence and social “closeness” in users due to their experience of virtual co-location (Witmer & Singer, 1998; Gee, 2004; Castranova, 2007). Our research examines the potential for such XR applications to support the increasingly popular activity of distributed professional and student teamwork.

When communication is mediated via technology, new challenges arise for teams. Short, Williams, & Christie's (1976) work on Social Presence showed that computer mediated communication reduces social context cues between individuals, which results in a reduced sense of social presence for those involved. Siegel et al. (1983) applied Social Presence theory to a study of group communication, where they showed that remotely connected teams made fewer remarks and took longer to reach consensus than co-located teams. Social presence can be described as the feeling of being there with somebody else. The term represents that feeling of being connected to another person in a social

situation. Short, Williams and Christie (ibid) claimed that communication media afford varying degrees of social presence based on their ability to transmit social cues. Social cues are those countless little expressions, either verbal or non-verbal (and frequently subconscious) acts that we employ to indicate to others how engaged we are with a social situation. Reading a social cue can offer some insights into the intentions of others (Phillips et al, 2011) and they have been shown to help establish trust (Xin et al, 2016). Social presence continues to be an increasingly popular lens with which to view engagement and the quality of connections between users of virtual spaces (Shirish, 2018).

The following research questions have emerged from a review of relevant literature in the investigation of this topic.

- How can we best use XR to mitigate the sense of social isolation that is frequently reported by remote workers in distributed teams?
- How can we leverage this sense of connection to support distributed transdisciplinary teams of students in constructing their own workflows and processes?

## 2. METHODS

A conceptual framework was developed to structure a literature review and identify the state of the art regarding design rules for multi-user virtual environments. Our aim is to contribute to the current knowledge in this domain by producing our own set of design rules, or heuristics, that will support social presence in virtual teams with the goal of improving team bonding and potentially faster convergence of shared mental models in novice teams.

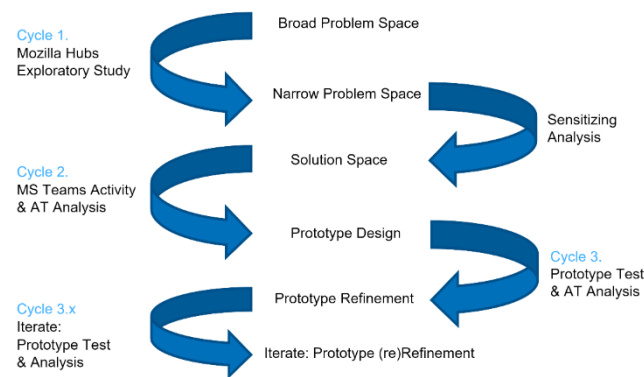
Our literature review suggested the following themes, which were helpful inputs into the design of cycle 1.

- The first design cycle needed to explore teamwork challenges in XR
- We recognized the necessity to include insights from students, stakeholders and communities of practice.
- Our study would aim to identify tensions or contradictions within teamwork activities that arise from the use of software tools; leveraging Cultural Historical Activity Theory, (Leontiev, 1978).
- Our study would leverage Distributed Cognition of Teams (DiCoT) principles, (Blandford & Furniss, 2005).

As the study applies a Design Based Research (DBR) approach (Fig. 1), an initial exploratory design cycle was conducted in the

Mozilla Hubs virtual environment with undergraduate students from the CHARM-EU 2019 Winter School. Students (n=7) met in a purpose-built Hubs meeting space as part of a social evening at the end of the Winter School. During the session they were encouraged to follow a pair activity where the first student needed to create a virtual object in the world and their partner would then edit it to add a hyperlink to a web resource. Of these students, a subset of the cohort (n=4) agreed to join a semi-structured group discussion activity based on themes from our literature review. This activity was then followed by a set of individual interviews with interested students (n=2), and the analysis of these was helpful in identifying topics for deeper investigation in subsequent cycles.

Our current design cycle (cycle 2) seeks to identify heuristics that can inform design rules for mixed reality team interfaces, which we aim to test with a prototype, designed using the heuristics in cycle 3.



**Figure 1. Proposed DRB cycles.**

Cycle 2 focuses on four individual teams from the first two cohorts of the CHARM-EU MSc. Three capstone teams (i.e., final year) were tasked with an exploratory group activity based on concepts from Cultural Historical Activity Theory, which views all activities as being mediated and modified by extrinsic factors. In this activity, teams were asked to identify any such factors that they recognized in their own teamwork projects and to record these on a worksheet. They were asked to consider how technology tools might have modified their teamwork while completing the worksheet. The activity was followed by a set of semi-structured team focus groups. A fourth group of students in their first year of the MSc were opportunistically included and while they did not yet have direct experience of a prolonged online project, they had a good deal of experience working in groups on MS Teams for class activities and a term long project. We note here that this fourth case included a blend of students from several first-year teams, rather than one complete team as with the capstone students. A focus group observation protocol was then created which was based on inputs from cycle 1 and relevant heuristics for online team interactions that we identified in our literature review. Four, one-hour focus group sessions were then conducted, where we explored what students thought of their online team interactions, how the software tools and environment modify or otherwise influences their work, and any workarounds that the students employed to overcome tensions or roadblocks in achieving their team project goals.

**Table 1. Cycle 2 Cases**

Case	Participants	Composition	Typical Team Sessions	Focus Group Format
1	5	Individual Team	Hybrid	Hybrid
2	4	Individual Team	Online	Hybrid
3	6	Individual Team	Co-located	Hybrid
4	7	Mix of several teams	Hybrid	Co-located

## 2.1 Analysis and Preliminary Findings

As the aim was to explore student views, there was a clear rationale for utilizing inductive coding. However, given the considerable body of relevant CSCW research that we had identified in the literature review, it was deemed important to opt for a blend of inductive and deductive coding. A set of pre-determined deductive codes was drawn from the literature research to form part of a conceptual framework. This approach gave us confidence that we could explore relevant teamwork themes while also ensuring space for student centered perspectives.

Deductive Codes were based on the following sources which we selected from our initial literature review, plus themes from cycle 1.

- Team interactions and processes informed by Activity Theory (Leontiev, *ibid*)
- Social Presence Indicators (Short, Williams and Christie, *ibid*)
- Expressing Intimacy - (Argyle and Dean, 1965) - physical distance, eye contact, smiling, and personal topics of conversation
- Immediacy (Wiener and Mehrabian, 1968) - a measure of psychological distance
- Social Expressions (Rourke, Anderson, Archer, and Garrison, 1999) - (Affective, Interactive, Cohesive)
- 21st Century Skills (Ravitz et al, 2012) - (Technical and socio-technical)
- Developing Shared Mental Models (Cannon-Bowers, Salas, & Convers, 1993)

After completing our deductive code book, we set it aside and began an inductive coding step as a first pass of our focus group transcripts. We then completed the deductive coding and are now in the process of triangulating both data sets to identify overlapping constructs. Our process has resulted in 69 codes in total (39 inductive, 30 deductive).

**Table 2. Top 10 occurrences of deductive and inductive codes**

Deductive codes	Refs	Inductive codes	Refs
Naturalness Principle	18	Desire for social cues	31
Suitability of tools to	12	Communications	24

tasks		Preferences	
Clarity of expression	12	Adapting to technology	21
Social protocols	12	Team Bonding	20
Giving and receiving feedback	10	Preference for in-person	20
Tool usage patterns	8	Reduced Social Presence	19
Developing shared mental models	6	Communications Tactic	18
Consequences of tool use	5	Work Practices	17
Working in multiple contexts	5	Limitations of technology	14
Effort to change	5	Division of labour	13

Cycle 1 produced the following areas where difficulty was noted by users as important factors for multiuser software.

- Establishing conversation was initially seen as challenging or confusing for most students, which most reporting that their lack of experience with the platform blocked their ability to communicate in a natural way.
- In an asymmetric pair-work activity where students were asked to complete a short multi-step task sequentially, we noted that students required a lot of prompting between one another to complete the sequence for their role.

Our cycle 2 analysis is ongoing however the following indicative themes are noted as emergent, based on frequency of code instances at this current early stage of our analysis (Table 1/2). It is apparent that CHARM-EU students are concerned with the topic of effective distributed teamwork and are enthusiastic about seeking solutions. In all cases students expressed a considerable desire for more social cues in their online team-based communications. They recognize that their communication tools limit their interactions to the extent that they feel unnatural. Students question the suitability of platforms like MS Teams to support their communications, although they are willing to adopt new workflows to overcome communication barriers, most notably giving and receiving extra peer feedback to ensure that they were understood by teammates.

### 3. PRELIMINARY HEURISTICS

Our early analysis suggests that our students recognize when social cues are filtered by communications technology and that this makes them consider their interactions to be unnatural vis-à-vis in-person sessions. They report that the inability to recognize direct eye-contact or control their proxemic distance both make them feel less socially present in online teamwork. This is consistent with Short, Williams and Christie's (1976) work on Social Presence as well as Edward Hall's (1966) work on proxemics. Students report that workarounds feel unnatural to them, which suggests that purposeful sharing of social cues may be problematic although this may depend on the type and frequency of cues being transmitted. We therefore infer the

following preliminary heuristics, which we plan to test in future design cycles.

**Table 3. Preliminary Heuristics to be tested in cycle 3.**

Area	Reference	Implied heuristics	Potential design rules
Teamwork theories	Tuckman, 1965; Inverardi & Tivoli, 2009	Tool should adapt to the users changing requirements	Users should be able to change settings
	Katzenbach & Smith, 1993	Assist users to be more specific in communication	Encourage voice chat. Don't automatically mute microphone; Allow for multimedia where appropriate; Accept gestural inputs; Don't force fixed perspective or positions onto users relative positioning.
			Recognise and manage relative priorities
		Employ a clear working approach	Adhere to best practices in our arrangement and style of audio-visual information
	LaFasto and Larson, 1989	Support intra-team feedback	Offer dedicated communication channels for feedback
Cognitive Dimensions	Green and Petre, 1996	Green and Petre produced 14 heuristics in total, but most relevantly: Abstraction gradient, Closeness of mapping, Consistency, Diffuseness & Progressive evaluation.	A variety of design rules relating to how users access and process information in a software tool.

Shared Mental Models	Salas et al, 2013	Offers supports for “roles and responsibilities, team mission objectives and norms, the environmental context, and team familiarity”	Include reminders, checklists and project or task management features
UX literature	Myers et al., 2000	Avoid assumptions regarding team member skill or dexterity levels	Begin with simple UI's
		Avoid overlapping layouts	Present feature in sequence
		Don't require the user's full attention	Users can easily dismiss and recall UI elements
	Rosenfeld, et. al, 2015	Rules for "labels, menus, descriptions, visual elements, content, and their inter-relationships	Be clear and concise
XR UX	Girvan, Tangney & Savage, 2013	The “high-floor” of virtual environments represents a steep learning	Give additional support to novice users. Offer extra guides in-app.
Social Presence	Design Cycle 1	Don't assume users will recognise UI controls	Use explicit labels & icons. Orientate user on first use.
		Provided detailed instructions	Offer guides, checklists and/or task wizards
	Design Cycle 2	Remote teams experience reduced social presence and often miss social cues.	foster social presence by including features that facilitating transmission of social cues between team members
		Interface controls that represent analogues of social cues should not feel unnatural to users.	Triggers for sharing social cues should be either automatic or have a low effort for the user to initiate

## 4. CONCLUSION

The ongoing rise in remote work presents several challenges for student and professional teams, particularly in relation to interpersonal and team communication, reduced clarity and increased confusion regarding team activities and processes. Pragmatic, student/user centered, design-based research is a useful approach to explore the innovative and emerging fields of team telepresence and mixed realities, where many of the rules and protocols for interaction are still being established. Following such an approach can help us to create tools that foster social presence and more meaningful team interactions, and distributed teams in particular can benefit from developments in the field to create closer connections and clarity of purpose in their teamwork. We welcome comments from the forum regarding our approach and future design cycles.

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