

Working Together Apart through Embodiment: Engaging in Everyday Collaborative Activities in Social Virtual Reality

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Computer-mediated collaboration has long been a core research interest in CSCW and HCI. As online social spaces continue to evolve towards more immersive and higher fidelity experiences, more research is still needed to investigate how emerging novel technology may foster and support new and more nuanced forms and experiences of collaboration in virtual environments. Using 30 interviews, this paper focuses on what people may collaborate on and how they collaborate in social Virtual Reality (VR). We broaden current studies on computer-mediated collaboration by highlighting the importance of embodiment for co-presence and communication, replicating offline collaborative activities, and supporting the seamless interplay of work, play, and mundane experiences in everyday lives for experiencing and conceptualizing collaboration in emerging virtual environments. We also propose potential design implications that could further support everyday collaborative activities in social VR.

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

Additional Key Words and Phrases: computer-mediated collaboration; social virtual reality; collaborative virtual environment; embodied interactions

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1 INTRODUCTION

Collaboration plays a central role in most people's social lives. This concept has been used in many ways and has a variety of meanings across different domains such as behavioral sciences, organizational studies, and education. For example, Wood and Gary defined collaboration as "a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible" [45]. D'Amour et al. considered collaboration a process to construct both a *collective action* that addresses the complexity of user needs and a *team life* that integrates the perspectives of each team member and in which team members respect and trust each other [11]. They especially highlighted

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five essential dimensions of collaboration, including *sharing, membership, interdependency, power, and process* [11].

As collaborative technologies continue to support distribution of work and play and help connect people in different times and space [5, 20], how people live, interact, and collaborate in various forms of social lives such as groups, organizations, and communities through technology has become a core research agenda in CSCW and HCI [1]. In particular, extensive research in CSCW and HCI has focused on collaborative dynamics in multiplayer online games (e.g., *World of Warcraft*) and 3D virtual worlds (e.g., *Second Life*) given that games and game-based activities are considered a legitimate form of human interaction, rather than merely online entertainment [8, 9, 13, 14, 16, 18, 22, 28, 32, 33, 39, 41, 43]. This body of research collectively highlights online games and virtual worlds as unique *collaborative virtual environments* (CVEs) [8] – online digital places and spaces where people stay connected and play or work together even when they are geographically apart [37].

As online social spaces continue to evolve towards more immersive and higher fidelity experiences, they seem to lead to even more nuanced forms and experiences of collaboration and novel methods to further support computer-mediated collaboration. One such space is social Virtual Reality (VR). Social VR refers to popular 3D virtual spaces in which multiple people can engage with one another using VR head-mounted displays (HMDs) [17, 29]. Compared to other traditional online social spaces, social VR dramatically changes how people communicate, connect, and socialize with each other via immersive 360-degree space, voice communication, and full-body tracked avatars (i.e., avatar's movements correspond to one's physical body movements), rather than merely looking at a computer screen. This uniqueness thus make social VR a promising new CVE where people can participate in various collaborative activities in more immersive ways. Yet, despite social VR being a growing research area in CSCW and HCI [3, 7, 12, 17, 19, 21, 23, 24, 26, 29–31, 38, 46], to our knowledge, what people actually collaborate on and how they collaborate in social VR has received little research attention.

Grounded in definitions and perspectives of collaboration in prior work (e.g., [11, 45]), in this paper we explain collaboration in social VR as *a shared activity in any context in social VR between two or more people that involves a common goal* (e.g., users need to work together to achieve the goal). We believe that an in-depth empirical investigation of collaboration in social VR is critical for the CSCW and HCI community for two reasons. First, as mentioned above, how people interact with others in social VR (e.g., through HMDs and full body tracked avatars) is fundamentally different than engagement in conventional virtual environments. How these new differences further change and extend the ways in which people work together must be explored to explicate the complex social dynamics and new phenomena mediated, supported, and facilitated by novel technology. Second, as global events such as COVID-19 have placed more focus on understanding and re-imagining remote experiences, we may expect novel online social spaces such as social VR to become even more important for computer-mediated collaboration in various contexts (e.g., conferences, workshops, meetings, camps, and classroom teaching) in the near future. In fact, social VR such as Mozilla Hubs has been used for holding academic conferences (e.g., IEEE VR 2020). This leads to a clear need for further exploring the role of social VR in supporting and facilitating the growing desire for remote collaborative activities.

Therefore, using 30 in-depth interviews of peoples' experiences of participating in collaborative activities in social VR, we explore the following research questions in this paper:

RQ1: *What type of collaborative activities for both work and play do people often conduct in social VR?*

RQ2: *How do people conduct such collaborative activities in social VR?*

RQ3: *How do people perceive the role of collaboration in their social VR experiences?*

We thus contribute to CSCW and HCI knowledge in three ways. First, our research broadens current studies in computer-mediated collaboration by providing an in-depth empirical investigation of new phenomena and strategies of building and experiencing collaboration in social VR, a unique and novel emerging online social space that has not been thoroughly studied as a potentially valuable CVE. In contrast to traditional online gaming and virtual worlds, our study reveals the novel role of social VR in transforming how people can engage in everyday collaborative activities in a more nuanced and embodied manner. Second, we highlight the importance of embodiment for co-presence and communication; replicating offline collaborative activities; and supporting the seamless interplay of work, play, and mundane everyday lives for perceiving and conducting collaboration in emerging virtual environments. These insights thus extend our current understanding of how online collaboration can be experienced and (re)conceptualized. Third, we also propose potential design implications for further supporting collaborative activities in social VR, which may inform future design directions for more socially satisfying online experiences.

2 RELATED WORKS

Technology-mediated virtual collaboration has been explored in a variety of contexts, such as in Mixed Reality Architecture, where multiple physical spaces are linked across a shared three-dimensional virtual world [36]. In this section, we focus our literature review on two strands of CSCW/HCI research: how traditional online gaming and 3D virtual worlds support collaboration; and social VR as emerging online social spaces. We especially emphasize collaboration in online gaming and traditional virtual worlds rather than other online settings because social VR, as an immersive 3D avatar-based virtual environment, is more comparable and relevant to virtual worlds and gaming environments.

2.1 Collaboration in Online Games and Virtual Worlds

Online games—especially Massively Multiplayer Online Games (MMORPG)—and virtual worlds are perceived as cultural phenomena and social worlds that differ from other types of new digital environments due to their focus on interactive experiences and avatar-mediated communication [14]. Many of these environments can also be conceptualized as *collaborative virtual environments* (CVEs) [8] where people can work, play, or stay connected together despite being geographically apart [37]. Therefore, collaboration has been long considered a dominant social activity in online games and virtual worlds because (1) it is a practical requirement in these environments; (2) it constitutes an essential part of the virtual social experience due to its five key dimensions of *sharing, membership, interdependency, power, and process* [11].

Collaboration As Practical Requirement. Many online games and virtual worlds are designed in such a way that some common game goals are almost impossible to achieve without collaboration among players. Previous findings indicate that collaboration in games is often task-driven and functional [34]: players collaborate because it is imperative for success in the game, both for winning battles and for “leveling up” their avatars. Moreover, such collaboration is usually considered to be large-scale, highly organized, and formal, as illustrated by guilds in *World of Warcraft (WoW)* [44]. Guilds are virtual associations run by players who are natural organizers. They usually have formalized membership and rank assignments in order to encourage participation; and they involve a complicated leader-subordinate and leader-leader relationship [2]. In this sense, guilds are highly collaborative groups that come together for the purpose of achieving higher or more complex goals. Unlike the stranger-based ad hoc groups that focus on completing quests or defending against other groups rather than socializing [33], guilds are more permanent associations consisting of players who have similar goals or play styles and stronger collaborative affiliations [43].

Five Dimensions of Collaboration As Essential Social Experiences. Many online games and virtual worlds are also designed in such a way that users will have a less enjoyable experience if they do not collaborate with others, making collaboration an essential social experience for enjoyment. For example, Nardi and Harris found that *WoW* players participated in a multiplicity of collaborations, from brief informal encounters to highly organized play in structured groups with friends or strangers [33]. Such a variety of collaborations made the game more enjoyable and provided rich learning opportunities. How esports players collaborate with their teammates not only serves to aid in the competitive goal of winning, but also constitutes an essential part of the players' social experiences and main sources of social support, including emotional support, informational support, instrumental support, and esteem support [18]. In traditional virtual worlds such as *Second Life*, collaboration is crucial as well. These virtual worlds not only create a common context for collaboration but facilitate global and simultaneous interaction, which enhance knowledge management and sharing processes [32]. Consequently, they facilitate a broad range of educational, entertainment, and self-improvement activities and can support effective collaborative learning [9].

It is clear that collaboration in online gaming and virtual worlds has become a well-established research agenda in HCI and CSCW. Previous studies have highlighted five dimensions of collaboration [11] in online gaming and virtual worlds: *sharing*, *membership*, *interdependency*, *power*, and *process*. *Sharing* encompasses a series of practices when collaborating in online gaming and virtual worlds, such as shared responsibilities, shared decision-making, and shared values. *Membership* requires open communication, mutual trust, and respect, which is shown in both short term and long term groups in online gaming and virtual worlds. *Interdependency* can best be understood as mutual dependence, wherein players need to effectively collaborate with each other to complete tasks, achieve shared goals, or exchange social support. *Power* describes how players build relationships and interact with each other, with aspects such as leadership playing a role in virtual collaboration. *Process* points out that collaboration in online gaming and virtual worlds is not static or predetermined, but changeable over time. For example, collaboration between two or more players - whether in a group, guild, or dyad - may foster substantial emotional bonds of friendship, affection, or even online romance over time [16, 18, 35].

Such studies have also pointed out how varied communication mechanics could support these dimensions of collaboration in online gaming and virtual environments. First, textual communication plays an important role in forming, developing, and maintaining collaborative activities, which is not only instrumental but also social in nature [13]. Second, voice communication is crucial for online collaboration as well, making gameplay more social and leading to an increase of liking and trust among collaborators [39, 43]. Third, non-verbal communicative alerts (e.g., map pings to draw collaborators' attention to specific locations) can allow for quick and targeted communication in a rapid paced game session, which may affect the performance and quality of potential collaborative efforts [22, 41]. However, as online social spaces evolve towards more natural and embodied interaction, how emerging novel social spaces beyond traditional gaming and virtual worlds may lead to new and more nuanced forms and experiences of collaboration in virtual environments requires further research attention. We thus introduce social VR, which may bring in new opportunities and challenges for computer-mediated collaboration.

2.2 Social Virtual Reality as Emerging Online Social Spaces

Virtual Reality (VR) has long been an important research focus of HCI. In VR, users are "able to view what appears to be a life-size, three-dimensional (3-D) virtual environment without the boundaries that they usually associate with TV or computer screens" [40]. However, VR has only recently become available on the mass consumer market: over the past five years, various social VR platforms (e.g., AltSpaceVR, VRChat, Rec Room, and High Fidelity VR) have increasingly become



Fig. 1. Social VR users collaborating using a virtual whiteboard (<https://glue.work/>).

popular digital social spaces where people meet, interact, and socialize in new and more immersive ways (Figure 1). Social VR refers to real time, high-fidelity 3D immersive virtual spaces with 360-degree content where multiple users can interact and collaborate with one another through VR head-mounted displays [29, 30]. Different social VR platforms also tend to support diverse activities and social atmospheres. For example: Rec Room focuses on VR gaming; VRChat supports a wide range of creative activities and avatar customization; AltspaceVR is well known for its combination of various activities, including communicating with others through chat and attending events and professional development; Facebook Horizon emphasizes virtual interaction with people who are already friends; and High Fidelity VR highlights large-scale public events and performances [29].

In particular, in most social VR platforms users can create, craft, and customize their avatars to enter the virtual spaces and interact with others. Their avatars support full-body tracking rather than merely being controlled by mouse, keyboard, or joystick on a computer screen (Figure 2). Using such avatars, social VR users can conduct and enjoy real-life like social activities such as walking in a public space, playing a game, watching a movie, participating in a concert, and having a party in highly realistic simulated 3D virtual environments.



Fig. 2. A social VR escape room game [6] with avatar movements (right) corresponding to user movements (left).

Considering this, many technologists and practitioners envision that social VR could become "[the] premier place[s] to attend live shows, meetups, cool classes, and more with friendly people from around the world" (<https://altvr.com/>). Designing and understanding user experience in social VR is also becoming an emerging research agenda in HCI and CSCW. Prior studies on social VR have focused on design strategies [21, 29, 38], communication and interaction modes

[3, 15, 23, 26, 30, 31], self-presentation and identity practices [17, 19], long-distance couples' and children's experiences [24, 25, 46], and harassment and potential solutions [7]. However, though social VR provides fundamentally different interaction modes compared to other conventional CVEs, how social VR may support and facilitate new collaborative activities and dynamics is still understudied. For example, there is little to no empirical evidence on what people may collaborate on and how they collaborate in social VR. Only a recent study by Maloney and Freeman explored what users are actually doing in social VR and what makes these activities meaningful to them [23]. Yet, this work does not specifically focus on the collaborative aspect of social VR activities or the unique collaborative dynamics emerging in social VR. With the increasing need for supporting and facilitating remote work nowadays (e.g., considering COVID) in mind, in this paper we explore (1) types of nuanced collaborative activities for work and play that people often perform in social VR (**RQ1**); (2) novel ways through which such collaborative activities can be conducted in social VR (**RQ2**); and (3) peoples' perceptions of the role of collaboration in their social VR experiences (**RQ3**).

3 METHODS

Recruitment. Due to the exploratory nature of our research questions, we conducted an interview study to investigate users' rich and in-depth personal experiences with conducting collaborative activities in social VR. This study was part of a broader research project on social experience in social VR. The university's Institutional Review Board (IRB) approved this study for research ethics. To recruit participants, we posted a recruitment message on nine popular online forums for social VR users (e.g., Reddit's r/RecRoom, r/AltspaceVR, and r/VRchat). We also directly recruited participants by entering popular social VR spaces (e.g., AltspaceVR and VRChat) and asking random users' willingness to be interviewed. We provided an informed consent document to potential participants based on their communication preference, such as email or Discord messaging. All participants who responded to our requests and agreed to participate were interviewed.

Interviews. As a result, 30 semi-structured in-depth interviews were conducted via text/voice chat over either Discord, Skype, or Google Hangouts, depending on the participants' individual modality preference. Participants were not asked to provide their name or any other identifiable information in order to protect participants' safety and privacy. Interviews began with questions regarding the participants' basic demographic information, as well as questions about the devices and social VR applications that the participants use the most. The main interview questions were related to participants' avatars, important interactive activities they participate in and social experiences they had in social VR, and their perceptions and understanding of social VR design features. Example interview questions related to this study included "Can you recall any experience you count as 'collaboration' in social VR?", "If so, how did you collaborate with others?", and "How did collaborating with others affect your social VR experiences?". As we mentioned at the beginning of this paper, we explained collaboration in social VR as a *shared activity in any context in social VR between two or more people that involves a common goal* (e.g., these users need to work together to achieve the goal) and communicated that definition to our participants. We only offered this broad description to encourage participants to freely recount and share as much detail as they felt comfortable and appropriate. The average length of the interviews was 60 minutes and participants were given a \$20 digital gift card after they completed the interviews.

Participants. Among the 30 participants, 21 self identified as Man and 9 as Woman. Four participants had trans status. Of the 29 participants who shared their ethnicity, 20 self identified as White, two as Black, five as Asian, and two as Hispanic. Participants were 18 to 65 years old (average age: 32.2) and had a wide range of experience with social VR, ranging from 5 months

Table 1. Demographic information of interviewees

ID	Gender	Trans/cis status	Age	Ethnicity	Experience (months)	Social VR platforms used
P1	Man	Cis	19	White	12	Rec Room, VRChat
P2	Man	Cis	23	White	18	Rec Room, VRChat
P3	Woman	Trans	30	White	6	AltspaceVR, VRChat
P4	Woman	Trans	32	White	6	VRChat, Rec Room
P5	Man	Cis	29	White	30	VRChat, AltspaceVR, Rec Room
P6	Man	Cis	29	White	4	VRChat, AltspaceVR, Rec Room
P7	Man	Cis	18	Asian	10	AltspaceVR, VRChat
P8	Woman	Cis	27	White	12	VRChat, Rec Room
P9	Man	Cis	24	n/a	24	VRChat, BigScreen, AltspaceVR, Rec Room
P10	Man	Cis	20	Asian	n/a	AltspaceVR, VRChat, Rec Room, High Fidelity, Facebook Spaces
P11	Man	Cis	21	White	5	AltspaceVR, VRChat, Rec Room
P12	Man	Cis	49	Asian	24	VRChat, Rec Room
P13	Man	Cis	46	Black	36	VRChat, vTime, BigScreen
P14	Man	Cis	32	Hispanic	24	AltspaceVR, Engage VR, Rec Room, Mozilla Hubs
P15	Man	Cis	26	White	36	Rec Room, VRChat
P16	Man	Cis	65	Hispanic	24	Sansar, AltspaceVR, Rec Room, Decentraland, High Fidelity, Sonoroom, vTime XR
P17	Woman	Trans	26	White	18	VRChat
P18	Man	Cis	55	White	30	Sansar, High Fidelity, VRChat, AltspaceVR
P19	Man	Cis	43	Asian	36	VRChat, Rec Room, PokerStars VR
P20	Man	Cis	20	White	24	VRChat, Rec Room, Pavlov VR, BigScreen
P21	Woman	Cis	45	White	n/a	VRChat, AltspaceVR, Somnium Space, High Fidelity
P22	Man	Cis	32	White	18	VRChat, Rec Room, BigScreen
P23	Woman	Trans	21	White	24	VRChat, High Fidelity, AltspaceVR, Rec Room, BigScreen
P24	Woman	Cis	27	White	6	AltspaceVR, VRChat
P25	Woman	Cis	20	Asian	9	VRChat
P26	Man	Cis	30	White	6	VRChat, Rec Room, AltspaceVR
P27	Man	Cis	45	White	n/a	AltspaceVR, Oculus Rooms
P28	Man	Cis	48	White	24	VRChat, Rec Room, AltspaceVR, Anyland, Sansar, NeosVR, High Fidelity
P29	Woman	Cis	21	Black	24	VRChat
P30	Man	Cis	43	White	36	AltspaceVR, VRChat, BigScreen, PokerStars VR

Note: n/a - participant preferred not to answer; "Trans/cis status" indicates whether the participant identifies with the gender they were assigned at birth.

to 36 months (average: 18.7 months). Two participants (P26 and P27) self-identified as persons with disabilities. Participants had also experienced a variety of popular social VR platforms, including *Rec Room*, *VRChat*, *AltspaceVR*, *High Fidelity*, *Facebook Spaces*, *Vtime*, *Engage VR*, *Mozilla Hubs*, *Sonoroom*, *Pokerstar*, *Oculus Rooms*, *Sansar*, *Anyland*, and so forth. Table 1 summarizes the participants' demographic information.

Data Analysis. We conducted an in-depth qualitative analysis [10] of the data collected from interviews. Our goal was to generate a rich and empirical examination of emerging collaborative activities and dynamics in social VR. Our analytical procedures did not focus on inter-rater reliability, but instead focused on elucidating the recurring concepts and themes of interest, finding relationships among said themes, and formulating themes into more complex groups and broader themes [27].

We analyzed all collected interview data in five separate stages. First, two authors closely read through the participants' narratives to acquire a sense of the whole picture as to how users engage in and experience collaborative activities in social VR. Second, two authors independently and carefully re-examined and reviewed each transcript, categorized participants' responses into thematic topics, and developed sub-themes that emerged in participants' descriptions of their

own experiences of collaborative activities in social VR for further analysis. Some preliminary themes were identified by the authors when re-reading participants' accounts, while some others were added as particular quotes sparked new additional themes or sub-themes. Third, all authors discussed and refined themes and sub-themes in a collaborative and iterative coding process in order to streamline users' experiences of collaboration in social VR, and to group these themes by each research question. Fourth, two authors extracted quotes based on themes and sub-themes refined in the third step. Finally, all authors further discussed and refined themes and sub-themes, and used the quotes gathered to generate a rich description synthesizing how social VR users experience collaborative activities in more nuanced ways. Throughout the data analysis process, we used a shared spreadsheet, copying participant's responses into cells with columns corresponding to each theme and rows corresponding to participant IDs. We additionally used color-coding to highlight and specify new emerging themes in the spreadsheet.

4 FINDINGS

In this section, we identify common types of activities that our participants consider as collaboration in social VR and explain their key methods for conducting and facilitating such collaboration. We also highlight important aspects of the perceived role of collaboration in users' social VR experiences. Table 2 summarizes our main findings.

4.1 Common Types of Collaborative Activities Emerging in Social VR

As Table 2 shows, our participants mentioned four types of collaborative activities they often participated in within a social VR setting.

4.1.1 Conducting Embodied and Transformative Creative Activities. Similar to playing conventional 3D online games or virtual worlds (e.g., Minecraft) on a screen, a main type of collaborative activity that social VR users often engage in is working with others to create worlds, digital assets, and content in various ways.

Collaboratively Building Virtual Places in Social VR. In social VR, people have the freedom and flexibility to customize and decorate virtual places, or even build spaces from scratch based on their preferences. Examples of such user-generated virtual places include a private personal room, an LGBTQ-themed beach house, and "sleep worlds" – virtual places in social VR designed entirely for people to sleep, complete with dark lighting and a calm ambiance. Building and customizing these virtual places and spaces in social VR can, however, be daunting and exhausting if it is done alone. Therefore, many of this study's participants preferred to collaborate with others to create such places creatively, as P4 (Woman, Trans, White, 32) explained,

"Building stuff in social VR requires so much work and effort. So I like to invite my friends into my realm and build stuff together there. It's fun to collaborate that way because you can really feel you are making something with others face to face since you are physically doing things together. This also helps you build trust."

For P4, building virtual places together with others was a unique type of collaborative activity in social VR. It was challenging as it required "so much work and effort." Yet, it was immersive and embodied – they felt they could create realistic artifacts with others similar to what they would do in "face-to-face" situations. For these participants, such collaboration seemed to become a valuable opportunity for building open communication and trust in an embodied way because they were "physically doing things together."

In fact, participants frequently considered building virtual places collaboratively an essential activity for spending time with friends in social VR. As P11 (Man, Cis, White, 21) summarized, it

Table 2. Summary of Key Findings

Research Questions	Key Findings	Examples
RQ1: What type of collaborative activities for both work and play do users often conduct in social VR?	• Conducting embodied and transformative creative activities	• Building virtual places within social VR; creating digital assets using third-party applications and then importing said assets into social VR for future use; and generating social VR-based content for external 2D platforms
	• Simulating physical collaborative gameplay	• Playing paintball, frisbee, or card games
	• Engaging in collaborative professional events in an immersive manner	• Meetings, conferences, and workshops
RQ2: How do users conduct such collaborative activities in social VR?	• Replicating mundane daily tasks in a natural way	• Studying with friends and online strangers; planning social events together
	• Leveraging multimodal communication strategies through	• Voice, body language, and full-body tracking
	• Exploring unique virtual interactive tools to assist collaboration	• Maker Pen, virtual brushes, and virtual screens
RQ3: How do users perceive the role of collaboration in their social VR experiences?	• Easily creating private virtual spaces for collaboration	• Private rooms that only allow authorized participants to enter
	• Collaboration is central to experience immersive co-presence in social VR	Building "fun, immersive, and engaging" experiences with others
	• Collaboration fosters a sense of close-knit social VR community	• User-generated novel content; collaboration as a retention strategy
	• Collaboration makes experiencing and engaging in social VR more challenging	• The onboarding process that requires a steep learning curve; the social stigma of using social VR for collaboration

was important to create a novel virtual place that a group could collectively call their own. Through this building process, the virtual space became a reflection of the collective vision of "*an ideal place to hang out*" (P11), where a given group inhabited and spent time for the ultimate purpose of getting to know one another and building relationships.

Collaboratively Creating and Importing Digital Assets to Social VR. Several social VR platforms, such as VRChat, allow users to import various types of digital assets (e.g., avatars) created by third-party applications like Unity and Blender to the VR environment and then use these assets as interactive objects. Participants described meeting others who shared similar interests in creating assets - and subsequently working together to create and import such assets - as constituting an essential part of their collaborative activities in social VR. In this way, creative collaboration actually went beyond the social VR platform itself. P2 (Man, Cis, White, 23) revealed,

"All the customized content creation definitely goes hand-in-hand with you getting to network with people and getting a team together. And then you start building and you have to come up with ideas. You're solving problems because there's going to be glitches that you have to solve. You're fighting against the user experience. So, it's not just about VR itself anymore but making sure that what you're making is fun for people."

To P2, creating customized content and assets for social VR inherently involved collaboration with other users both within and out of social VR. These collaborative units engage in active communication with other people who try out created content with the ultimate purpose of gathering feedback (e.g., about glitches and user experience), which can subsequently be used to further improve the group's creation. In this sense, P2's experience with collaboration in social VR is *transformative*: the intention to be creative in social VR can be transformed into creative collaborative activities both in and out of VR, and that collaboration can extend beyond co-creators to those who experience the created content.

It is also common for social VR users to bring in artwork created outside social VR and collaboratively showcase them in social VR. P17 (Woman, Trans, White, 26) and P8 (Woman, Cis, white, 27) considered this an important collaborative activity:

"Last summer, I collaborated with others on art drawings outside VR. Then we would work together to set up an art gallery in social VR and display them. That's a good way to publicize and promote our artwork in a very immersive way." (P17)

"There is a graffiti world in VRChat I love. I love painting with all the graffiti artists. I love parties where you get to paint with other people and show off the work you created outside VR as well. That's pretty much like in real life except that in VRChat, I have unlimited ink." (P8)

For P17 and P8, the uniqueness of social VR lies in the ability to co-create, display, and showcase their artwork as if they were in offline world art galleries. In this sense, social VR seems to bridge online and offline creativity: participants can create artwork offline and then collaborate with other artists to showcase their art in virtual galleries in social VR, or participants can enjoy creating artwork collaboratively with others in social VR. For our participants, such activities to collaboratively engage in art creation are immersive, realistic (e.g., *"pretty much like in real life"*), and nuanced (e.g., *"have unlimited ink"*).

Generating Social VR-based Content for External 2D Platforms. Social VR users often use first-person point-of-view recording tools or virtual cameras embedded within social VR to create content about the user's social VR activities. These tools allow them to capture images or video within the 3D social VR space that can then subsequently be viewed as conventional 2D media. The recordings can then be shared and posted on external 2D platforms such as Twitter, Youtube, or Instagram. In this way, even those without access to a VR device can understand and experience what engaging in social VR means.

Participants described the collaborative nature of this type of creation as a two step process. First, they would discuss and negotiate with other users to achieve a consensus of the activities that would be recorded and what tools would be used to record the activities. Second, participants would work with others to "stage" and "script" the activity and then physically "perform" said activity in social VR. For example, P26 (Man, Cis, White, 30) explained how he collaborated with others to create meme or music videos in social VR. His experience shows that this type of collaboration is an iterative process that involves planning, staging, scripting, directing, and recording, all located within the social VR. However, the act of performance in the social VR is both virtual and physical in nature. While the created content is situated in a virtual environment, the physical movements become the content being created – e.g., users physically dancing makes their avatars dance virtually, thus creating the video content. Finally, P26 also suggested that certain aspects of collaboration could exist entirely outside of the social VR (e.g., refine the video using video editing tools, and work together to upload the finalized creation to other online social platforms).

When asked about his collaborative experiences in social VR, P16 (Man, cis, Hispanic, 65) shared a similar story:

"I go in [social VR] and then there's always something new going on, such as the events created by the platforms themselves, administrators, or other users. For example, one world had DJs from Amsterdam. My friends and I usually like to record the events. We talk about which ones to record, how long we record, and which part of the events we want to record. We often use some open broadcaster software to record the events and then post them on our Twitter accounts. I think recording things and documenting things are a big part of our collaboration in social VR. We consider ourselves photographers and videographers."

Here it is clear that P16 considers recording and documenting events occurring in social VR "a big part" of his collaborative activities with his friends. In much the same way that "photographers and videographers" operate in the offline world, P16 and his friends collaboratively plan the themes for recording and documenting, work together to conduct the recording using third-party tools (e.g., open broadcaster software), and release said recordings on other online social platforms. This appears to serve not only a social and collaborative purpose, but also as a way to introduce and promote social VR experiences to the general public.

4.1.2 Simulating Physical Collaborative Gameplay. Similar to traditional online gaming and virtual worlds, collaborative gameplay was also highlighted by our participants as a primary form of collaborative activity in social VR. However, unlike the types of collaborative gameplay seen in MMORPG and esports - i.e., forming a team to level up, completing in-game tasks, and/or competing with other teams- collaborative gameplay in social VR focuses more on simulating physical activities that social VR users would be engaged in in the offline world, such as playing paintball, frisbee, or card games. As P4 (Woman, Trans, White, 32) and P11 (Man, Cis, White, 21) described,

"I like to get in social VR with my friends and play a couple hours of paintball against other teams that are probably number one. I also play Dodgeball and disc golf with folks. Stunt Runner just came out. It's kind of like a Ninja warrior type deal. There are a bunch of community maps that people make. And recently climbing came out, so now you can do bouldering. And on those maps, it was kind of cool because people would get stuck on the same spots. Someone made an obstacle course, and we were talking to each other, 'How do you get here?' They would say something like, 'You can jump here, and you can skip that part.'" (P4)

"We played shooting games like paintball and then the escape room type games and sometimes we just threw around a frisbee in VR." (P11)

Both participants highlighted how performing physical activities (e.g., paintball, bouldering, golf, obstacle course running, and frisbee) was the main theme of collaborative gameplay in social VR for them. Mirroring other online gaming scenarios, they described having to share in responsibility for helping their team win against other teams, especially with competitive activities like paintball and Stunt Runner. Such competitive processes require users to trust each other and help each other work through the game. As P4 mentioned, his friends and he would constantly share tips and information in real-time regarding how to pass through an obstacle course in Stunt Runner.

Yet what is unique in social VR - as compared to either other online gaming scenarios or offline gameplay - is that users seem to have more flexibility to design and customize their collaborative gameplay. For example, P4 described how they are able to design and implement user-generated maps and obstacle courses for people to play collaboratively. More importantly, users have to physically perform the activity to collaborate with others in social VR: swinging a golf club, throwing a frisbee or a ball, climbing, and picking up an item and examining it, as examples.

This more embodied collaboration in a virtual environment thus makes gameplay both more challenging and enjoyable, as it requires users to physically perform those activities in the offline world rather than simply doing so through a series of clicks and keystrokes on the screen. One example is how people play card games in social VR. Unlike playing card games in 2D screens where users can only simply point and click, social VR users are able to utilize a full physical range of motion to pick up a card and hold it in a manner that is similar to what one would do in the offline world. As P6 (Man, Cis, White, 29) and P27 (Man, Cis, White, 45) described their experiences of playing card games and *Dungeons and Dragons*, even collaborative gameplay that does not require extensive physical body movement can still be uniquely engaging experiences *"because you can really show and explain things to people"* (P27).

4.1.3 Conducting Collaborative Professional Events in An Immersive Manner. In social VR, users can hold and participate in meetings, conferences, and workshops using voice communication, customized avatars, and full-body tracking. Compared to traditional conferencing solutions (e.g., Zoom, Skype for Business, Microsoft Teams, Google Suite), social VR provides many more interactive tools (e.g., whiteboards, immersive space, and 3D interactive tools) and enhanced communication through body language as performed through avatars. Given this, it is unsurprising that our participants also described increasingly using social VR for professional activities, where they could collaborate with their colleagues or other users to develop and improve various skills for the workplace. For example, P10 (Man, Cis, Asian, 20) detailed,

"The biggest collaboration in social VR I did was when I was part of a production team. We would host these weekly talk shows in social VR. I started off as just the person who created the slideshow for their talk show. And then I ended up growing and then becoming essentially the producer for their talk show so I was essentially taking a pretty large role in the team. I was managing several other people to produce these weekly shows. Typically, for each show, they would decide who should be the producer, create the slides, do marketing and advertising, and moderate the live streaming. Then we would recruit the host of the show as well as at least one guest. So, I ended up collaborating with a pretty large team. And it was on a very frequent basis. Now I'm looking for opportunities to use these skills outside VR, such as hosting a talk show offline."

Starting as someone whose sole task was to make slides, P10 gradually took on more responsibilities and learned various skills needed to plan, organize, and assign and navigate through different roles and responsibilities of a shared task (e.g., producer, content creator, recruiter, and moderator) in a production team by working collaboratively in social VR. Importantly, because operating and collaborating with a production team in social VR appears to be quite similar to work in the offline world, he can apply such skills to contexts beyond VR to further advance his career (e.g., *"hosting a talk show offline"*).

Other participants also echoed this view and explained that the similarity between collaborative activities in social VR and those in the offline world was the primary motivation for engaging in professional activities with others in social VR. P14 (Man, Cis, Hispanic, 32) added that the uniqueness of social VR's use in professional activities and events lies in the ability to collaborate with others in an immersive virtual environment but *"still realistic and natural."* Despite not physically being co-located in an actual room, P14 and his colleagues were apparently able to engage in collaborative activities just as they would in a face-to-face situation (e.g., *"move stuff physically and pass them around"*). The additional immersiveness and physicality provided by VR, therefore, enables the interaction to feel both "natural" and efficient.

4.1.4 Replicating Mundane Daily Tasks in A Natural Way. Participants in this study mentioned that their social VR mediated collaboration practices were often task-driven. In contrast to traditional online gaming or virtual worlds, though, these practices often focused on mundane daily tasks rather than tasks or goals set by the game or virtual world. Participants especially pointed out two forms of mundane daily tasks that they often collaborated on in a social VR setting: studying with friends and online strangers, and planning social events together.

Studying Together with Friends or Online Strangers. Participants described that in social VR, they could easily work with others on everyday activities (e.g., doing homework), in a similar way to how they would do such activities in the offline world. For example, when asked about collaborative activities he had engaged in with others in social VR, P1 (Man, Cis, White, 19) considered social VR a valuable collaborative platform for him and his offline friends to help each other study. First, him and his friends each had a more embodied presence (e.g., via full-body tracked avatars) when engaging in collaborative studying than in other virtual environments, making their virtual collaboration similar to a co-located collaboration. Second, they could use various interactive virtual tools (e.g., "mini flashcards with the maker pen") to naturally replicate in the social VR setting a daily collaborative activity that they would do in the offline world - like studying with a group using flashcards .

While P1 collaborated with his friends, other participants added that collaborating with online strangers on studying and homework was also quite common in social VR. These participants indicated that engaging in such collaboration often occurred quite naturally, even spontaneously. P7 (Man, Cis, Asian, 18) and P29 (Woman, Cis, Black, 21) revealed,

"I've helped people from different countries with their homework, and they will help me with my homework. [...] I was helping some people with math, and someone from Japan was helping me with my Japanese. I just go to a world and say, 'Hey, I need help with my homework.' Some people came up to me and helped. Other times I was like, 'I knew this person was taking this class.' So I asked them, 'Hey, I know you're taking this class. Could you help me out?' and they said 'Yeah!'" (P7)

"I remember I was doing an essay with my friend; we were doing it together in Social VR. I recall the goal was to learn new stuff, like learning new sentences in new languages. I also work with strangers. For example, I usually use VRChat when I have language homework. If I need something in French, then I would go in and ask any French users" (P29)

Both P7 and P29 used social VR to either help others do homework or receive help from others on their own homework in a collaborative manner. According to these participants, engaging in collaborative learning and studying in social VR seems to be quite simple and straightforward – just approach and ask others for help with a task. In addition, in contrast to the offline world, our participants seem to have a more straightforward "access" to a broader scope of potential collaborators with diverse cultural backgrounds (e.g., Japanese and French). For them, this seems to be an effective and authentic way of approaching collaborative learning and studying.

Planning Social Events for Both In and Out of Social VR Together. Another type of task that participants often indicated that they collaborate on in social VR is planning social events both for social VR and for the offline world. For example, when asked about their collaborative experiences in social VR, P17 (Woman, Trans, White, 26) shared how they planned an offline trip with their friends using social VR. She especially highlighted the advantage of using social VR for collaboration as the ability to present, share, and communicate information "through emotions, voice, and body language in the moment." Such multidimensional communication was especially valuable for daily tasks that require a significant "brainstorm" process for collaborative decision

making, such as planning a trip together. Compared to using regular text-based social platforms (e.g., Discord) for such collaborative planning tasks, P17 found that social VR could alleviate the challenge of the lack of non-verbal cues and body languages when discussing and negotiating different ideas due to the predominant use of voice communication and full-body tracking.

It is also possible for social VR users to plan regular offline social activities that take place concurrently in social VR and in the offline world. When replying to the same interview question, P23 (Woman, Trans, White, 21) revealed their experience of collaboratively planning monthly pizza parties in VRChat:

"A group of social VR friends and I have actually worked together to plan our monthly pizza parties. We will get everyone's schedule and decide when and where to meet in VRChat. We will get pizza and eat it in real life while talking and having fun in VRChat together."

P23's story is interesting because the activity in question - planning a shared meal in social VR - requires coordination both within and outside of the social VR. She and her friends have to identify a virtual place to host such pizza parties within the social VR while also accommodating everyone's offline schedule and coordinating the ordering of pizza - all so they could eat real pizza at the same time while in social VR. For P23's group of friends, collaboratively planning and conducting such events seems to have become a fun monthly ritual.

Indeed, for many participants, planning such social events was their primary collaborative endeavor, one in which the participant could translate their offline social lives to social VR. As P3 (Woman, Trans, White, 30) summarized,

"We work together to plan recurring events in a given week. I'd call it the most important thing we collaborate on. Monday nights we decide which movies we want to watch and watch them in VR. Then Tuesday through Thursday, we just brainstorm and find a place in VR to hang out in general. Usually Friday nights we have some sort of party. Everyone will get together and collaboratively decide the theme of the party. I do a lot of dancing and stuff like that at the parties. And then, Saturdays are just usually us finding a place and hanging out again in social VR."

For P3 and their group of friends, one crucial task was to coordinate both time and space in a novel virtual space - gathering everything together and setting up a schedule of various activities that they would share each week at different times and different virtual locations. Clearly this required tremendous collaborative efforts from everyone to make it happen, including group decisions on when and where to meet and what they should do together as a group. For P3, this thus became *"the most important thing"* they had collaborated on, as these planning sessions involved both temporal and spatial dimensions and constituted their key social lives in social VR.

4.2 Key Methods to Conduct and Facilitate Collaboration in Social VR

We have identified common types of collaborative activities users often engage in in social VR. In this section, we explain key methods that social VR users utilize to conduct and facilitate such collaborations as shown in Table 2.

4.2.1 Leveraging Multimodal Communication Strategies Involving Voice and Body. As mentioned earlier in this paper, social VR affords a broad spectrum of communication modes, including both verbal and non-verbal interactions such as voice, gestures, proxemics, gaze, facial expression, and bodily movements through full-body tracked avatars. This richness of multimodal communication channels directly affects how collaboration in social VR can be conducted and facilitated in more

nuanced ways. For example, P17 (Woman, Trans, White, 26) highlighted the benefit of full-body tracking for conducting collaborative activities in social VR,

"I think, for me, full-body tracking is incredibly validating. In social VR, my avatar mimics every movement that you're making in real life. So you are like, oh, I'm moving my left arm up this way and I'm moving my right leg this way. Then you see how your avatar reflects that in real time. This really makes you think, wow, that's really me! I'm building this castle or playing this game with others. It's really me there collaborating with other real people."

According to P17, the fact that the avatar moves in the virtual environment in the same way they are moving their physical body in the offline world validates and further enhances the sense of self-presence and body ownership in social VR. As she mentioned, such embodiment made her feel that it was indeed her— rather than her avatar— that engaged in collaborative activities with others in social VR. This also affected how she perceived potential collaborators – as "real people" rather than virtual avatars.

P5 (Man, Cis, White, 29) further explained the importance of leveraging voice and body in the process of collaboration in social VR,

"My main experience of collaboration in social VR is collaborating with others to play some fast paced games. Since it is so fast paced, we have to come out with different callouts for different situations. So, there's a lot of collaboration both in voice chat and in body language and positioning. I think these are the two most important ways to collaborate in social VR. Also, I've tried to help new users to learn their way around and explain to them strategies for the game. It's an interesting teaching experience because with your body language you can explain certain things better. And since you see the learners' body language, you can kind of get a picture of their understanding based on how they're moving around. If they're looking down or something like that, you can tell that they may still be confused."

As P5 points out, voice communication and body language "are two most important ways to collaborate" in social VR. Through the predominant use of voice chat, social VR users are able to share and exchange information at a fast pace, which facilitates quick and efficient collaboration and coordination in the moment. More importantly, the accurate correspondence between one's avatar body movement and physical body movement facilitates the conveying of non-verbal cues, elevating the critical role body language plays in conducting collaborative activities in social VR. Through body language, P5 describes not only being able to better explain and share knowledge with newcomers but also being able to more accurately read others' reactions and expressions. He can then use that information to, for example, provide more encouragement in response to a learner's body language indicating confusion. In this sense, the combination of voice communication and full-body tracking seems to help social VR users collaborate more effectively.

4.2.2 Exploring Unique Virtual interactive Tools to Assist Collaboration. Many social VR platforms provide various virtual interactive tools such as pens, markers, and whiteboards designed to be used in the same way as their counterparts in the offline world (e.g., virtual pens for writing and whiteboards for displaying content). Our participants specifically explained how these real-life-like virtual tools effectively assisted and enhanced their collaborative activities in social VR. For example, P4 (Woman, Trans, White, 32) and P1 (Man, Cis, White, 19)) highlighted the benefits of using "Maker Pen":

"There is a tool called the Maker Pen in social VR. It looks a little bit like a hot glue gun but essentially you can use it to make things in 3D space in social VR. That's really what

appealed to me the most and I think that's an awesome tool to facilitate any type of collaboration you could have in VR. For example, you can use it to visualize a 3D model or create some other objects you need." (P4)

"We make mini flashcards with the Maker Pen. We then write notes on the flashcards and use them to test each other. It definitely feels much better to have actual 'cards' in hand. I think this helps us learn better, similar to the difference between a physical textbook vs. ebook." (P1)

For P4, the Maker Pen appealed to him most because he could create 3D objects for visualization, which proved helpful for *"any type of collaboration"* in social VR. As mentioned previously by P1, his friends and he often studied together in social VR. For them, using such a tool added a layer of physicality to their virtual studying (e.g., *"have 'actual cards' in hand"*), making it more natural and realistic.

In addition to Maker Pens, other participants described virtual brushes as a valuable tool for conducting collaborative activities. P30 (Man, Cis, White, 43) explained,

"The brush is totally free and easy to do. You can use a tilt brush to get some sort of artistic rendering of an idea or better express to others a project that you might want to do. It is very useful if you work with others on a project. Definitely more useful than looking at a screen or looking at somebody projecting onto a screen."

Here P30 describes using brushes in social VR as similar to the methods in which he would use a paintbrush in the offline world. This similarity likely makes using such a tool in social VR easy and highly intuitive. For P30, such a tool is especially useful for social VR users looking to engage in creative and collaborative tasks because art acts as a way to visualize others' ideas in a more immersive manner than simply *"looking at a screen."*

4.2.3 Easily Creating Private Virtual Spaces for Collaboration. In the offline world, people must often be co-located and situated in a suitable space for the specific collaborative activity they plan to conduct (e.g., a conference room or a workshop). In traditional online gaming or virtual worlds, people also need to be at an appropriate virtual place for potential collaboration (e.g., a battlefield for team competition). In contrast, social VR uniquely provides users with the ability to swiftly design and create virtual spaces specifically suited to their collaborative needs. Such virtual spaces can handily be created as private rooms and only allow authorized participants to enter, making the collaborative experiences even more intimate and protected.

P30 (Man, Cis, White, 43) and P17 (Woman, Trans, White, 26) described how easy and convenient creating such virtual spaces for collaborating in social VR can be:

"In BigScreen, it's dead easy to set up a room and set up a screen. Then a particular set of people can just go in and have a nice space to collaborate with ideas or create something together. It's totally easy and very convenient. You will have everything you need for your virtual collaboration almost immediately." (P30)

"You can just set up a private space for people to meet up and then ask certain people to join. Then you and your group can have private conversations and conduct projects there and nobody can disturb you. I think having such a space is very important if you want to collaborate on something – you will have a quiet place to have serious conversations and meetings etc." (P17)

According to P30, users can easily set up meeting space and a virtual screen in BigScreen if they need to conduct any collaborative activities. For P30, this convenience is highly valuable, as it means collaborators can have an appropriate space in social VR to engage in conversations and brainstorming almost immediately after deciding to collaborate. P17 further highlighted the

importance of creating private meeting places in social VR. For her, such privacy is crucial for conducting collaborative activities in social VR. Because almost all social VR platforms are open virtual worlds, there is always the possibility that bystanders in social VR could overhear conversations (through voice) or even interrupt ongoing collaborative activities as a form of trolling or harassment. Creating private collaborative spaces thus not only prevents such disruptions but also better protects user privacy and safeguards the content of collaborative activities.

4.3 The Role of Collaboration in Social VR Experiences

Our participants also collectively pointed out how they perceived and understood the role of collaboration in their social VR experiences.

4.3.1 Collaboration Is Central to Experience Immersive Co-presence. Participants continuously expressed a high appreciation for the novelty of social VR, calling its unique features such as voice communication, full-body tracking, and immersive 360-degree virtual content "*powerful*," "*mind blowing*," and "*eye opening*." However, they also expressed that they would much prefer to experience these incredible features with other social VR participants rather than just by themselves. In fact, when asking, "*do you do social VR activities alone or with others?*," all 30 participants said that they most often engaged in activities with other people rather than exploring social VR alone. For them, collaboration with others is central to how they enjoy social VR – it is an important way for them to experience co-presence (i.e., the awareness of one's own existence and other people's existence in one place or environment [42]) in an immersive way.

For example, when asked how they feel about the impact of collaboration on their social VR experiences, both P5 (Man, Cis, White, 29) and P18 (Man, Cis, White, 55) described feeling like they were really interacting with other people when collaborating in social VR. This in turn made their social VR experiences more satisfactory and realistic than engaging in traditional gaming or virtual worlds:

"I like to collaborate with people in social VR on a variety of things. In fact I think that's the most important part of my social VR experience. I feel like I actually did go out, hang out, and work with those people as opposed to just playing a game on PC or console with them. Even if I was voice chatting with those people in an online game, it wouldn't necessarily feel quite the same and I'd still have the desire to go out and meet people in person. But in social VR it is different. The collaborative experience feels so real and I feel it can even replace face to face in some ways." (P5)

"It's important for me to go to an event or do something with a group of people in social VR, like playing a game or building something. I think those are social VR's main appeals to me. And after I take off my VR headset, it really feels that I've interacted with other people, even though I haven't physically left my house." (P18)

Here it can be seen that, by collaborating with others, both P5 and P18 experienced a more realistic form of co-presence in social VR in two dimensions. First, the sense of co-presence that emerges while collaborating in social VR is qualitatively different from merely playing with others in a traditional on-screen PC or console game. As P5 mentioned, though voice chat is not exclusively used in social VR, collaborating in social VR still seemingly leads to more immersive interactions than traditional gaming or virtual worlds due to the combination of voice, embodied avatars, and immersive content, the latter two being more exclusive to VR. Second, the sense of co-presence that emerges while collaborating in social VR is comparable to face-to-face interactions. P5 highlighted that he felt he did "*go out, hang out, and work with*" others in social VR, and P18 revealed that – even after he left social VR – his experiences of co-presence with others still felt so real despite him physically sitting in his house alone. For both participants, the ability to engage in collaborative

activities and experience immersive co-presence is the main appeal of social VR, which successfully satisfies their shared desire to "go out and meet people in person" without actually going out and meeting people in person.

4.3.2 Collaboration Fosters A Sense of Close-Knit Social VR Community. As has been mentioned earlier in this paper, social VR is still considered a somewhat niche community despite the increasing popularity of various social VR platforms - primarily due to the relatively high cost of VR headsets and other technical requirements and equipment. P20 (Man, Cis, White, 20) pointed out that, compared to traditional online gaming or virtual worlds, it was more challenging for many people to access social VR. For him, social VR is still a niche technology that attracts tech savvy people of similar interests. Therefore, social VR users are likely more inclined to collaborate with each other in order to further develop their shared interests, with the ultimate goal being to "build a community" (P20).

Importantly, participants considered collaboration crucial for fostering a sense of the new social VR community and potentially expanding said community in the future. P7 (Man, Cis, Asian, 18) noted,

"I have played a lot of games before this but with social VR I made a close-knit group of friends online. We know each other in VR and we have been collaborating on so many things – organizing events, parties, and creating assets. These are people that are like ride-or-die. It's nice to have such a community with people who love doing all different types of things together in VR." (P7)

In P7's experiences, social VR users tend to be a "a close-knit group" with like-minded people. Working with other users on a variety of tasks further closely connected users together in a more organic way. In this process, a sense of community and social bonding seems to emerge.

With this in mind, it is important to note that participants often acknowledged the need to expand the user population in order to enrich and diversify the content and experiences that social VR can provide. P16 (Man, Cis, Hispanic, 65) and P29 (Woman, Cis, Black, 21) expected that their collaborative efforts geared toward creativity and community building could help expand the user base of social VR:

"Social VR has the potential of bringing people together and to connect people together from all walks of life. Now lots of people are collaborating and creating new contents in social VR. The contents are getting better and better. I think this will definitely attract new users."(P16)

"I think collaboration in social VR helps you find the people who have the same interests as you or same goals as you. Once you both know that you are both into the same stuff, you are kinda connected because you are in the same thing. This encourages you to open more to your collaborators. This also keeps you and others constantly coming back to VR to work together. So it's like a retention thing." (P29)

P16's account highlights an essential fact about social VR: users act as both the consumers of content and the creators of content through the practice of interacting and collaborating with others. Consequentially, people's collaborative activities help sustain the social VR community in two ways. First, their collaboration directly leads to user-generated novel content, which in turn builds a robust and appealing VR environment for newcomers. Second, their collaboration also serves as a retention strategy – sharing the same interests and goals and constantly working together brings people closer together and invites them be open to one another. This thus motivates users to continue engaging in social VR to maintain the strong relationships they have formed.

4.3.3 Collaboration Makes Experiencing and Engaging in Social VR More Challenging. In general, participants considered collaboration a significant and essential part of the social VR experience. However, in some sense, participants also felt that collaboration made experiencing and engaging in social VR more challenging.

More specifically, learning how to use social VR for collaboration can present a significant challenge to users. Efficiently conducting collaborative activities - especially for professional development purposes - requires familiarity with the technology (e.g., how to draw using the handheld devices) and the virtual environment (e.g., how to navigate meeting spaces and do slideshows on a virtual screen). Unfortunately, the onboarding process may often involve a steep learning curve, which could be particularly discouraging to some users. When responding to the question about challenges in their VR collaboration, P10 (Man, Cis, Asian, 20) and P14 (Man, Cis, Hispanic, 32) revealed that endeavoring to collaborate in social VR sometimes undermines rather than enriches peoples' social VR experiences. As an emerging novel technology, the learning curve associated with using social VR is already steep for potential users seeking to learn about this new interaction mode. The requirements for conducting collaborative activities in social VR, therefore, introduce additional barriers to entry, such as navigating the virtual space and coordinating with others through a VR device (e.g., pressing a button to move items). For some users, this can lead to unnecessary frustration, making them reluctant to collaborate in social VR or even engage in social VR in the first place.

Another challenge is the social stigma of using social VR for collaboration. P12 (Man, Cis, Asian, 49) mentioned that the general public is still not familiar with the concept of social VR, and is even more unfamiliar with collaborating in social VR. P17 (Woman, Trans, White, 26) elaborated on this stigma,

"I've tried to get people I know in the real world to use social VR to collaborate with me, like moving our meetings or workshops in social VR. But it turns out that there's some weird stigma about VR. And everyone I know in the real world looks at VR like it's some crazy person thing. I've tried convincing them to give it a try. But they've all been like: no, it's not for me. I feel social VR attracts a certain type of people and now I spend all my time doing things with them in VRChat."

According to P17's statement, people whom she knew in the offline world all tended to perceive VR as "some crazy person thing." While it is unclear from P17's account why such a perception existed in her case, it is clear that the niche reputation of social VR and the prerequisites to use the platform becomes a barrier to entry. As P17 noted, social VR currently seems to attract a certain type of tech savvy user who shares similar interests in VR and passions to collaborate in social VR. This helps users build an emerging close-knit community, as we discussed in the last section. Yet, this also makes some people reluctant to adopt the VR technology or use it as a potential collaborative platform - for example, there seems to be a general assumption/bias that only tech savvy people (e.g., nerds or geeks) should want to use social VR.

5 DISCUSSION

The findings of this study, as summarized in Table 2, reveal several key concepts that are important for gaining a greater understanding of collaboration in social VR. In this section, we further discuss how these findings shed light on nuanced forms of collaboration and novel strategies for collaboration in emerging online social spaces, which expand existing HCI and CSCW knowledge of computer-mediated collaboration. Based on these findings, we also discuss implications for designing future social VR platforms as potential CVEs.

5.1 Understanding Social VR as A Nuanced Collaborative Virtual Environment

In contrast to traditional online gaming and virtual worlds, collaboration is not a practical requirement for engaging in social VR – users could either enjoy social VR alone or with others. Yet similar to existing research [8, 9, 14, 16, 18, 28, 32, 33], our findings demonstrate that collaboration is still an essential social experience and a significant way to build a sense of community in social VR. However, in this study, we also reveal the potential of social VR to be a nuanced CVE. In this sense, social VR provides promising opportunities for working, playing, or spending everyday lives together in new and more novel ways.

Social VR in the Five Collaborative Elements. Our findings first further explain how the five basic elements of collaboration [11] can be manifested and strengthened in emerging novel online social spaces. For example, regarding *sharing* and *power*, our participants emphasized the importance of identifying shared goals and responsibilities (e.g., building a virtual place, creating virtual arts together, or hosting a virtual talk show) and assigning various responsibilities and leadership roles (e.g., deciding who would make slides and who would advertise the talk show) through multimodal communication channels (e.g., voice and body language) when engaging in collaborative activities in social VR. Regarding *membership* and *interdependence*, participants highlighted that collaborating in social VR further strengthened their sense of social bonding and mutual support as they had to physically conduct activities together (e.g., passing objects around or dancing together). Regarding *process*, participants mentioned that they often came back to social VR to immersively work with others on a regular basis – either by playing a game, attending or organizing events, or creating assets. For them, these collaborative efforts over time not only fosters a close-knit social VR community but also potentially expands the community by both retaining current users and attract new users.

Nuances of Social VR-mediated Collaboration. With these considerations in mind, social VR therefore seems to become a potential CVE [4] where users can engage in various collaborative activities in more immersive and embodied ways. Compared to traditional online gaming and 3D virtual worlds that have been extensively studied through the collaborative/group dynamics lens [9, 16, 18, 32, 33], social VR supports more diverse collaborative activities in a natural way (e.g., ranging from creative activities and physical gameplay to professional events and mundane daily tasks), which could even be extended beyond social VR (e.g., collaborating on creating content both in and out of social VR). It also offers novel ways for users to engage in virtual collaboration, for example, through voice, full-body tracking, various platform embedded interactive tools, and user-generated private virtual spaces. Our findings especially highlight three significant nuances of social VR mediated collaboration.

The first is the focus on *embodiment* for conducting and facilitating virtual collaboration. Previous literature on computer-mediated collaboration in online gaming and virtual worlds has emphasized the role of textual communication [13], voice [39, 43], and non-verbal communicative alerts such as pins [22, 41] in coordinating and facilitating such activities. In contrast, in social VR, collaboration and interaction between users is mainly achieved by embodied interactions and experiences. Considering the inefficiency associated with textual chat, and the lack of ability or will to use voice chat in all social VR scenarios, the embodied presence of the user becomes the primary collaborative experience. As our findings have shown, one's sense of being physically immersed in the virtual environment is significantly enhanced in social VR due to the fact that avatar behavior in social VR corresponds to the ways one's body moves in the offline world. This may lead to a higher awareness of body ownership and more physical and transformative interactive experiences (e.g., creating an artwork together in social VR requires making physical movements of drawing or painting in the offline world), which strengthens the sense of engagement, immersiveness, and

co-presence in social VR collaboration. Many participants thus commented that their social VR mediated collaboration felt similar to face-to-face collaborative activities. Additionally, the level of joint involvement and user connectedness is also enhanced by the broad spectrum of both verbal (e.g., voice) and non-verbal (e.g., gestures, gaze, and body language) communication modalities that social VR facilitates. This provides more potential methods to conduct and facilitate effective collaborative activities through one's virtual body. In this way, the enhanced sense of *embodiment* in social VR adds an important dimension in computer-mediated collaboration by facilitating one's awareness of self (e.g., "I am the one working with others, not just my avatar") and awareness of others (e.g., "I am working with others, not just their avatars").

The second is the emphasis of *replicating offline collaborative activities*. Our participants especially highlighted how social VR allowed them to collaborate on everyday activities that they would normally conduct in the offline world, such as doing homework, planning trips, organizing parties and social events, and attending workshops and talk shows. Social VR also provided them with virtual collaborative tools that replicated counterparts in the offline world, including white boards, screens, or pens. With such similarity between the context, goals, and expectations of collaboration in social VR and that in the offline world, social VR seems to mediate virtual collaboration in a more natural and immersive way. As such, users could easily engage in regular everyday activities collaboratively using familiar virtual tools, rather than being driven (or forced) to accomplish unfamiliar tasks and shared goals set by the system (e.g., as in online gaming).

The third nuance is the *seamless interplay of work, play, and mundane everyday lives* in social VR collaboration. Previous studies have shown that collaborative activities in gaming and traditional virtual worlds are not only instrumental but also social [13]. Yet, there still seems to be a fine line between when instrumental or social collaboration should be conducted in a virtual environment. In our study, social VR appears to afford a seamless interplay of work, play, and mundane everyday life when it comes to collaboration. It can be leveraged for work-oriented purposes such as collaborative studying, content creation, and professional events; it can be used for play, such as creating digital assets or artwork for fun and playing physical games together; and it can also be used to coordinate mundane everyday tasks, such as planning pizza or dancing parties. Our participants acknowledged that social VR supported the wide range of collaborative activities, making it possible for users to easily and comfortably switch between collaborating on work, play, and everyday tasks. For our participants, social VR seems to be a more open and flexible collaborative space that can accommodate diverse collaborative contexts and needs.

In summary, these nuances indicate that collaborating in social VR seems to be similar to collaborating in face-to-face situations in the offline world, and participants felt that the methods through which they facilitated collaboration in social VR were natural, immersive, and realistic. Participants also indicated that they engaged in similar types of diverse collaborative activities as those they would do in the offline world, which involved work, play, and mundane everyday tasks. Despite the existing onboarding challenges and social stigma for using social VR for collaboration, these nuances point to the importance of taking embodiment, realism, and naturalness into account when perceiving, experiencing, (re)conceptualizing, and designing for computer-mediated collaboration in emerging virtual environments that evolve towards more embodied interaction in the future.

5.2 Design Implications to Support Collaboration in Social VR

Grounded in our findings of social VR users' main types of collaborative activities and their key methods used to conduct such activities, in this section we outline three design implications to better design social VR as a nuanced CVE.

Specific Onboarding Process Catering to Different Collaborative Tasks. In our study, participants indicated that one of the main challenges for effectively using social VR as a CVE

was the learning curve: as a novel technology, many users did not know what social VR features could be used for collaboration or how to use them. Existing tutorials offered by the platforms also did not provide much useful information. Therefore, there is a clear need for straightforward and easy-to-follow onboarding processes based on the specific collaborative contexts and tasks. This can be achieved by providing a simple feature that allows new users to enter "what would you currently like to use social VR for" when logging in. After entering their query, they could be transported to a tutorial virtual place where they would be introduced to and would practice a variety of virtual tools and control settings specific to their collaborative tasks (e.g., for studying, gameplay, creativity, or event planning). This would also efficiently help newcomers quickly understand and familiarize themselves with the unique benefits of social VR, which may mitigate the current social stigma towards using social VR mentioned by our participants.

More Interactive Tools that Simulate Offline Tools for Collaboration. Participants also commented that various interactive tools in social VR (e.g., flashcards, pens, whiteboards, and private meeting rooms) were highly convenient and effective for facilitating their collaboration, mainly because they were designed and used the same way as their offline counterparts yet without physical limitations (e.g., a virtual pen with unlimited ink, and a meeting room that was more private and safer than a physical room). Participants thus expressed the demand for more such simulated tools that can be used in virtual collaboration. Such tools as shared digital calendars, shared notepads, or co-writing workstations can make collaboration in social VR feel more natural, immersive, and close to face-to-face collaboration depending on the specific collaborative needs.

Supporting Collaboration Beyond Social VR. One other important insight from our findings is that there seems to be a need to transform collaborative activities within social VR to ones outside of social VR, or vice versa. For example, participants mentioned planning a trip together in social VR then conducting the trip together in the offline world. Participants also frequently transferred collaborative efforts between social VR and other platforms (e.g., creating and importing digital assets or creating social VR-based content for other platforms). It would be valuable to introduce features that further support such needs, such as directly posting screenshots in social VR on other social media platforms, directly live streaming ongoing social VR events, or accessing users' collaborative notes in an external 2D platform such as Dropbox. However, we also suggest that designing and implementing such cross-platform features should take potential privacy and security risks into account, including the absence of consent and the disclosure of too much personal biographic information.

5.3 Limitations

A few limitations of this study should also be noted. All interview participants were recruited from online forums or social media. There is a potential bias towards social VR users who maintain an active social media account. Another limitation is the lack of even distribution between participants and the platforms they use. While our participants reported their use of diverse social VR platforms, they mainly focused on mainstream commercial platforms including Rec Room, VR Chat, and AltspaceVR, so future work should aim to recruit a larger participant pool with more diverse social VR platforms to capture a more comprehensive picture of diverse collaborative activities in social VR (e.g., a large scale survey).

6 CONCLUSION

How do emerging novel technologies shape people's collective lives in various contexts? In this paper, we have explored how social VR provides people with valuable opportunities to work, play, or spend everyday lives together in new and more novel ways. These insights further explicate social VR as a nuanced CVE that focuses on embodiment for co-presence and communication,

replicating offline collaborative activities, and supporting the seamless interplay of work, play, and mundane everyday lives. These insights also point to clear needs for making the onboarding process for collaboration in social VR less challenging and mitigating potential social stigma surrounding using social VR for collaborative purposes. We thus hope that our findings can help the CSCW and HCI community further examine nuanced forms of computer-mediated collaboration and novel methods for collaboration in emerging online social spaces and guide future efforts to design more supportive and socially satisfying CVEs.

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