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Fostering Group Work in Virtual Reality Environments: Is Presence Enough?

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Abstract:

Previous research on Virtual Reality (VR) has been largely concerned with individual users' engagement in domains such as healthcare and gaming. Our study extends this research by investigating group work within a professional development context. Grounded in Construal Level Theory, we examined the experience of spatial, social, and temporal presence within immersive VR learning environments and their impact on group dynamics. Qualitative data were collected from participants undergoing an extended reality instructor certification, including VR session recordings, reflections, and focus groups. Findings confirm the influence of presence on local and global group dynamics; additionally, we find that the effects of presence on group dynamics are moderated by VR task-technology fit. Our study contributes to a richer understanding of three dimensions of presence in VR environments for group work. Based on our findings, we have proposed relationships between various facets of presence and group dynamics.

Keywords: Virtual Reality, VR Campus, Presence, Group-Work, Construal Level Theory, Group Dynamics.

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1 Introduction

Virtual Reality (VR) has emerged as a powerful tool for individual learning, gaining popularity due to its high engagement potential (Su, 2022; Allcoat & von Muhlenen, 2018). Research consistently shows that a key factor in VR's effectiveness for user engagement is the strong sense of *presence* it can evoke (Huang et al., 2021; Slater et al., 2009). *Presence* refers to the feeling of being truly immersed in a virtual environment, a subjective perceptual state where the virtual world is experienced as the dominant reality (Schuemie et al., 2001; Schwind et al., 2019). This perceptual state is also understood as the subjective feeling of being "closer" to the virtual physical space, people, or moments (Nam et al., 2008; Slater & Wilbur, 1997). Therefore, presence is the experiential manifestation of low psychological distance within the VR context. According to Construal Level Theory (CLT), psychological distance encompasses spatial, social, and temporal dimensions (Trope & Liberman, 2012). When users feel a sense of presence, they engage in a more concrete, lower-level construal of their experience, which is expressed through the dimensions of spatial, social, and temporal presence (Elder et al., 2017). Prior studies have demonstrated that a heightened sense of presence across these dimensions enhances user engagement and learning in diverse fields like education, healthcare, and gaming (Egan et al., 2016; Laarni et al., 2015; Bystrom et al., 1999).

Building upon the demonstrated efficacy of VR for individual learning, recent years have witnessed a surge in VR-based multi-learner environments offering diverse spaces for meetings, presentations, and networking (Abi Raad & Odhabi, 2021; Singer, 2021). This trend is evident in the growing number of university VR labs (Animation Career Review, 2023) and the increasing adoption of VR and Augmented Reality (AR) in employee training (56% of global businesses) (Grid Raster, 2024). Given these substantial investments in virtual technologies for professional development, it becomes crucial to investigate how learners experience, perceive, and interact within VR spaces that are modeled as real-life campuses, thereby informing the effectiveness of these burgeoning educational and training approaches.

Additionally, our review of existing research on VR revealed a focus on individual learning outcomes (Haryana et al., 2022; Li et al., 2020; Chavez & Bayona, 2018), and limited research has explored its impact on group work and group-level outcomes. Given the prevalence of group work in professional settings, including the increasing number of globally distributed teams (Blanchard Research, 2024), a crucial question arises: Can VR effectively facilitate group work, especially when 2D platforms like Zoom and Teams, with features like breakout rooms, are already widely used? We know from the study by Bystrom et al. (1999) and subsequently supported by education researchers that interactive platforms help learners; in fact, a clear link has been established between the sense of presence in immersive environments, such as VR, and individual performance. Consequently, a more specific and critical question emerges: *Does the sense of presence in VR directly translate to improved group outcomes?* Building on the work of Abdulla et al. (2019), who found that VR can enhance group work skills by fostering collaboration in a problem-based learning context, our study investigates the relationship between spatial, social, and temporal presence and group dynamics.

We apply an abductive research process (Fisher et al., 2021; Sætre & Van de Ven, 2021) to investigate VR-based professional development group work. The empirical context is an immersive VR campus, named Edstutia, designed for collaborative learning and professional development. Users in this VR campus, typically interact with this 3D virtual campus environment using a head-mounted display (HMD), such as an Oculus device. The participants of this study were enrolled in the multi-learner VR-based training solutions primarily focusing on leadership and soft skills development. All participants were professionals seeking to enhance their confidence and competence in leveraging VR within their respective organizations. Qualitative data for this study is derived from participant reflections on group work in the penultimate session of training for seven different cohorts (2021-23) and two focus groups conducted in 2023 and 2024.

The findings of this study have significant implications for the further development of VR-based group work in both higher education and corporate contexts, particularly given the increasing prevalence of hybrid and remote learning (Abi Raad & Odhabi, 2021; Singer, 2021), alongside hybrid and remote work (Shanbhogue, 2023; Yarborough, 2024). We conclude by proposing six key testable propositions about the components and facets of social, spatial, and temporal presence experienced by participants in the VR campus, which positively impact both local and global group dynamics, a crucial group-level outcome.

2 Background Literature

We have structured this section by first synthesizing previous literature on VR technology for learning and training, with a particular focus on studies investigating user experiences in VR environments for engagement, learning outcomes, and group work. Next, we elaborate on findings from prior studies directly relevant to our specific context: group work within a multi-learner professional development VR platform. We highlight that these previous studies largely explored VR integration into traditional coursework, often with a focus on individual outcomes. Notably, we extend this body of research by specifically investigating user experience in VR and its implications for group-level outcomes. In this section, we also summarize relevant work outside of VR research on group-level outcomes. Finally, we introduce our theoretical framework and present of our research model, grounded in previous studies.

2.1 VR for Learning and Training

Given the emerging nature and varied use cases of VR technology in learning, previous research has explored the experiences it provides to individuals across numerous contexts. A significant body of work has investigated individual-level outcomes in areas such as healthcare and psychological skills training, with studies examining everything from the use of virtual objects in clinical settings (Lee et al., 2014), training of instructional designers (Lee et al., 2014), corporate training (Criollo et al., 2024; Brayshaw et al., 2023; Sounti et al., 2022; Muth et al., 2021), technical communication (Tham et al., 2018) to managing anxiety during public speaking (Wallach et al., 2009). Researchers have also measured the impact of VR on individual learners through physiological metrics, such as eye scans and heart rate (Egan et al., 2016; Jordan & Slater, 2009), and have highlighted VR's effectiveness in eliciting emotional responses for training purposes (Diemer et al., 2015). These studies collectively suggest that VR can provide impactful learning experiences for individuals. It is important to note that most of this research has focused on individual-level outcomes. While some exceptions exist, such as Biocca et al. (2001), who demonstrated VR's efficacy in enhancing group-based medical learning. Overall, the overwhelming majority of studies have not focused on group-level outcomes. A key concept in the individual-focused research is presence, where a strong sense of "being there" in the virtual environment is shown to positively influence engagement and contribute to learning (Jordan & Slater, 2009; Egan et al., 2016).

Notably, since 2020, a new wave of articles has explored the intersection of VR for learning in a post-pandemic context, investigating learners' perceptions and organizational outcomes for new virtual learning modalities (Criollo et al., 2024; Brayshaw et al., 2023). These studies demonstrate that VR can be effectively incorporated to enhance individual skills such as storytelling strategies (Fisher & Samuels, 2021), investigating how VR-delivered training can translate to real-world performance (Cooper et al., 2021). However, these studies, while relying on a wider range of survey-based measures, do not investigate learners' subjective experiences of specific interactional activities or elements within VR environments. This is where our study comes in. We are interested in understanding learners' subjective experiences in response to activities and engagements in VR, specifically within the underexplored context of group interactions. Additionally, our review indicated a paucity of studies investigating VR's role in professional development contexts, a gap our research aims to partially address. Specifics of our context are detailed in the methodology section of the paper.

2.2 Group Level Outcomes

Our review revealed that research on group-level outcomes in VR environments for learning and training is relatively limited, with most studies focusing on dyads (Wei et al., 2022). To address this gap, we extended our review to include findings from studies involving larger groups. For instance, Moustafa and Steed (2018) found that interpersonal aspects of pre-existing groups remained unchanged during their VR interactions. Pedersen and Koumaditis (2020) also demonstrated that VR can facilitate synchronous, remote collaboration, thereby enhancing learning. Similarly, Hennig-Thurau et al. (2023) showed that creativity in group submissions depends on various interaction-related factors experienced in VR, while Han et al. (2023) investigated how manipulating virtual environments affects the evolution of group dynamics among students. Despite these insights, a comprehensive understanding of drivers of positive group-level outcomes in VR remains limited. To broaden our perspective, we also reviewed studies on group work in traditional and 2D immersive environments. We found that scholars frequently reference Astin's college impact model (1996), which highlights the link between students' involvement with each other during group work and overall learning outcomes. Group dynamics is another key outcome of interest, often operationalized as a multidimensional construct. For example, Mannix and Neale (2005) measured it as a higher-level outcome of team performance, while Caruso and Williams Woolley (2008) focused on emergent interdependence and effective engagement. Researchers have also investigated group forming and norming as both an outcome and a process (Tuckman, 1965). Building on this existing research, we aim to investigate group-level outcomes as subjective understanding of group dynamics, recognizing that a group's outcome is "more whole than part"—not just a summation of individual experiences (Cronin et al., 2011).

2.3 Construal Level Theory (CLT) and Presence

We are interested in understanding the relationship between the experience of working in a VR environment and subsequent group-level outcomes. Our extant review revealed that CLT (Trope & Liberman, 2012) provides a suitable theoretical lens for this investigation. CLT helped us in theorizing the experience of being in VR and working with a group, by relating to mental constructs formed by learners as they describe their interactions with the VR environment and group members (Cahalane et al., 2022). According to CLT, cognitions of psychological distance—defined as the distance between an individual and an object, event, or person—are manifested as subjective experiences (Elder et al., 2017). In the context of VR, this experiential manifestation of psychological distance is conceptualized as presence (Cahalane et al., 2022; Trope & Liberman, 2012). That is, a learner's subjective experience of being "present" in the virtual environment is the primary way the cognition of low psychological distance is manifested in VR. Consistent with research by Usoh et al. (2000), we conceptualize presence not as a singular dimension, but as a construct composed of spatial, social, and temporal dimensions. These dimensions are the specific facets through which users experience and describe their interactions in VR. For example, a learner's sense of spatial presence and temporal presence is their subjective experience of being 'there' in the virtual space (Weidlich et al., 2024) at that time (Vincent & Frewen, 2023), which reflects their psychological proximity to the VR environment. Similarly, social presence is the feeling of being with others and reflects psychological proximity to group members in VR. We argue these dimensions are not antecedents of presence, but rather the constituent parts that, when combined, define the user's overall sense of presence. Overall, the foregoing discussion, along with the study by Elder et al. (2017), suggests that mental representations of constructs pertaining to a learner's perception of psychological distance in VR (involving space, people, and time) are expressed through a subjective and vivid sense of presence (Schuemie et al., 2001; Schwind et al., 2019). To state it another way, presence is the experiential manifestation of psychological distance in the VR context spanning across spatial, social, and temporal dimensions (Weidlich et al., 2024). This, in turn, can concretely influence interactions among learners in VR working together in a group. As users' sense of presence in VR environments increases, it makes them more involved with the moment, people, and elements in the VR (Trope et al., 2007; Uhm et al., 2022). Therefore, CLT provides an apt theoretical framework for understanding the relationship between presence and group-level outcomes in VR training environments.

2.4 Construal Level Theory (CLT) and Group Dynamics

Previous research often defines group-level outcomes through indicators such as complementary leadership, role stability, and role differentiation, which are collectively known as group dynamics (Bales & Strodtbeck, 1951; Mannix & Neale, 2005; Caruso & Williams Woolley, 2008). CLT proposes that these dynamics are influenced by an individual's developing cognitive understanding of working with group members (Delice et al., 2019). For example, Wilson et al. (2009) extended CLT to distributed teams, demonstrating how reduced psychological distance—manifested as increased presence—positively impacts group interactions and decision-making. Despite these insights, limited research has examined group dynamics as a specific outcome in virtual environments. Our study builds upon this by applying CLT to guide our research on group dynamics in work groups in VR. In this study, we consider a group as a work group composed of individuals who share a common goal and work together to achieve it (Campbell, 1968; Carron et al., 1985). We rely on McGrath and Argote's (2001) categorization of group dynamics, specifically focusing on local and global dynamics. Local dynamics refer to the immediate, observable interactions between individuals that occur within the group. These are the moment-to-moment behaviours that constitute the work process. Examples include individuals coordinating a specific task, offering help to a group member, or using shared resources within the immediate virtual context. This category captures the micro-level behaviours of group members. Global dynamics, in contrast, refer to the broader, more abstract factors that define the group as a whole and shape its overall effectiveness. These include the development of group identity and cohesion, overcoming internal conflicts, and the group's collective ability to work towards improving overall task performance. Building on this categorization, our study aims to precisely capture how the presence experienced in VR influences both the micro-level behaviors and the macro-level outcomes of group dynamics.

In the next section, we build our research model from previous studies, inspired by Cornelissen's (2023) approach to abductive reasoning in management research, to examine the practical phenomenon around work groups in VR.

2.5 Research Model Development

Our theoretical framing of study by applying CLT enables us to understand the relationship between various dimensions of the learner's experience of presence and group dynamics in the VR environment. Presence here involves spatial, social, and temporal dimensions while group dynamics include both local and global dynamics. Spatial dimension of presence, i.e., spatial presence pertains to the feeling or state of 'being there' within an environment, such that one occupies space meaningfully and interacts with the surroundings authentically. Spatial presence can be abstracted from the learner's experience of how they can interact with the VR environment and an increased sense of being in VR (Wirth et al., 2007). Therefore, learners can perceive themselves as spatially present and articulate this perception when discussing their VR experiences. Studies by scholars such as Mavri et al. (2020), Hew and Cheung (2010) underscore the role of spatial presence in creating engaging and effective learning environments. Berkman and Akan (2024) suggest that spatial presence can enhance the engagement and motivation of users of VR platforms. Kumari et al. (2023) emphasize the role of VR in overcoming physical space related barriers and creating interactive learning environments when participants feel spatially present. Overall, previous research indicates that spatial presence can drive interactions among learners. Also, we know that increased interactions among learners contribute to group dynamics. Based on this, we propose that an increased sense of spatial presence will positively influence both local and global group dynamics.

Previous research underscores the critical role of social presence in shaping individual-level outcomes within virtual environments. Social presence refers to the perception of 'being there' with others and having the capacity to reach out for social interactions (Nash, 2018; O'Leary et al., 2014). It is the sense of engaging with others and doing social interactions, such as clapping together (Harms & Biocca, 2004). Vincent and Frewen (2023) provide evidence of the enhanced social presence afforded by VR in live sports viewing, demonstrating the technology's potential to create more engaging experiences. As Biocca (1997, p. 2) explains, social presence encompasses the perception of "access to the intelligence, intentions, and sensory experiences of another." Seufert et al. (2022) demonstrated that a heightened sense of social presence within VR-based training enhanced participant engagement and learning outcomes. Bozgeyikli (2021) further emphasized the importance of interactive design elements in fostering social connection and, consequently, the paper theorized that the perception of social presence contributes towards meaningful social interaction. In the corporate realm, Friess and Gnadlinger (2021) investigated the implications of social presence on behavioral outcomes and highlighted the role of social presence in building trust and facilitating collaboration among remote teams. Oksanen (2013) provided empirical evidence of the positive impact of social presence on group formation and cohesion within a VR-based collaborative game. In the case of group-based assignments, social presence is particularly relevant for ensuring interactions and connection (Short et al., 1976). Thus, social presence could potentially positively impact local and global dynamics within VR-based learning environments.

Temporal presence encapsulates the subjective experience of an individual's location within the timeline of a virtual environment. Here, temporal presence means experiencing the interactions in VR as if they were happening *now* (implying the time portrayed in VR) (Vincent & Frewen, 2023). This construct, crucial to user engagement, remains relatively understudied in the realm of VR. Saker and Frith (2019) contend that VR creates a temporary dominant experience where digital time overpowers physical time. Similarly, Chung and Gardner (2012) explored the relationship between temporal presence and skill evolution in first-person shooter games. This also aligns with findings from Förster et al. (2004), who demonstrated that temporal presence could influence cognitive processes, such as abstract thinking and creativity, suggesting that manipulating temporal cues in VR could similarly impact group collaborative outcomes. Building upon these studies, we anticipate that similar temporal presence-related experiences could benefit interactions among learners working in groups within multi-learner interactive virtual environments. Thus, we posit that temporal presence will positively influence group dynamics.

Overall, within the broad framework of CLT for group work in VR (Figure 1), we expect to see a positive relationship between three dimensions of experience of presence and improvements in group dynamics (Neeley, 2015; Wilson et al., 2009).

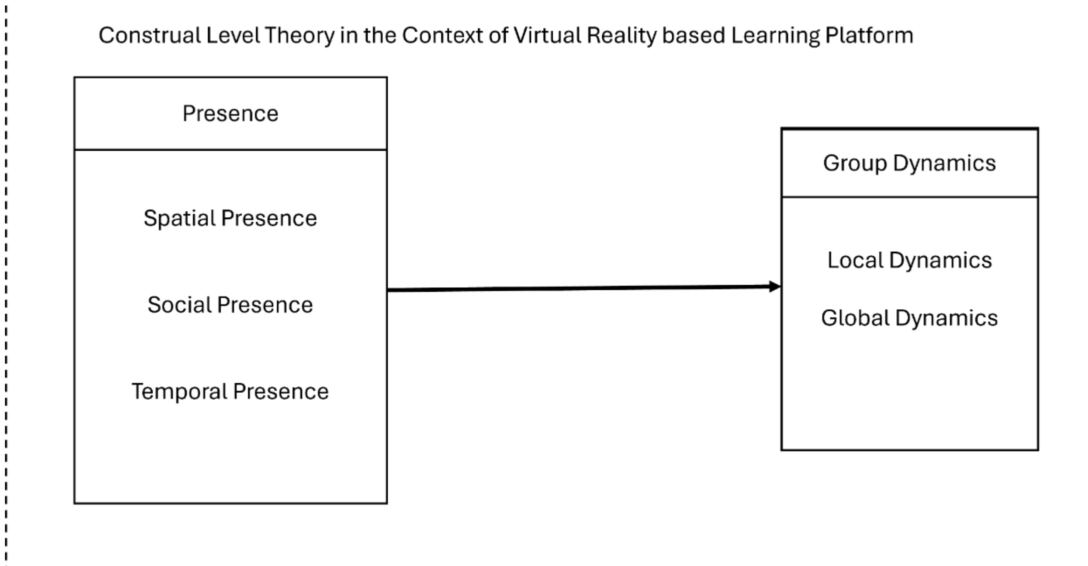

Figure 1. Research Model

3 Methodology

We conducted a qualitative study to investigate experiences of presence as an antecedent for group dynamics in VR-based professional development. Based on a comprehensive literature review, we developed an initial framework (Figure 1, discussed previously), emphasizing the importance of framing research questions with practical significance, as recommended by Alvesson and Sandberg (2023). This framework informed our data collection and analysis, aligning with the principles of abductive reasoning (Sætre & Van de Ven, 2021). The research design and data collection protocol were approved by the TouroNY-IRB (IRB 19298).

3.1 Data Collection and Analysis

Data was collected from participants of a VR training course on the Edstutia platform. Edstutia is an immersive learning company that designs VR-based learning programs for academic and corporate clients. Edstutia's platform is created with a "campus" layout with multiple spaces for meeting and collaboration (See Figure 1 in Appendix A for options of spaces available on the VR campus). Their flagship product is the Instructor Certification in Extended Reality (ICXR), a train the trainer program intended to help learning leaders, instructional designers, and university professors integrate immersive technology into corporate training and academic curricula. The program is a live, instructor led, cohort-based online course with 11 sessions meeting on Zoom and on the Edstutia VR campus. The VR campus platform is accessible through the Meta App Store (Meta Horizon) via headset-based and desktop-based versions. Edstutia has used the hub and spoke model to create interactive VR environments on a single "campus," including the ability for group-based communication, meetings, networking, team building, and problem solving, as well as group-based instruction, including virtual collaboration tools and team project-based assessment.

Some examples of Edstutia's VR campus interaction spaces are an amphitheater, a meditation dome, a rooftop bar, and a boardroom (See Figures 2a-d in Appendix A). Participants have access to all these spaces for the duration of coursework to meet with their group members for project-related interactions or join the campus independently (See Figure 3 in Appendix A showing how participants can access these spaces). Sessions are taught by subject matter experts and organized by the Edstutia operations team.

Session topics include VR onboarding, using VR for group and solo learning, instructional design for VR, assessment and outcome measurement within VR, and group coaching for a capstone project. Assessment is based on group work within VR. Each group is tasked with completing a capstone project, namely designing a VR experience using the Edstutia collaboration tools and interactive spaces (a list of topics chosen by participants, along with the pseudonyms referred to in the findings section, is provided in Appendix B). Cohort sizes vary from 3 to 12, and group sizes are 2 to 4 participants in each group. It was recommended that participants meet in the VR campus, along with virtual synchronous meetings with their teammates, to practice their module delivery before the final session. The groups were to make presentations on their topics in the penultimate sessions (Refer to Figures 4a-4d in Appendix A and Appendix C for the screen grabs of sample presentations by groups across different cohorts in VR). After the presentations in the final session, all participants were asked to reflect on their experience of working with group members and specifically about their VR campus-related experiences. These reflections were recorded (session duration is included in Table 1) and became the primary qualitative data for our analysis. By December 2024, the program had certified 104 participants globally. To ensure feasibility of data collection, we focused on 7 cohorts between Sept 2022 and Sept 2023.

The ICXR program has no prerequisites in terms of VR knowledge or experience, resulting in a wide range of VR competence and confidence at the start of the program. Each group had mixed levels of VR skills, resulting in instant interdependence conditions within groups already in week 1 of the program. Details regarding each cohort, number of participants, and group count are provided in Table 1. The participants included academicians and practitioners with diverse professional backgrounds. Their experience spanned geographies including India, Europe, and the United States. The group encompassed some individuals who were frequent VR users in their organizations, while others were first-time VR users who even borrowed VR headsets specifically for this course. Thus, this breadth of VR competence and confidence also gave our study variance across participants, from expert to novice VR users.

Table 1. Cohort and Group Details

Cohort number	Cohort (Year Month)	Count of people	Number of subgroups	Last session duration (reflection session)
1	22 Sept	9	3	99 min
2	22 Nov	3	3	104 min
3	23 Jan	9	3	70 min
4	23 Mar	9	3	110 min
5	23 May	12	3	90 min
6	23 Jun	11	3	27 min
7	23 Sept	6	2	98 min

Additionally, two focus groups were conducted with volunteer participants across cohorts, one held on Zoom and one within the VR campus (See Figures 5a -5c, Appendix A for screen grab of focus group in VR and Zoom). We organized focus groups without the Edstutia executive team present so that participants felt free to speak. We asked users how their experience was as they participated in group work within VR. Details regarding focus group participants are provided in Table 2 and the group discussion guide is provided in Appendix B. Thus, the focus group, along with the last session recordings for all cohort, is the data used for analysis in this article. All reflection sessions (last sessions) and focus groups were audio and video-recorded and transcribed, and then corrected with the assistance of two research associates.

Table 2. Focus Group Details

Focus Group	Participants Details Speaker Number	Modality	Duration
Focus Group 1	1,2,4,5,25,26	Virtual Synchronous	74 min
Focus Group 2	1,2,5,7,8,9,11,19,23,24	VR Campus Board room	56 min

To reiterate, our objective in this research is to identify the relationship between spatial, social, and temporal presence on outcome in group projects in terms of group dynamics (Fisher et al., 2021). For this, we started with the initial research model and refined it with a two-step analysis process. Transcripts were reviewed by the first author and a research assistant to identify qualitative data that aligned with the initial model constructs. Following the process suggested by Boyatzis (1998), we then pinpointed "codable moments," sentences that contain important information or insights within the data about VR-related experiences around group work. We followed the Strauss and Corbin (1997) recommendations for coding data. An indicative list of identified codes for each category is presented in Appendix E; as well as representative quotes for each code. After finalizing initial codes, we divided researchers into two groups: one with two authors and another with one author and two research associates. Both groups analyzed identified claims supported by evidence (ground truth or quotes) mapped to codes associated with the axial category of interest (spatial, social, and temporal presence, along with group dynamics). The analysis centered on arguments related to participants' expressions of presence while working on the virtual campus for group projects. Sentences containing clear evidence for these arguments were coded to identify claims. This aligns with Habermas's (1981) perspective, often referred to in social science research, and as explicated in Baldamus (1992); claims backed by evidence can serve as valid arguments indicating potential relationships. Thus, in line with this process of data analysis, grounds (indicative statements in the data) for each relationship are also provided in the findings section.

After gathering arguments, we mapped these arguments onto predefined constructs (axial categories) in the research model (Figure 1) based on their core assertions regarding the type of presence and group dynamics in VR environments. These assertions further suggested that virtual campuses offer varying experiences of spatial, social, and temporal presence depending on available technology features and how well the technology fits the task. This led to one additional code category emerging from the data: VR task-technology fit. Finally, all arguments were synthesized to create meaningful patterns (Weick, 1995). The revised framework, informed by the data analysis, is presented at the end of the findings section (Figure 2 and Figure 3). We first present our findings, and then in the discussion section, we summarize our arguments in the context of existing research.

4 Findings

4.1 Spatial Presence Related to Group Dynamics

We find that VR's ability to create an increased sense of spatial presence in turn creates better group dynamics among participants. This is achieved through a sense of realism in elements of VR environment, occupying the space meaningfully for a purpose, and interacting with people and surroundings authentically, the three elements of spatial presence which we elaborate below with examples, along with their implications for specific group dynamics.

4.1.1 Sense of Realism in Elements of the VR Environment

Participants shared their excitement about the ability to create and manipulate 3D objects or spatial drawings within the VR campus. They could hold these objects close, pass them to a group member, or use the handheld controller to mindfully adjust their distance from other group members or objects. Notably, these actions are related to the sense of presence that Tham et al. (2018) found crucial for group communication; we observed similar findings, which we'll elaborate on later. During focus groups, participants asserted that interaction with other participants and objects in VR created a sense of realism in their experience once they put on their headsets. Also, in the Edstutia VR app, learners can use controllers to teleport themselves from one location to another (see Fig. 6 in Appendix A for how participants interact with VR campus environments during teleportation). For instance, users can move to different venues, such as the boardroom, or enter an entirely different and distant location, like marketplaces around the world. We found that, at an individual level, the ability to explore freely or "walk" with a groupmate in VR to a venue not only created a strong sense of relatability with the VR environment but also provided a sense of reality association and a comparison with physical-world experiences within the VR campus location. The ability to interact with VR environments in a lifelike way (i.e., mirroring the physical world) is directly related to an enhanced perception of spatial presence (Laarni et al., 2015; Wirth et al., 2007), as noted by two participants quoted below.

Ground truth:

“When you go in, you really feel that you're on campus. You have these locations that you can go to, which mirror where you might go in a place you're used to. You can bump into people, say hello, and just move around. But the idea of just how present and immersive the nature of VR is, it's like, "Oh man, this is so cool." Speaker 22, Cohort 4

“So for me, it was like I was a paleontologist just working with the bones of dinosaurs. But coming to this course was like actually entering Jurassic Park and interacting with real dinosaurs. So it was really fun, very, very eye-opening on many levels.” Speaker 26, Cohort 7

Claim: The VR experience creates a strong sense of spatial presence by making users feel as if they are in a real-world environment. Further, in the VR-environment when interacting with objects mimics real-world experience, such as touching and moving objects, bumping into people, and experiencing lifelike interactions such as saying hello.

4.1.2 Sense of Realism in Occupying Space Meaningfully in VR

Participants shared that they not only felt a sense of reality within elements of the VR environment but also a sense of meaning in that reality, along with a connection to lifelike experiences. They discussed their experiences relating to the ability to interact with and react to VR spaces in a meaningful way. For instance, a group of participants experiencing an immersive spice market (see Figure 7 in Appendix A) reported wanting to step out of the way of an oncoming car or wanting to touch the spices in sacks in front of them. The same immersive spice market activity in VR had built-in hotspots where participants were required to interact with elements in VR and with each other. This was mentioned to be beneficial for group assignments, which we will elaborate on later, as it contributed to their group's overall performance in designing their projects.

Another group also shared the experience of being in a data center in VR and feeling it to be closer to reality. Both groups appreciated the ability to integrate information or learning checks in real time within the VR space.

Ground truth:

“You really feel an embodiment that you don't otherwise. [Y]ou really feel a sense of intention, like, "I am in this room with them," not like we're on Zoom.” Speaker 14, Cohort 1

Claim: Virtual environments feel more real and meaningful occupation of space than group meeting tools such as Zoom, enhancing the sense of presence and meaningful shared experience.

Occupying space meaningfully in VR also appears in the form of greater engagement with the space and objects. Speaker 23 shared that in VR, people are more physically engaged, often moving around and sometimes knocking things over on their desks, indicating a high level of engagement. Whereas in most in-person or online group meetings and learning interventions, participants typically remain seated even if encouraged to stand or move, suggesting that VR promotes more physical movement and interaction, offering a different and more immersive spatial experience compared to the static nature of traditional boardrooms.

Ground truth:

“I remember most of them the same way I remember meeting up in real life with people. It's like your brain doesn't perceive the difference between this and real life, whereas your brain

has a serious barrier with Zoom. And I think it's because of the spatialness. Real life is spatial in real life. Like Speaker 14 is over there and Speaker 6 is over there, and your brain remembers where they were. But you don't remember where someone's which screen they were, which tile they were in some [Zoom] session. Like my entire team is all over the planet, but we jump up into VR and we're all together, and that's the magic." Speaker 23, Cohort 1

Claim: The VR experience allows users to interact with virtual people in a way that mimics real-world interactions, including remembering their spatial locations within the virtual environment.

Our findings corroborate the insights of Akpan et al. (2013) and Slater (2018) as we find that realism in experiences of occupying a physical space in VR is a critical element of spatial presence within VR learning environments.

4.1.3 Sense of Realism in Interacting with People and Surroundings Authentically in VR

Participants reported that the VR platform enabled them to feel a sense of closeness despite physical separation, allowing them to interact with group members and environments authentically. Speaker 5's statement that he felt like he was in the same room as others highlights VR's ability to enhance closeness and spatial presence in their subjective experience by compressing the perceived distance. Our findings are in line with the studies by Slater (2018) and Diemer et al. (2015), demonstrating that the intricate interplay of authentic responses (here, like the physical world) elicited by a location of elements within the VR environment (such as closeness with the Avatar or the room) is instrumental in fostering spatial presence within VR learning environments. Specifically, we found that VR experiences induce engagement with people and elements in VR, leading to a profound sense of "being there" among participants. This is especially critical in the coordination and communication among group members, as globally dispersed team members get to know each other and establish ground rules for working together.

Observing proxemics, or the amount of space group members find necessary to keep in VR, it is apparent how group members who initially maintain distance in VR space as they begin working together gradually close the VR spatial distance, often ending up celebrating their success in the performing stage through group hugs and high fives. These combined factors significantly contributed to the formation of a shared virtual space, facilitating authentic interactions (Akpan et al., 2013) and further leading to enhanced local and global group dynamics, as we will discuss later. Two representative examples are given below:

Ground truth:

"I think one of the most powerful use cases for VR is when it has you at the edge of your seat, you know, when you are sweating" [while participating in a difficult conversation.] Speaker 5, Cohort 5

Claim: VR interactions with groups can create a strong sense of shared experience, making users feel as if they are physically present and reacting to stimuli in the same way as others in the virtual environment.

Ground truth:

"I really didn't get VR until [our group] worked on the project together. In fact, I can tell you the exact moment when I really did get it was when Speaker 23, Speaker 2, and I—Speaker 2 in India, me in New York, and Speaker 23 in California—had to get together to work and plan out what it was that we were going to do. And the three of us, you know, spread across the face of the planet, using technology that's still, let's face it, in the developmental stage, came together and met with really no distance amongst us. We felt like—I think at least my feeling was—that the three of us were in the same room, and all of a sudden, you know what happens is you can see the power of this to connect people together, to let them share authentically, to remove distance, and bring people together." Speaker 6, Cohort 1

Claim: VR can transcend geographical barriers, allowing people from different locations to feel as if they are physically together in the same space, fostering a sense of shared presence which furthers their collaboration.

VR environments provide more than just hearing and seeing cues to create realism; for example, hand gestures and other body language can lead to a more focused work environment, contributing to a heightened sense of spatial presence (Wirth et al., 2007). Feeling someone's proximity in VR can influence how connected and comfortable participants feel while working together virtually (discussed next), and it can indicate the degree of realism they experience while being present in VR. For instance, a sneeze from a group member in VR was observed to elicit feelings of concern about personal health for a brief moment, as the perceived spatial proximity created the fear of exposure to infections. But then, we also noted that spatial proximity in VR can be problematic and distracting: avatars can accidentally collide in VR when working on tasks that require them to work closely together. Although these interactions were harmless, they are limited by the fact that they do not perfectly represent physical cues that contribute to spatial presence in real life. This also indicates that the limitation of technology could be impacting the learners' presence experiences in VR (Bystrom et al., 1999).

4.1.4 Spatial Presence and Global Group Dynamics in VR

Task Performance and Cohesion

Participants in Cohort 1 experienced a virtual data centre together while performing a group task. During the final session, they mentioned that this shared experience contributed to greater group dynamics by enhancing cohesiveness. Some learners also noted that working with other participants in authentic VR spaces, such as an Indian spice market, enhanced their ability to interact with an unfamiliar culture in real time. Our analysis of focus group responses and final group presentation recordings revealed that VR environments limit multitasking compared to synchronous video conferencing platforms. This led to a more focused and present state of participation, resulting in higher performance during group assignments. By eliminating distractions and fostering presence, VR platforms can cultivate group dynamics to achieve better task performance by promoting active contribution. Speaker 23 (focus group 2) mentioned that she feels less focused in synchronous video calls due to distractions in her environment. Her reflection of working in VR suggests that spatial presence experiences there might contribute to better performance of group members during group assignments by keeping participants more present and liable to engage with each other and objects in the VR environment.

> ***Ground truth:***
>
> *"Well, one of the things we noticed right away is that we all kind of felt weird if you didn't look at the person you were talking to or if you were looking away and looking at something, you know, not directly engaged in what was. So it actually forced us to actually address each other as we were sitting at the table. You know, you turn in the chair and like I'm looking at Speaker 9 now and looking at Speaker 8, you know, we would just make sure that. And it was different, we didn't expect that. It wasn't something that we expected, right? Because if you just put your controllers down and take the headset off, you look like you're all slumped over, right?*
>
> *"So, we kind of recognize that, hey, you can't multitask in VR.*
>
> *"That's the cool thing about it, right?"* Speaker 23, Focus Group 2

Claim: The objects similar to the physical environment when modelled in VR made people feel spatially present, which in turn helped people engage with each other efficiently, like physical settings.

VR environments create a sense of shared space, much like any physical setting, and with that comes the feeling and experience of being watched by other participants. This, in turn, reinforces social norms and etiquette, such as maintaining eye contact during conversations, leading to more focused and meaningful interactions, and ultimately making the group more cohesive (Sparks et al., 2025). For instance, Speaker 23 believed this made group work more efficient and improved performance and deliverables on group tasks. Participants also shared that this positively enhanced the likelihood of asking for help from group members, as they experienced being in the "same space." They reported being able to seek help and learn technology better, which contributed to the group's overall performance. Similarly, Speaker 2 (Cohort 1) attempted to "spawn" (create) an object in VR, encountered difficulty, and sought clarification from Speaker 11. Speaker 11 was able to physically move to stand next to them and provide guidance. This suggests that tasks in VR, such as creating an object, can require collaboration. With greater local group dynamics, as we will discuss next, higher-order dynamics (i.e., global dynamics) also become greater (McGrath & Argote, 2001).

Participants further reflected on their group work experiences, sharing that it is easier to encourage others in their group to try things out in VR-based interactions because they are virtually present together but distant from real-world consequences. As we noted before, feeling "at the edge of your seat" might create a sense of being more embodied within the VR experience. Overall, the rich and engaging virtual world (such as a bar with a view, see Fig. 8 in Appendix A) fosters a sense of being fully present in the virtual space with others. This experience indicates enhanced experience of spatial presence by replicating some aspects of real-life focused interaction. Participants in Cohort 4 (and also focus group discussions) agreed with their instructor that "hanging out" in some of their favorite locations was an attractive feature of the VR campus environment that created a sense of cohesive group identity for them (McGrath & Argote, 2001; Sparks et al., 2025).

4.1.5 Spatial Presence and Local Group Dynamics in VR

We found that a sense of realism in the interaction with tools and resources within a shared VR environment strengthens local group dynamics. Specifically, we observed that an enhanced sense of spatial presence led groups to make efficient use of their work time for coordination, enhance collaboration through the effective use of shared 3D assets, and use environmental features like spatial audio for more effective communication.

Effective communication, collaboration, and coordination

Participants noted that VR audio, much like in a physical space, is directly tied to the location of the person speaking. We provide ground truth for this below (Speaker 19). The spatial audio creates a more natural and immersive soundscape, which fosters a stronger sense of realism and authenticity. This enhanced spatial presence is also linked to a feeling of being more present with others, or social presence. This, in turn, can lead to better coordination and collaboration, especially during demanding tasks that necessitate careful communication.

> ***Ground truth:*** *"Especially with the spatial audio, you know, it felt like we were in the same room together. So, I thought that collaboration was a little better, and we did a lot of our project was kind of complicated, so we did a lot of dry runs there. So yeah, it was really effective to be able to do that in VR."* Speaker 19, Focus Group 2

Claim: The combination of spatial audio and visual cues in VR can facilitate better collaboration and understanding among group members, especially during complex tasks and discussions.

In another instance, Speaker 11 urges Speaker 12 to move quickly within the VR space during a scavenger hunt group competition to achieve something together. The request to move faster by Speaker 11 indicates that collaboration was indirectly influenced by perceptions of spatial presence in VR, as urgency to move is a concept that applies authenticity in interactions in virtual space, similar to the real world (Sparks et al., 2025). In Cohort 6, the group project of piecing together a puzzle creates a similar sense of urgency and drives collaboration by leveraging the sense of spatial presence. We also noted that the selection of a boardroom—a commonplace environment— for group work enhanced spatial presence within VR. This familiarity mitigated the novelty of the VR environment, increasing comfort levels and coordination among group members when they engaged with available resources in the VR environment. The familiarity with the realisms of VR spaces encouraged groups to effectively navigate the storming stage of their development. By providing a comfortable environment for expressing disparate points of view and working through differences, VR fostered effective communication among group members (Tuckman, 1965). This observation is underscored in the ground truth below, where Speaker 5 emphasizes both "hanging out" and "experimenting" as their group's modus operandi. Consequently, they were also able to coordinate effectively during group work.

> ***Ground truth:***
>
> *"Yeah, we would just go to the campus (VR campus). We pick a room, and then we just call, go there, and we'd hang out and experiment. A lot of times we'd go to the Board Room because we could sit at the table and pretend like we're in a room together."* Speaker 5, Focus Group 1

Claim: VR environments can provide spaces for both formal and informal interactions, allowing users to switch between focused work sessions and casual social gatherings within the same virtual space, and hence collaborating effectively.

Our participants also shared that the ability to co-create physical-world-like designs and sculptures in VR contributes to the collaboration between group members (Refer to Figure 9 in Appendix A to understand the kind of objects participants' interactions are possible in VR). We found that this authentic co-creation using objects and tools in VR is one of the most compelling features of VR that enhances group learning and interactions among participants. For instance, in focus group 2, speaker 8 expressed excitement about the 3D drawing feature, which is not only related to the functionality of VR itself but also indicated the user's experiencing realism and embodiment within the virtual space.

4.2 Social Presence Connected to Group Dynamics

Social presence emerged as the perceived interdependence between self and others, created by access to the sensory experiences, intelligence, and intentions of other group members (Nash, 2018; O'Leary et al., 2014). We discuss our participant responses around the social presence and group dynamics as perceived by them while working in VR.

4.2.1 Sense of Interdependence and Familiarity Through Access to Sensory Experiences in VR

We find that accessing sensory experiences such as eating popcorn, singing karaoke (Figure 10 in Appendix A), or starting a firework display together led to a sense of interconnectedness and interdependence. Participants shared that exploring a hidden room together, such as a VR bar, created a casual and enjoyable atmosphere for social interaction. This sense of ease and enjoyment further contributed to a stronger sense of social presence by making individuals feel comfortable and connected to their teammates (Neeley, 2015).

Our participants also reported during reflection and focus group discussions that VR enabled them to create a sense of their unique identity through sensory markers, enhancing their capacity to interact with each other at varying sensory (auditory, visual, haptic, etc.) levels. The carry-over of elements from real life into VR creates an interesting way to construct and own identity (O'Leary et al., 2014), making that identity accessible to other participants through visual and auditory experiences in social interactions. This is consistent with previous research on the interactional nature of social presence mediated by features of the technology platform (Goel et al., 2013; Schultze & Brooks, 2019)

For example, we found that a learner who performs ballet held her controllers in a manner mimicking the first position in ballet, creating a non-verbal, sensory cue that she owned as an avatar. This made people in their cohort feel that they were interacting with her and knowing her socially, as in real life. In another instance, Speaker 23 (Cohort 1) shared his experiences while discussing group work and the benefits of using multiple avatars in the Metaverse. He shared that he tailors his avatar to the situation, dressing more conservatively in business settings and going wild in more playful environments.

On an individual level, we observed that participants who were able to 'bring their whole self' into the VR platform experience through appearance and wardrobe choices for their avatars, mimicking real-life characteristics or expressing their individuality, were better understood by others, which we discuss later. This had a significant impact on local group dynamics.

4.2.2 Sense of Interdependence Through Access to Combined Skills in VR

We find that shared skills between group members in VR are the main means of creating closeness and interdependence between self and others that leads to a strong sense of social presence (Bales & Strodtbeck, 1951; Goel et al., 2013). Herrera et al. (2018) had found that VR enhances empathy demonstrated by Speaker 32 in Cohort 3. This relates to the findings of a study by Schultze and Brooks (2019), as they highlighted social presence as a skillfully coordinated outcome of people reciprocating each other's skills and contributions. For instance, Speaker 13 in Cohort 3 mentioned how social interaction and relying on other group members for help with tasks led to a more concrete sense of being a group (cohesiveness in the group).

> ***Ground truth:*** *"So that hands-on [ability to work as a group] was really good. Speaker 32 - cohort 3 was super supportive when I would be like, 'Wait, where do we find that?' And he'd*

> *help out [because he is more advanced with his VR skills]. He was patient and kind."* Speaker 13, Cohort 3

Claim: VR environments can provide opportunities for learning via mutual support, allowing users to experience dependence on group members' knowledge and skills.

> ***Ground truth:*** *"I mean, we had a good group—all three of us. I think we got together multiple times, you know, outside of this, and I think we enjoyed our time together. And as Speaker 22 - cohort 4 said to you the other day, you know, we had so many diverse ideas and so many iterations on this by relying on each other's strengths."* Speaker 28, Cohort 4

Claim: The shared virtual space can create skills-related interdependence among group members.

4.2.3 Sense of Accountability Through Access to Others' Intentions in VR

Participants shared during reflection on doing activities and interacting with the group in VR that developing an understanding of each other's intentions can significantly impact a sense of social presence. This experience of presence was sensed by people via elements in VR that enabled applications and the viability of social protocols in the VR environment, like telling who is moving hands frequently or who is not using a headset. Participants believed that VR enabled them to question and understand the intentions behind the actions of others better. This even leads to a greater sense of obligation and accountability towards social protocols (Schultze & Brooks, 2019), in declaring or being receptive to each other's intentions and feedback.

Ground truth:

> *"VR provides a safe space for giving feedback candidly and without judgment, potentially because the feedback is directed towards an avatar and not a 'real' person. Group members in VR were more open and receptive to feedback, potentially due to the same reason."* Speaker 24, Cohort

Claim: VR environments can provide a safe space for declaring one's intentions and providing candid and honest feedback.

***Ground truth*:**

> **"***I found that because it's not me talking, it's my avatar talking. I found it silly, but I found it a little easier sometimes to disagree, and I'm someone who avoids conflict. I'm very aware of it. I avoid conflict. So I find it difficult to express something I don't like, and I found it a little easier."* Speaker 25, Focus Group 1

Claim: The use of avatars can reduce social inhibitions, making it easier for users to engage in interactions and express intentions more freely.

VR's potential to distance individuals from feedback providers also reduced intimidation, fostering increased receptivity to others' intentions and feedback, including criticism. VR thus becomes a safe space for the group storming stage, as disagreements can be expressed and conflicts resolved on an "avatar" level without necessarily being construed as a judgment or criticism of the "real" group member. This has been demonstrated in previous research (Vaast, 2007). Speaker 25 from focus group 1 noticed that VR interactions also opened up the ability to vocalize divergent intentions and express disagreement in group work. Participants also noted that VR builds empathy towards others' intentions and experiences through perspective-taking. Thus, enhancing coordination and improving communication leads to better local group dynamics, discussed later in detail.

Participants also shared that because of social protocol, those who were distracted told others beforehand that they had other tasks. The need for greater focus in VR environments can lead to a greater sense of accountability towards being present in the group. Similarly, participants realized that others could learn about their hand movements and infer their intentions and actions. Thus, VR environments can reduce multitasking and improve focus by making users accountable to others, prompting them to engage more fully in the task at hand—a facet of presence highlighted by Slater and Wilbur (1997).

Ground truth:

> *"I think it's a really great tool if you want people to focus on what you're saying to them, because I can't multitask*." Speaker 5, Focus Group 1

Claim: VR environments foster a greater sense of accountability within interactions. Thus, reduced distractions and improved focus allow users to engage more fully in conversations and activities.

Ground truth:

> *"I actually agree with Speaker 5 - focus group 1 very much. Because you're right, you can't just quickly do emails as the participants do in Zoom."* Speaker 25, Focus Group 1

Claim: VR environments encourage users to engage more fully in the present moment and with the people and the task at hand. This reduces multitasking and enhances a sense of being there while being accountable.

4.2.4 Social Presence and Global Group Dynamics in VR

We find that a greater sense of social presence positively affects cohesion and contributions, improving group task performance. Thus, social presence became particularly relevant in strengthening group dynamics during VR-based group work (Bales & Strodtbeck, 1951). It contributed positively to the group dynamics and group-level outcomes of geographically dispersed and not socially connected group members. We will elaborate on this next.

Cohesion

Participants shared that the ability to perceive visual cues beyond simple names within VR cultivated a feeling of "being together," thereby enhancing agreements during group work. Interpersonal presence within VR was further amplified by realistic scenarios and characters, rendering group activities and tasks in VR more engaging and impactful, as exemplified by Speaker 18, who utilized an avatar that replicated his look in the physical world to enhance the interpersonal presence. Participants agreed that feeling socially interconnected and sharing a common experience in VR platforms fostered a cohesiveness among them (McGrath & Argote, 2001; Oksanen, 2013).

We found from participants' reflections that the quality of group discussions within VR platforms was enhanced by their experiences of feeling integral to the learning environment. Speaker 21 noted during a focus group that this could be achieved through visual and auditory stimuli, as well as a thoughtfully designed virtual world that fostered a sense of connection with both the learning content and fellow participants (i.e., experience of social presence). Moreover, as noted above, VR groups exhibited a propensity to experiment with diverse interactive settings (e.g., boardroom versus open lawn), enabling multiple team-building activities. These activities facilitated bonding and shared experience, further strengthening cohesiveness during group assignments. A similar relationship between group cohesiveness and social presence has been studied by researchers in 2D settings (Sparks et al., 2025; Torro et al., 2022). Schultze and Brooks (2019) in their study related low involvement and hence lower social presence to indifference and hence reduced cohesion among participants.

Task performance

Social presence in VR group assignments was enhanced when participants connected their VR experiences to follow-up discussions or activities. For instance, as highlighted by Speaker 8's experience using unique elements (Fig. 11 in Appendix A), it fostered a sense of connection and shared experience during group work. This aligns with Speaker 16's experience, where the VR presentation connected to a video, likely prompting reflection and potential discussion. In both instances, groups achieved good outcomes on assigned tasks, and they attributed it to the interconnectedness with other participants they experienced during preparation for group work in VR. Speaker 15, who was in the same group as Speaker 5, agrees: "*VR is a very effective platform for collaboration."* Notably, with greater local group dynamics, i.e., increased collaboration, their task performance (i.e., global dynamics) also becomes better (McGrath & Argote, 2001; Short et al., 1976).

> ***Ground truth: "****I mean, we practiced everything ahead of time. We had submitted our stuff like a week early, and we were in training, seeing what potential issues could be. So we were, I think, our collaboration was just awesome and we took advantage of as much as we could see."* Speaker 18, Cohort 5

Claim: VR environments can be used for practicing and understanding the skills of group members in a simulated environment. This, in turn, can affect their group's performance.

Speaker 5 highlights a crucial distinction: the suitability of features in VR for brainstorming and creative thinking, followed by the use of non-VR online platforms, such as Zoom, for efficient task execution. Our observations indicate that VR group work is not conducive to the group norming stage when suitable features are not present in the VR platform. When groups strive for shared objectives, effective division of responsibilities, and task completion, they typically transition from VR environments to online collaboration tools like Zoom (Slater & Wilbur, 1997). Nevertheless, participants noted a strong awareness of social protocols within their VR groups, which, as demonstrated by Sparks et al. (2025), is foundational for improving group task performance.

4.2.5 Social Presence and Local Group Dynamics in VR

Effective Communication

In terms of nonverbal communication, participants noted that the sense of being socially present in VR enabled some level of embodied haptic interaction, such as the act of giving high-fives. As we discussed earlier, this outcome of social presence mirrored real-world and strengthened connections. Speaker 7's desire to mimic Speaker 9's hand movements within the VR environment indicated that VR platforms allowed for more lifelike gestures and body language. Speaker 9 demonstrated how to achieve this to Speaker 7, and they later shared this with the entire group during the focus group. Participants generally mentioned that such interactions effectively contributed to more nuanced synchronous communication among group members. This is a frequently repeated finding, as many previous researchers have shown that realism in a technology-mediated interaction of a user, i.e., a socially present user, results in effective communication (Gunawardena, 1995).

> ***Ground truth: "****Yes, we would high-five each other. And yeah, it was fun in that sense. Ease of expressing agreement, acceptance of feedback among peers, improvements in team projects—these are all easily done in VR."* Speaker 4, Focus Group 1

Claim: Enhanced social interaction experiences in VR make it easier for users to communicate synchronously and effectively within a group setting.

> ***Ground truth:*** "*I had this one experience with Speaker 9 Cohort 6. We just wanted to have a little play in the VR space, and we went into this extra room, like a bar. You have to go through a hidden door to get in there. And we were overlooking some sort of Miami skyline, and all we needed was a glass of wine, and we would have had a really lovely conversation.*" Speaker 25, Focus Group 1

Claim: VR environments provide opportunities for informal social interactions, allowing users to engage in casual conversations and shared experiences in virtual spaces that mimic real-world social settings.

Finally, in terms of contributing to local group dynamics, group members commented that the shared social skills and intentions created a safe space for respecting the whole person. For instance, VR group learners took the time to acknowledge or comment on appearance and wardrobe within the safe space of VR because the comment was removed from them in space outside the VR headset, i.e., it was about an avatar and not the real person.

Effective coordination and collaboration

We have already established that VR-based group work involves greater sensory involvement, including manipulating objects, active interactions with resources, the use of spatial audio, and movement, along with verbal and interpersonal skills. We found that VR enhanced the performing stage of group work by facilitating group collaboration and coordination through group members' strategic interdependence on each other while doing group tasks. We also discovered that ease of sharing intelligence and creating a cohesive group identity, as observed in a maze-run group competition conducted in VR, contributed towards the effectiveness of coordination in group tasks. Participants shared that group members were able to assist the individual maze crosser through the group's collective intelligence (see Figure 12 in Appendix A to understand how groups worked in this activity). For example, individual members excelling at deploying spatial VR skills were able to advise the maze runner to raise their height for a bird's-eye view of the maze or utilize the ability to pass through walls in VR. Similarly, a strategy sub-group was able to flex according to the specific maze navigation challenge, using verbal instructions and encouragement.

We find that interdependence on each other's intelligence fostered group collaboration. For instance, Speaker 5 discussed during a focus group the greater sense of accountability for "showing up" in VR as opposed to other group work platforms, created by the ability to see a group member's lack of intention to participate because when their headset is off, the avatar icon says "Person X is away" (findings similar to study by Friess and Gnadlinger (2021) and Vincent and Frewen (2023)).

> ***Ground truth:*** *"Historically, we've been using teams and webinars and Zoom and stuff to do all our stuff. And you know, people see each other [in VR], and we engage. [On Zoom,] my camera is not even on."* Speaker 4, Focus Group 1

Claim: The shared social norms in VR can facilitate more focused collaboration among group members.

> ***Ground truth: "****I was pretty familiar with VR, not at all with AR, so that was really interesting. I felt completely out of my depth [during our group project meeting in VR], and luckily Speaker 33 - cohort 1 has a lot of experience, so I was able to, you know, through her brainstorming and everything, it was like, 'Oh yes, now I can see the value and I can understand why mixed reality is sometimes the best option'."* Speaker 8, Cohort 1

Claim: VR can be used as a tool for learning and skill development, allowing users to explore new technologies by collaborating with their group members.

However, the need to exit VR for notetaking or switch between a computer interface and the VR headset to achieve maximum productivity and efficiency in group work could be a deterrent to VR-based group work at the norming stage. Overall, our findings reveal that social presence in VR for group assignments seemed to be a delicate balance. While VR can create a sense of social presence, limitations with VR platforms might require supplementary tools such as 2-D synchronous video platforms and asynchronous communication platforms to fully establish social connections that could positively drive local group dynamics.

4.3 Temporal Presence Related to Group Dynamics

We find that the temporal presence experienced by the participants in VR has also led to positive local group dynamics. However, participants shared that for coherence to emerge in terms of time, a disassociation with time at their physical location is required. Thus, group members working on tasks or doing activities in VR need to be aware of the time warp generated by VR, where digital time dominates real time.

4.3.1 Sense of VR Time Warp

Our analysis revealed that VR time cues played a significant role in creating a sense of a time warp, where digital time dominated real time for the participant in the VR environment (Chung & Gardner, 2012; Saker & Frith, 2019). This became evident when Speaker 25, focus group 1, noticed that time-related features were not as present in VR as they were in real life or in group work platforms such as Zoom affected temporal presence. They discussed that one has to break out of VR and cut out the sense of presence by lifting off the headphones. Once they lift off their headset to be able to see the watch or the clock. Thus, immersive VR experiences can disrupt the perception of real-world time, making it difficult to track the passage of time within the virtual environment. In focus group 2 conducted on the Edstutia campus, digital clocks were available in each room, and participants could customize them to get a sense of time in their physical space, their geographic time zone. Discussions around experience with time and tracking during the focus group revealed that even though group members were able to use the time cues provided within VR, they still experienced a warped sense of time. Niknam et al. (2024) and Moinnereau et al. (2023) had a similar finding that environmental cues in VR make users lose track of time.

> ***Ground truth: "****You know, it's really amazing how fast time flew. We had watches on campus, so we could kinda check, but it was amazing how fast time flew. You're more conscious of time when you're on the computer, right? Because you can see it right in front of you. But we thought, "Oh, we've only been here 10 minutes," and it would be like 30 minutes. Seriously, and I wasn't the only one. I remember-Speaker 9 – Cohort Group 6 as well. We would go, 'What? Is that the time already?' It was quite surprising. Whereas, of course, in real life, I would be a bit more aware of time. I mean, this is our real life, right? But yeah, it's like it moves faster."* Speaker 26, Focus Group 1

Claim: Immersive VR experiences can significantly distort one's perception of real-world time, making it feel as though time passes more quickly within the virtual environment.

Speaker 4 described an experience of losing track of time in VR, suggesting a feeling of being less anchored to the passage of time. Participants noted that in physical environments and Zoom meetings, external cues (like body sensations or shifting daylight) are used to gauge the passage of time. VR's immersive nature and the artificial environment programmed into the platform weakened these cues, leading to a distorted sense of temporal presence and a feeling of being less "present in the real world." Thus, we find that if task-relevant cues, including temporal indicators (Cooper et al., 2021), are used in VR, they could create a sense of being divorced from reality, which some group participants found difficult to adjust to (Niknam et al., 2024).

Furthermore, participants shared that as they entered the Edstutia platform, the sunny blue sky induced a sense of alertness, regardless of the actual time at their location. Similarly, the night sky of the rooftop bar immediately created a relaxing mood. This temporal remoteness with the physical world while being present in VR was also disorienting when users removed their headsets and encountered the sunlight in their real environment.

> ***Ground truth:*** "*Like when you leave VR, it's the equivalent of, like when you go to the movies in the daytime and then you come out and it's all like, 'Right?' And you feel very discombobulated in the world. Yeah, yeah, like you're totally removed*." Speaker 29, Run 3

Claim: Immersive VR experiences can significantly distort one's perception of real-world time, leading to a sense of disorientation upon exiting the virtual environment.

Furthermore, participants shared that they felt present when they could carve out individual time within a shared timeline in the VR. We find that features in the VR platform enhance the ability to calibrate time within a session, giving participants the ability to accelerate or decelerate individual time in group experiences. Speaker 5 highlighted a specific moment during a collaborative project where a line dance activity connected with personality assessment scores slowed time down for the group, as they took the time to own their space on the line and compare self-scores with group members' scores (See Fig. 13 in Appendix A). An example of an accelerated sense of time was a VR simulation of an active shooter scenario with a group work task of responding to the situation while being immersed in the soundscape of gun sounds getting louder, indicating the impending threat to the group's lives (Images for activity in Figures 14a and 14b in Appendix A).

4.3.2 Temporal Presence and Local Group Dynamics in VR

Temporal presence's implications for group dynamics in VR can be seen in efficient coordination, such as using VR time efficiently, and effective collaboration, as group members develop a sense of time that is passing or flowing together.

Effective coordination and communication

Participants shared that the temporal presence they experienced in VR can enhance coordination and synchronization among group members, leading to timely project completion. In addition to this, our analysis of focus group discussions revealed that reducing time zone issues could be a potential advantage of VR platforms. If time zone differences hindered collaboration in synchronous video modalities like Zoom, VR platforms might be a better fit for tasks requiring focus, synchronous collaboration, i.e., for the group performing stage. VR minimized the impact of time zones and allowed for a more immersive and engaging group work experience, influenced by temporal presence (Saker & Frith, 2019). For instance, Speaker 25 - cohort 3 commented on temporal efficiency within VR-based group work:

> ***"****We all have very busy schedules, and we had stuff coming up, and we were able to efficiently organize our time while in VR to get our work done. With the artificial time pressure of limited time in VR, it's a pleasure to be able to engage and see deliverables with minimal hiccups and maximum value."* Speaker 25, Cohort 3

Effective collaboration

Participants shared that they had expected that working across time zones could create scheduling difficulties and limit opportunities for synchronous collaboration in VR. But when they experienced meeting with group members in VR, they found that VR also diminished the impact of time zone differences among participants, making collaboration easy for them for group tasks. Speaker 8's experience highlighted one way that temporal features (like the synced clock with physical time) in VR could affect collaboration in VR group assignments. Similarly, Speaker 5 shared their experience of working in VR with a group across time zones and geographies.

> **Ground truth**: *I really didn't get the course until we worked on the project together. In fact, I can tell you the exact moment when I really did get it was when … Speaker 2 in India, me in New York, and Speaker 28 in California, had to get together to work and plan out what it was that we were going to do."* Speaker 5, Focus Group 2

Claim: VR can facilitate real-time collaboration and communication among individuals located in different geographic locations, transcending time zones.

Temporal presence in VR is clearly linked to local group dynamics. This is because VR features create a sense of shared time, regardless of varying time zones and geographical distances among group members. However, our data didn't show participants connecting temporal presence to global group dynamics, which we operationalized as cohesion or task performance. This warrants further investigation. We suspect that because technology features have a more immediate effect on temporal presence, and in some interactions, learners experienced a need to reduce temporal presence, no one was clearly able to link it to global group dynamics. Förster et al. (2004) conducted an experiment on temporal presence and reached a similar conclusion: the effect of temporal presence on performance is highly context-dependent and may not be directly evident in most situations.

Figure 2 summarizes the findings up to this point, listing various facets of all three types of presence (local and global dynamics) specific to our VR learning environment.

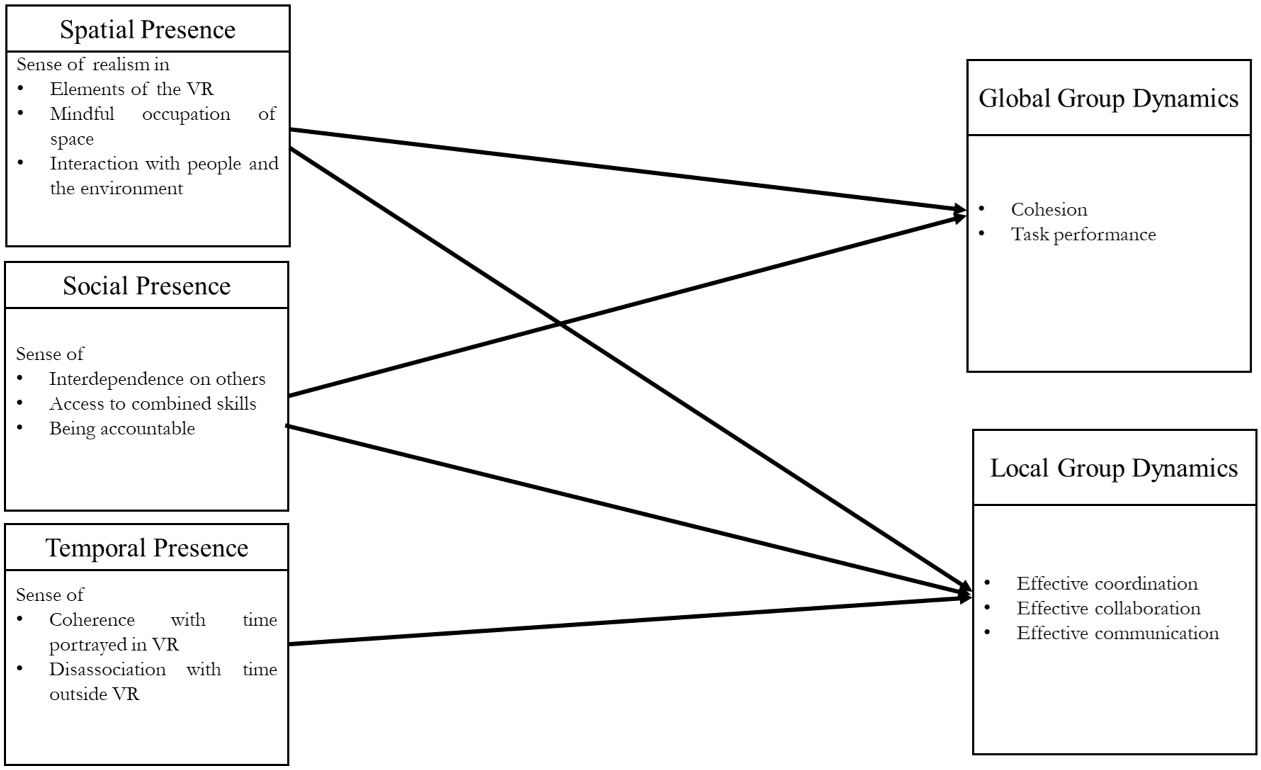

Figure 2. Relationship Between Different Aspects of Presence and Group Dynamics in VR

4.4 Task Technology Fit Moderating Relationships

We found that basic technological issues, such as disrupted connections and technical difficulties, generally unrelated to the task at hand, hindered the feeling of temporal presence and weakened the sense of spatial and social presence during group assignments on VR platforms. This has been noted in presence research and VR technology studies since their inception (Bystrom et al., 1999). However, with recent advancements in technology and the increasing use of VR for meetings and group interactions, researchers have also begun to analyze IT artifacts in terms of their affordances or capabilities to mediate interactivity and flow in VR (Grabowski et al., 2024). In our analysis, we observed an interesting pattern regarding task-technology fit, which positively and negatively impacted the relationship between presence and group dynamics. This finding aligns closely with previous research highlighting the role of facilitators and facilitating technologies for group dynamics in VR (Nicolopoulou et al., 2006). In this section, we elaborate on these findings. We highlight the potential relationship between the tasks designed for VR and the VR features that either facilitated or, if missing, negatively impacted participants' interactions with their group members. Thus, grounded in our empirical data, we propose that the relationship between experienced presence and group dynamics is moderated by task design in accordance with features present in the VR environment. Specifically, we demonstrate how the strength of the relationship between presence and group dynamics is contingent upon the alignment between the specific features available in the VR environment and the technological expectations of the group tasks designed for VR—what we term "VR task and technology fit."

4.4.1 VR Task Technology Fit Moderating Relation Between Spatial Presence and Group Dynamics

We find that when technical features were in line with the task, i.e., task design considered available features, the relationship between spatial presence and group dynamics was further enhanced. Participants experienced better collaboration, coordination and reported improved task performance. Participants across focus groups and sessions shared that the inability to write things down in VR hinders the ability to record ideas and decisions, potentially weakening the feeling of being mindfully engaged and "present" during brainstorming or planning sessions in VR platforms. This finding corroborates that of

Krokos et al. (2024) in observing that the lack of easy text input in VR negatively affected performance. Discomfort and disorientation while staying for a longer duration in VR for certain tasks negatively impacted feelings of spatial presence while executing group tasks and working with a group of participants in VR platforms. Sensory disruption, such as losing spatial awareness and experiencing physical discomfort (heavy headset for a longer duration or small font text projected on the screen to read), disrupted the natural connection between them and their environment. This made it harder for the participants to feel spatially present in the VR space where the group assignment took place. Speaker 4 from Focus Group 1 expressed discomfort with the feeling of 'physically moving to a different room' while collaborating with group members on tasks that required extensive interaction with objects in the VR environment. This discomfort led to a reduced sense of presence, ultimately affecting her cohesiveness and coordination with group members.

VR also limited spatial presence by requiring users to exit the VR space for tasks like notetaking, as many preferred typing notes on a laptop. This disrupted the sense of being spatially co-located with teammates and hindered the feeling of working together in a shared space. We further found that for some VR tasks requiring high levels of focus, the absence of multitasking options within the VR environment actually helped groups achieve better performance and cohesion. Participants also shared that the ease of detecting inattentiveness in VR encourages active participation and focus during group work, compared to physical settings where body language can be misleading. This technological aspect was found to be particularly relevant for interactive tasks and suitable for situations where someone might otherwise be a passive listener.

For instance, Speaker 29 from Cohort 3 highlighted the relevance of interacting with objects and each other within the VR environment. However, they additionally stated how a technology hiccup their team faced during project delivery underscored the importance of spatial presence. This speaker emphasized that the sense of being together, particularly through auditory experiences, is a crucial aspect of presence in virtual environments. Similarly, when a task aligns well with the technology used, such as leveraging the auditory features of a VR environment (e.g., designated corners for private conversations or an auditorium for delivering a speech), it can significantly enhance group dynamics by impacting the sense of presence. Participants generally agreed that the positive impact of spatial presence on group dynamics is amplified when audio features are properly integrated into the task to enrich the overall experience. They also felt that VR is best suited for collaborative tasks requiring creative thinking and hands-on practice, rather than discussion-based tasks that rely heavily on notetaking and documentation. For instance, VR allowed for some level of hand and body movement, which could be particularly relevant for specific group assignments if the platform facilitated using these movements for collaborative tasks (e.g., manipulating virtual objects during brainstorming).

> **Ground truth**: *"We had a couple of sessions inside [VR] where we were all there, and it just felt like I was in a room with these people. [Our group] would get together in the VR space and have a conversation and brainstorm in the VR space. Then we would jump out to Teams or Zoom or Google Meet and document what we did, because there was no way to type in the [VR] space. So, we couldn't document what we were doing. So, we would jump out, type it all up, and then come back to brainstorm some more."* Speaker 9, Cohort 6
>
> *"We couldn't write things down, and so there'd be disagreements afterward about what had been decided. Or the productivity I felt was not as good in VR*." Speaker 11, Focus Group 2

Claim: VR's limitations in supporting traditional notetaking and documentation practices can negatively impact spatial experiences of group members and overall productivity.

> **Ground truth***: "While it was unfortunate for Speaker 13 - cohort 3 and her team that the sound wasn't working properly yesterday, for me, it actually showed how valuable the VR experience is. You know, it's nice and it'll be, but the auditory trickery of it and the sense of presence that it creates to me is the biggest eye-opener of VR. So, it was pretty stark, sort of feeling, you know, having to listen to the Zoom microphone yesterday versus us being able to break up into our separate sides of the room."* Speaker 5, Focus Group 2

Claim: VR's ability to create a sense of spatial presence can significantly enhance group collaboration and communication. However, the experience can be more positively impacted when the audio features are leveraged properly in the task.

4.4.2 VR Task technology fit moderating relation between social presence and group dynamics

Our analysis revealed that frustration with VR feature limitations during group tasks led to a negative social atmosphere and hindered open communication during brainstorming or planning—both crucial aspects of social presence and group dynamics. Specifically, VR's limitations for documentation, such as typing, disrupted the VR workflow and communication flow. These disruptions made it harder for participants to feel connected and to rely on teammates in casual interactions, ultimately contributing to a reduced feeling of social presence and diminished collaboration during group assignments.

However, most participants felt that VR was a good fit for tasks requiring rapport building, fostering a positive cohesion, i.e., global group dynamic. The boardroom setting within the platform simulated such an environment, facilitating experimentation with social interactions and enhancing communication during group assignments. Similarly, participants mentioned that avatars in VR made it easier to receive criticism, making it a good fit for tasks requiring sensitive feedback or high emotional involvement. This contributed to better coordination and cohesion among group members. Speaker 5, for example, highlighted the effectiveness of VR features in certain tasks for group cohesion and effective communication.

> **Ground truth**: “*So I was very proud that we were in and doing something, and it really did become clear how making the case for VR in that particular context of conflict resolution and eliminating some of those barriers, I really got.”* Speaker 5, Cohort 5
>
> **Ground truth**: *“And even being able to embed poll questions or things in that, or also pre-recording the avatars of different races, ethnicities, ages, and genders, each stating a microaggression they experienced instead of having the AR component. I think that the recording feature in this is great, putting people in that role-play situation, recording it, and letting them, the participants, look back and go, "You know, OK, yeah, how did I feel?"* Speaker 21, Cohort 2

Claim: VR can be used to create immersive and interactive training experiences that address sensitive topics like microaggressions and bias. Tasks designed well could make people more accountable and dependent on each other, and hence enhance communication and cohesion.

Participants further shared that several social interaction-enabling features and tasks appeared to enhance overall group skills through information sharing, consequently fostering a stronger sense of social presence and better coordination in group work. These included storytelling and simulations within VR, which, according to participants, significantly boosted social presence. Storytelling exercises, such as those based on randomly selecting a card with a photo, led to more interactive group assignments in VR. Speaker 2 noted that such techniques positively affected the relationship between the sense of social presence, connection, and collaboration within the virtual environment. Speaker 15's emphasis on emotional response suggested that storytelling within VR had the potential to heighten the impact of joint intentions and group cohesion, contributing to both local and global group dynamics.

4.4.3 VR Task technology fit moderating relationship between temporal presence and group dynamics

We find that frequent exits of participants because of multitasking requirements from VR also disrupted temporal presence. The constant switching between the virtual and real world to execute some part of tasks in different environments made it difficult to maintain a sense of focused time spent working on the group assignment in VR. Further, participants shared that short battery life (1.5 hours) in VR headsets could disrupt both social presence (feeling connected to others) and temporal presence (feeling like time was passing normally) during group assignments in VR platforms due to involuntary interruptions. In addition to positive relationships when tasks fit the feature, we further found that long sessions (more than 1.5 hours) could be physically cumbersome and lead to discomfort, potentially affecting coordination in long group assignments.

> **Ground Truth:** ***“****After we take off the thing it's very disorientating. it, kinda I think. And also, as trainers, what we learn is after you take it off. Just allow people the time to ease back and breathe, and so on, because that’s very and also for me, I would physically be in a different room because I realized that if I was on Zoom, to begin with, my laptop was on the table. I did not have the space to maneuver.”* Speaker 4, Focus Group 1

> **Ground truth**: *“I did absolutely see value in meeting in VR, especially if it was if we were planning out our activity or trying to practice or anything like that. When it was discussion-based and we really needed to get things written down and nailed down, then I didn't see as much value in it, especially because of the time factor. It does seem like you put your headset on and people just kind of forget about the time.”* Speaker 9, Focus Group 2

Claim: Certain group tasks in VR (like discussion and debate) requiring participants to align with digital time were more effective in terms of group performance outcome.

Participants also shared that sometimes they wanted to work in VR in groups. Being in VR for lengthy periods of time is not currently possible due to hardware limitations in terms of battery life, weight, and eye strain. Participants felt that this created a need to use VR time efficiently as a group. This, in turn, improved group coordination and communication if tasks were designed so that thirty to forty minutes of continuous engagement on VR platforms was sufficient. Otherwise, there was a reduced sense of presence hindering coordination and communication.

> **Ground truth**: *“So we had a few Zoom meetings, and it wasn't quite connecting completely. But then when we were in VR together and like practicing and setting up our game, that was super cool. It was like everything came together.”* Speaker 31, Cohort 4

Claim: VR could facilitate effective collaboration for temporally dispersed teams if task are designed for the optimal duration and do not cause much dissociation with the time outside of the VR environment.

> **Ground truth**: *“So even though one feels presence, that is limited by discomfort due to technology-related adoption and adjustment around the forehead and eyes. So, I think the technology is not quite ready yet for lengthy periods of time. Over and out. Like, I think 45 minutes is ideal.”* Speaker 4, Focus Group 1

Claim: The current limitations of VR technology, such as discomfort and fatigue for some participants and requiring them to put on heavy headsets, can restrict the temporal presence experiences and hence the effectiveness of group work sessions.

Figure 3 summarizes our findings, which indicate the moderating role of VR task-technology fit and its various aspects. Overall, we find that VR environments, through their features utilized during group tasks, influence the relationship between users' perceptions of spatial, social, and temporal presence and group dynamics. The effectiveness of these multiple dimensions of presence in enhancing group dynamics is contingent upon the alignment between tasks designed for group work in VR and the technological capabilities of the VR environment (Dávideková et al., 2017; Zhang et al., 2017).

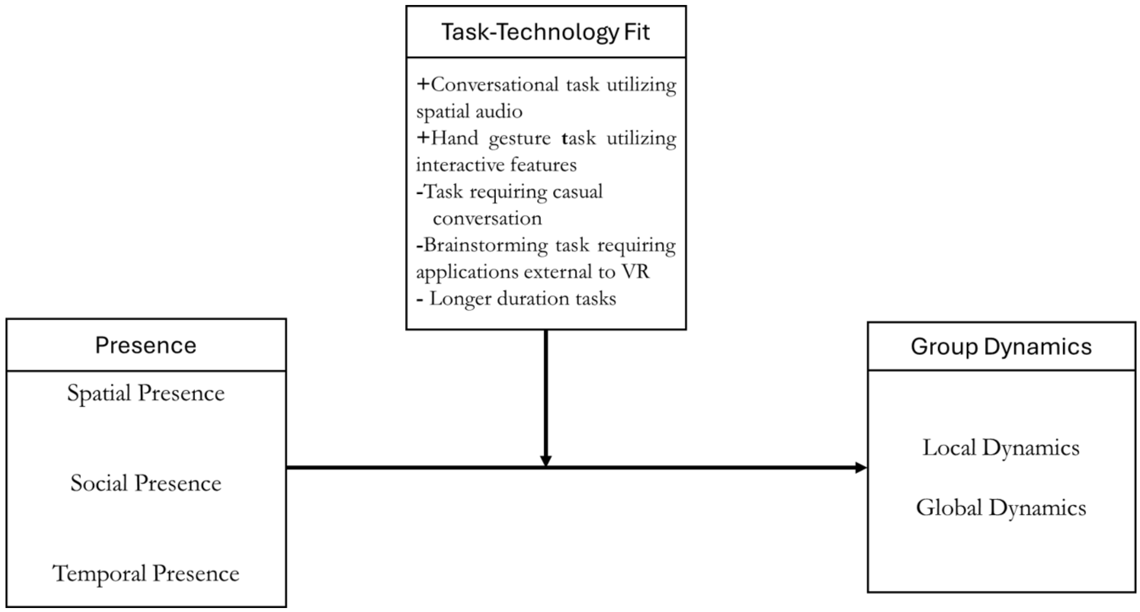

Figure 3. Task-Technology Fit Moderating Relationship Between Presence and Group Dynamics in VR

5 Discussion and Conclusion

5.1 Summary of Findings

Key findings of this study related to group work in a VR environment are:

1) Participants experienced spatial presence in VR. It is characterized by enhanced interaction between individuals, their environment, and mindful occupation of space. This, in turn, positively affected the group level outcomes, such as local group dynamics involving collaboration and communication among group members, and eventually led to improved performance and cohesion (global group dynamics)

2) Participants experienced social presence in VR which is characterized by access to combined social skills, perceived closeness, and accountability. Social presence positively impacted local and global group dynamics.

3) Participants experienced both coherence and dissociation in relation to the time in a VR environment while working with groups. This experience of temporal presence contributes positively towards local group dynamics involving coordination, collaboration, and communication. Overall, group dynamics tend to improve in the VR environment because of the enhanced spatial, social, and temporal presence. Figure 2 summarizes these findings with different facets of spatial, social, and temporal presence listed. Our findings help in contextualizing presence-related constructs for the VR environment, especially for professional development and group work.

4) We also find that VR task-technology fit is crucial as it moderates the relationship between presence (spatial, social, and temporal) and group dynamics. Figure 3 illustrates this relationship. Specifically, a positive task-technology fit, characterized by tasks leveraging auditory and interactive VR features, strengthens the positive influence of these three types of presence on group dynamics. For instance, spatialized audio for closed group communication in a virtual meeting room enhances spatial and social presence, and this enhanced presence, in turn, more effectively contributes to local group dynamics when the task design appropriately utilizes such audio features. Similarly, when tasks like collaborative 3D object manipulation (designed for group discussion) effectively leverage interactive features, the resulting temporal and social presence has a stronger positive effect on local group dynamics. Conversely, a poor task-technology fit weakens the relationship between presence and group dynamics (Ouyang et al., 2017). This occurs, for example, when tasks require extensive casual conversation (hindered by less nuanced non-verbal cues in current VR environments), necessitate the use of platforms outside the VR

environment, or are of longer duration. In these instances, the effectiveness of spatial, social, and temporal presence in fostering robust group dynamics is diminished. This aligns with previous research emphasizing that the alignment between technological affordances and user/task requirements is crucial for optimizing group-related outcomes in virtual environments (Grabowski et al., 2024; Nicolopoulou et al., 2006).

5.2 Theoretical Contribution

In this study, rooted in CLT, we extend existing research on virtual environments by examining the implications of presence for group-level work within the specific empirical context of professional development settings (Fisher et al., 2021). We operationalized presence as the experiential manifestation of psychological distance in the VR context spanning across spatial, social, and temporal dimensions (Weidlich et al., 2024). While prior research has largely focused on individual-level outcomes, our study contributes to the understanding of factors influencing local and global group dynamics among group members in VR environments (Osmers et al., 2021). Participants' ability to manipulate 3D objects and spatial drawings, along with their experience of realism in VR elements and a sense of meaningfully occupying space, relate to the theorization of spatial presence by Seufert et al. (2022) and Bozgeyikli (2021). We provide empirical evidence that spatial presence in VR directly drives group dynamics. Spatial presence experience improves group cohesion, effective coordination, and communication, consistent with the foundational role of presence in group communication noted by Tham et al. (2018) and the impact of spatial presence on cohesion by Sparks et al. (2025).

Second, we identify specific facets of social presence in VR, such as a tangible sense of accountability and interdependence, as well as the mutual understanding of unique social protocols (Schultze & Brooks, 2019; Hew & Cheung, 2010). We demonstrate that social presence in VR strengthens local group dynamics—including coordination and collaboration—a finding consistent with traditional group work studies (Bales & Strodtbeck, 1951). Furthermore, our observations align with Mavri et al. (2020) in that participants developed a sense of interdependence within the shared virtual space, which directly contributed to group cohesion.

Third, regarding temporal presence, our research reinforces the notion that VR can mitigate challenges posed by diverse time zones, thereby facilitating a more immersive and engaging group work experience, as suggested by Saker and Frith (2019). This indicates the potential for VR to effectively bridge both geographical and temporal distances. However, a limitation of our findings is that while temporal presence enhanced the immersive experience, our data did not establish a direct link between it and global group dynamics (operationalized as cohesion or task performance). This warrants further investigation into the complex interplay between temporal presence and higher-level group outcomes.

In addition, our study introduces VR task-technology fit as a moderator of the relationship between presence and group dynamics. We extend the work of Dávideková et al. (2017) by finding that the presence or absence of task-technology fit can significantly influence user experiences with group work in VR environments. We find that the suitability of VR technology for the specific group task shapes the relationship between presence and subsequent group dynamics. Simply said, during facilitator-led VR experiences, when tasks were designed keeping in mind the technological features of VR, they enhanced group dynamics as participants experienced a sense of presence. For instance, when tasks are designed with a clear goal for group work and by setting the context for different features such as teleportation and spatial transitions, they minimize disorientation among participants and positively affect relationships and group dynamics. Our findings resonate with Zhang et al. (2017), who emphasized the importance of task-technology fit in optimizing learning outcomes, suggesting that indiscriminate use of VR without considering learning objectives could be counterproductive (Ouyang et al., 2017). Thus, while VR offers unique advantages for group dynamics, certain limitations, such as the absence of robust note-taking capabilities, necessitate the exploration of other delivery modalities in specific contexts. To maximize the benefits of VR for group work in the context of professional development, careful consideration of task design and available VR technology fit is essential. We propose six testable propositions based on our findings.

Proposition 1: Enhanced spatial presence in the VR environment positively impacts global group dynamics.

1a Enhanced spatial presence in VR, characterized by the sense of realism in elements of the environment, positively drives group cohesion and improves task performance.

1b Enhanced spatial presence in VR, characterized by a sense of mindful occupation of space, positively drives group cohesion and improves task performance.

Proposition 2: Enhanced spatial presence in the VR environment positively impacts local group dynamics.

2a Enhanced spatial presence in VR, characterized by a sense of mindful occupation of space, positively affects the collaboration among group members.

2b Enhanced spatial presence in VR, characterized by a sense of realistic interactions in the environment, positively affects coordination, collaboration, and communication among group members.

Proposition 3: Enhanced social presence in the VR environment positively impacts global group dynamics.

3a Enhanced social presence in VR, characterized by a sense of familiarity with other participants in VR environments, positively drives group cohesion.

3b Enhanced social presence in VR, through access to the combined skills of other participants in VR environments, positively drives group cohesion and improves task performance.

Proposition 4: Enhanced social presence in the VR environment positively impacts local group dynamics.

4a Enhanced social presence in VR, through access to the sensory experiences of being accountable in environments, positively affects coordination, collaboration, and communication among group members.

4b Enhanced social presence in VR, characterized by a sense of familiarity with other participants in VR environments, positively affects coordination and collaboration among group members.

4c Enhanced social presence in VR, through access to the combined skills of other participants in VR environments, positively affects collaboration among group members.

Proposition 5: Enhanced temporal presence in the VR environment positively impacts local group dynamics.

5a Enhanced temporal presence in VR, characterized by a sense of coherence with time portrayed in the VR environment, positively affects coordination, communication, and collaboration among group members.

5b Enhanced temporal presence in VR, characterized by a sense of disassociation with time outside the VR environment, positively affects coordination among group members.

Proposition 6: Alignment between group tasks and VR environment features moderates the relationship between presence (spatial, social, and temporal) and both local and global dynamics

6a Tasks utilizing available auditory and interactive features in the VR environment positively affect the relationship between spatial and social presence and group dynamics.

6b Tasks requiring users to access platforms outside the VR environment negatively affect the relationship between spatial and social presence and group dynamics.

6c Tasks requiring users to stay for longer periods in VR environments negatively affect the relationship between temporal presence and group dynamics.

6 Practical Implications and Future Research

Some interesting findings at the feature level that have implications for practitioners are: Increased spatial, social, and temporal presence associated with VR increases engagement in team meetings compared to face-to-face or virtual synchronous modalities, where participants are typically seated and less physically engaged. This suggests that organizations with global teams requiring frequent travel to meet should invest in VR environments. The use of avatars leads to greater receptivity to constructive feedback and allows greater freedom of expression during feedback exchanges compared to face-to-face and virtual synchronous discussions. This has been shown to be of practical relevance in earlier studies, especially for conflict management and tasks requiring direct feedback for improvement (de Melo et al., 2013; Lin et al., 2021). Our findings showcasing VR's potential to create a heightened sense of presence that could be leveraged for group-level tasks are relevant for practitioners, as group dynamics at both the local and global levels are highly desired outcomes. However, the current stage of VR technology necessitates a cautiously optimistic approach. Feature integrations are still in the nascent stages, and technical challenges underscore the need for careful design of tasks in VR for group work. Careful attention needs to be paid to ensure that VR group work design considers group development stages where it has a positive impact i.e., the forming, storming, and performing stages (Aquino et al., 2022). VR is not ideally suited for the norming stage due to task-technology fit limitations. Supplementation with virtual synchronous tools and traditional communication methods may be necessary (Lin & Roan, 2022).

Future research could delve deeper into the interplay between avatar embodiment, social presence, and task performance in VR environments. A promising avenue is to investigate how the self-presentation of avatars with different roles, responsibilities, genders, ethnicities, and abilities influences a participant's perceived image and their social interactions in an organizational context. Our findings also suggest the potential for a comparative study between 2D platforms (such as Zoom) and VR as modalities for group interaction. Additionally, exploring the impact of a heightened awareness of inattentiveness in VR on social presence and participation could shed light on the unique dynamics of virtual collaboration. Another critical area for future research is the role of spatial computing in mitigating concerns around task-technology fit. By examining how these capabilities can enhance task performance, reduce cognitive load, and improve user experience, researchers can identify strategies for optimizing VR environments for specific tasks and user needs. Finally, as we captured presence-related experiences inductively, their interdependencies became particularly evident in our findings. Therefore, we recommend that future research should further explore the complex relationships between the different dimensions of presence and their influence on group-level outcomes in VR.

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Appendix A

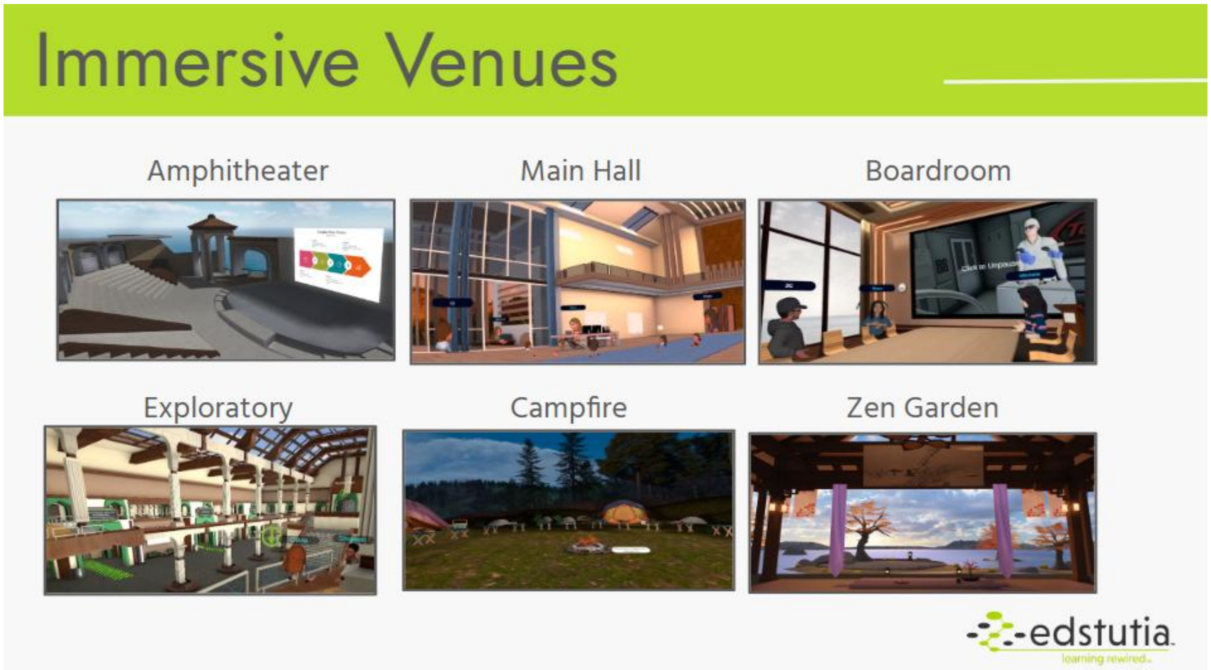


Figure A1. Group Workspaces in the Edstutia Platform

Figures A2a – A2d depict the layout of spaces for interaction on the Edstutia VR Campus

Figure A2a. Boardroom [participant names blacked out]

Figure A2b. Amphitheatre Lawn [participant names blacked out]

Figure A2c. Meditation Space

Figure A2d. Rooftop Bar

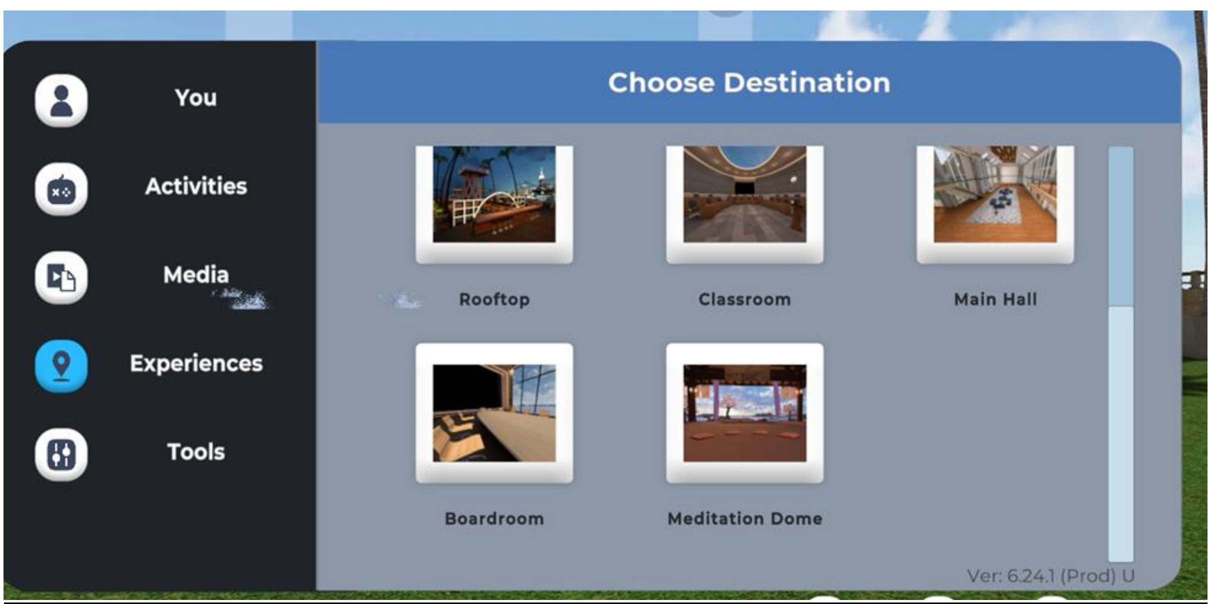


Figure 3. Layout of in-VR Menu Providing Access to Group Interaction Spaces

Figure 4a. Cohort 1 Group Presentation in VR [participant names blacked out]

Figure 4b. Cohort 6 Group Presentation in VR [participant names blacked out]

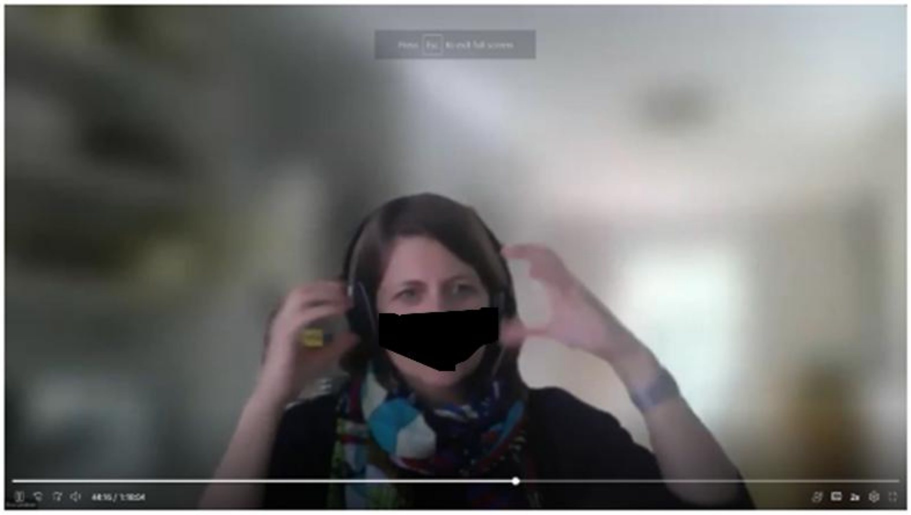
Figure 4c. Cohort 3 Group Presentation in VR [participant name blacked out]

Figure 4d. Cohort 5 Group Presentation in VR [participant names blacked out]

Figure 5a. Focus Group in VR set up

Figure 5b. Focus Group in VR Look and Feel Inside Campus

00:44:10.020 --> 00:44:18.139 EL:



Speaker 10: Yes, completely. Also, you can't lift. You have to lift off your headset to be able to see the watch or the clock.

Figure 5c. Focus Group on Zoom, Screen Grab of Speaker with Transcript

Figure 6. Using Controllers in VR Environment for Teleportation

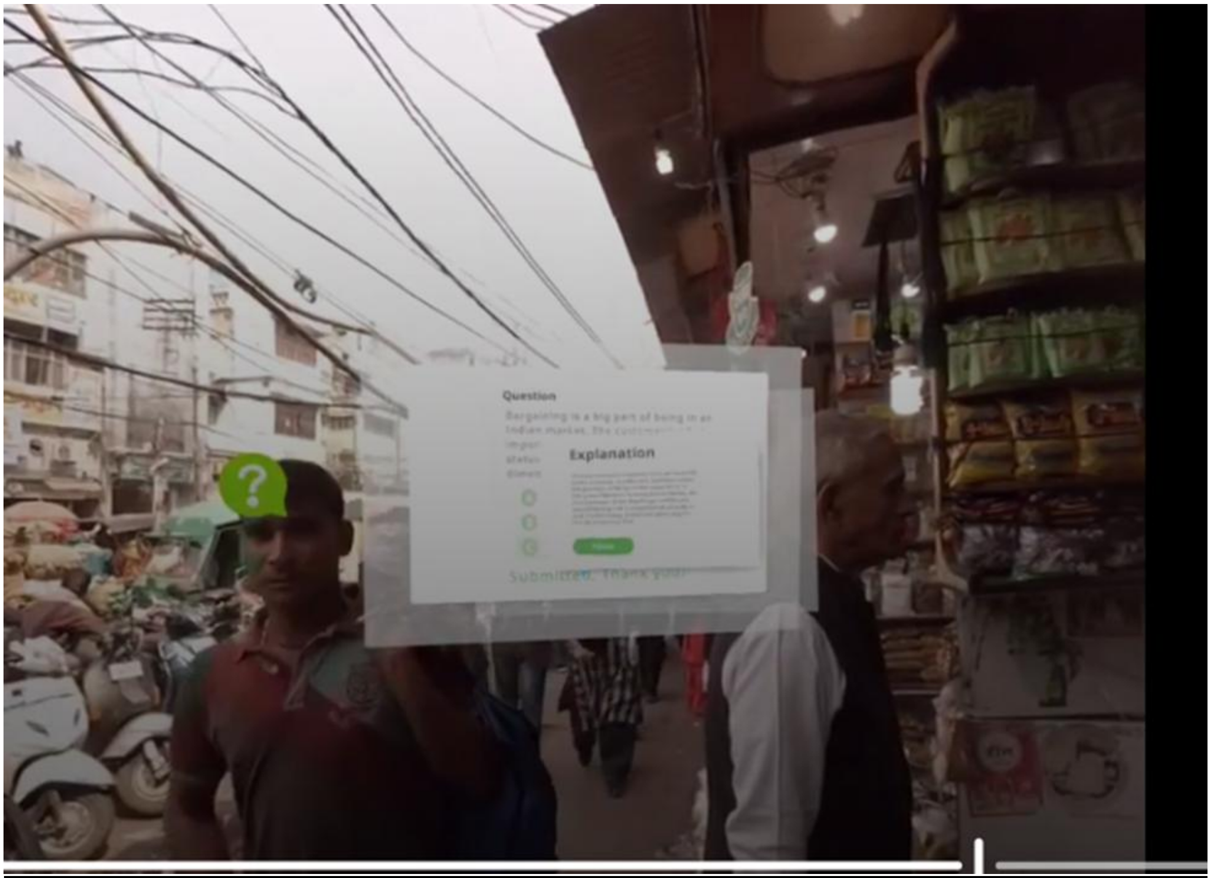


Figure 7. Immersive Indian Spice Market Interaction on VR Campus for Group Work

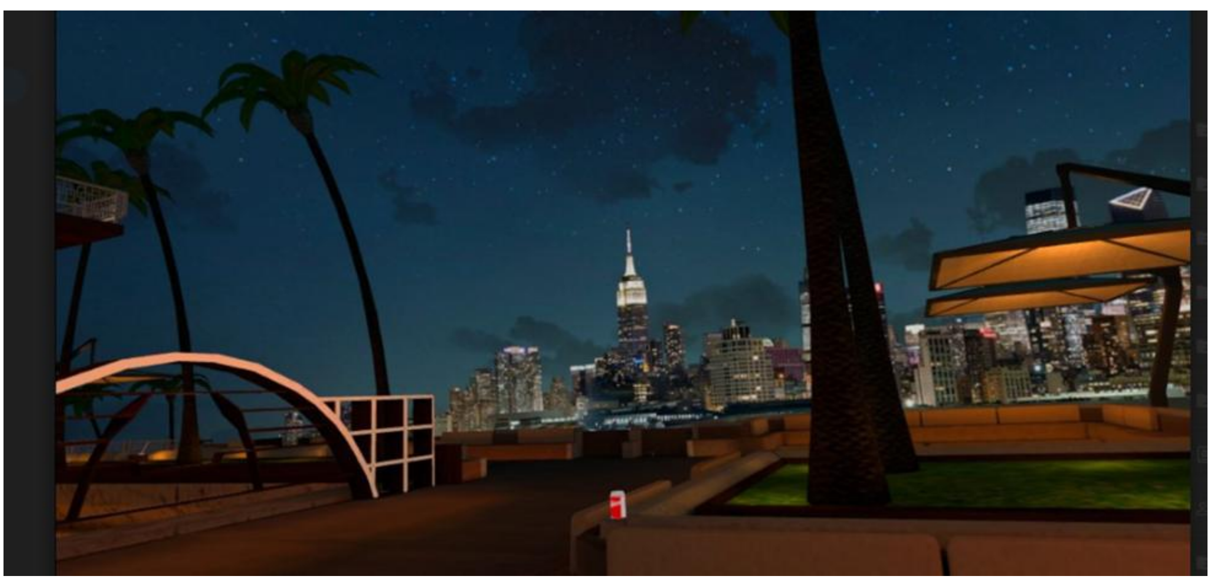


Figure 8. Rooftop Bar View

Figure 9. Object Manipulation in VR

Figure 10. Karaoke in VR

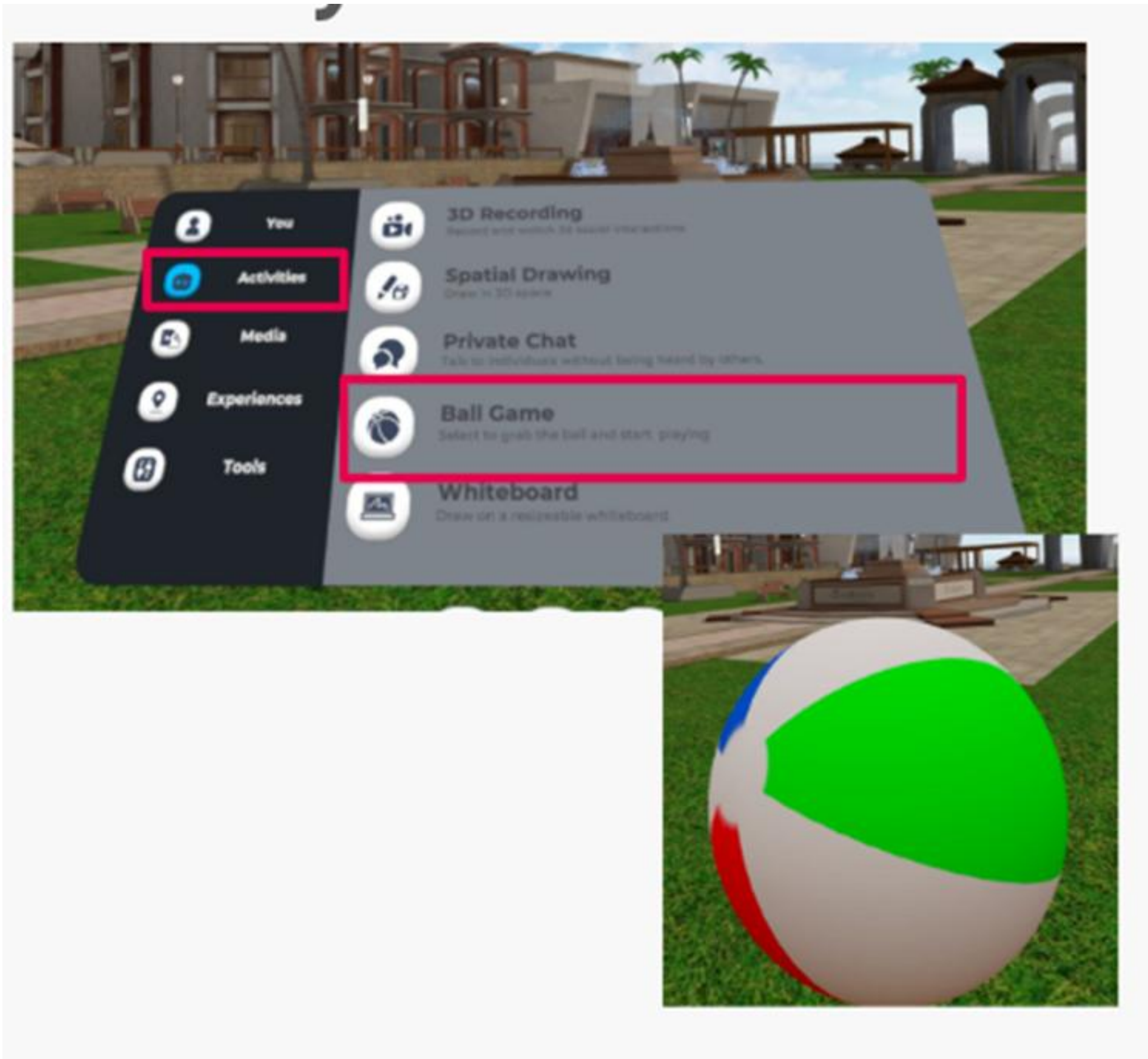


Figure 11. Ball Game Activity in VR

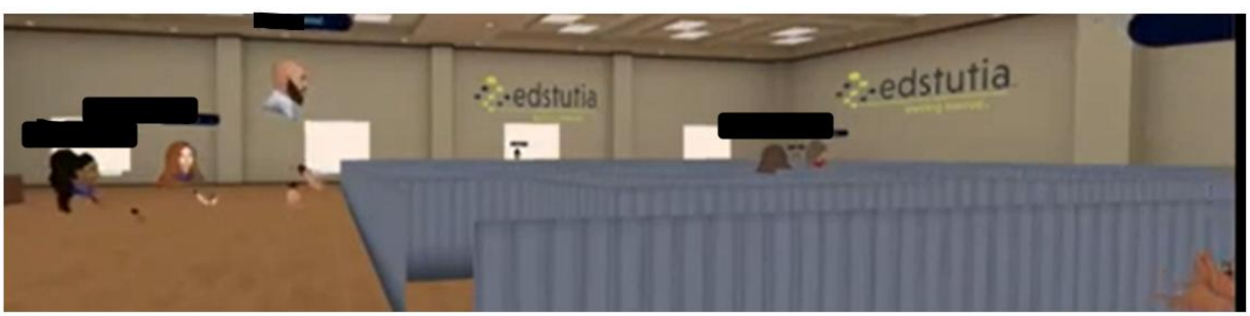


Figure 12. Group Work in Maze Crossing Activity [participant names blacked out]

Figure 13. Line Dance Activity in VR [participant names blacked out]

Figure 14a: Active Shooter Training- “run, hide, fight” Steps Practice in VR with Immersive Audio

Figure 14b. Active Shooter Training- “run, hide, fight” Steps Practice in VR with Immersive Audio [participant names blacked out]

Appendix B: VR Group Participant Codes, Cohorts, Projects

Speaker Code	Cohort Number	Group Project Title
Speaker 1	0 (pilot)	Leadership coaching roleplay
Speaker 2	1	VR and persuasion: making the case for digital transformation
Speaker 3	0	Giving instructions with visual aids
Speaker 4	6	Diversity and inclusion training
Speaker 5	5	Nuclear power plant technical training
Speaker 6	6	Gender identity and bias
Speaker 7	2	Mindfulness training: employee wellness
Speaker 8	1	Empathy training for healthcare providers
Speaker 9	6	Communication training
Speaker 10	6	Communication training
Speaker 11	1	Empathy training for healthcare providers
Speaker 12	4	Employee onboarding
Speaker 13	3	DEI training: unconscious bias
Speaker 14	1	Leadership coaching: giving feedback
Speaker 15	0	Organizational culture training
Speaker 16	5	Nuclear power plant technical training

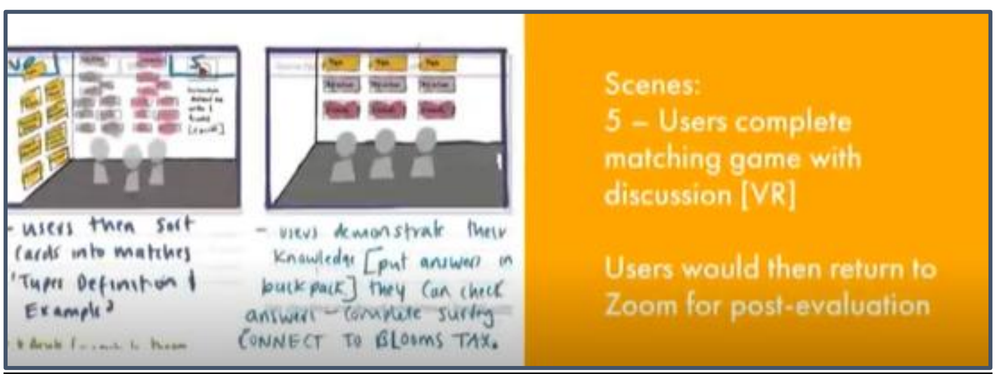
Speaker 17	5	Active shooter simulation
Speaker 18	4	Employee onboarding
Speaker 19	1	Leadership coaching: giving feedback
Speaker 20	3	Intercultural training: trust building
Speaker 21	3	Medical simulation: emergency room response training
Speaker 22	4	Leadership communication training
Speaker 23	1	VR and persuasion: making the case for digital transformation
Speaker 24	2	Nursing training: administering injections

Appendix C: Screengrabs of Group Project Presentations and VR Assets

Cohort 1: Empathy Training for Healthcare

Boardgame

In-VR Group Presentation of Activity Flow

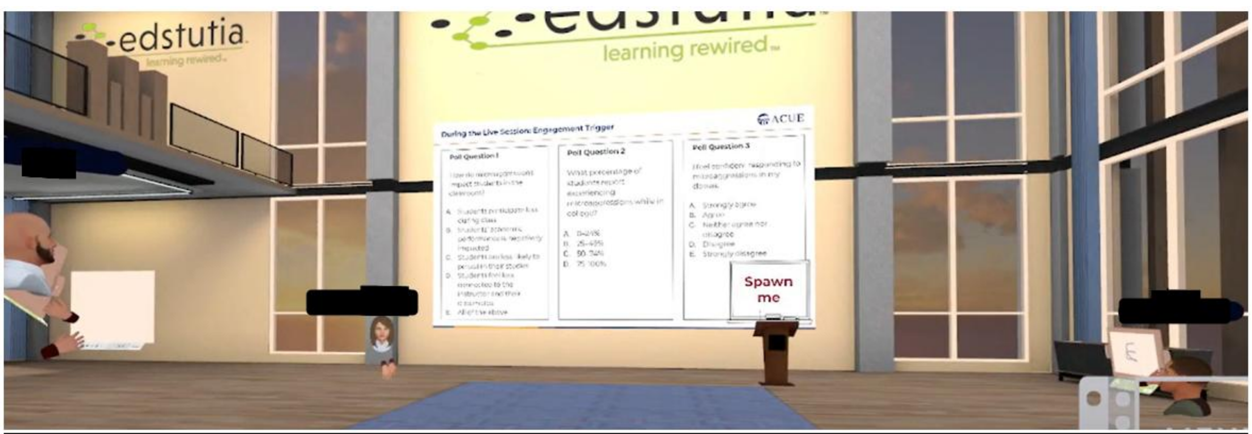


Cohort 3: Intercultural Training

[participant names blacked out]

Cohort 6: Diversity and Inclusion Training

[participant names blacked out]



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