A Virtual Space for All: Exploring Children's Experience in Social Virtual Reality

Divine Maloney
divinem@clemson.edu
Clemson University
Clemson, South Carolina

Guo Freeman
guof@clemson.edu
Clemson University
Clemson, South Carolina

Andrew Robb
arobb@clemson.edu
Clemson University
Clemson, South Carolina

ABSTRACT

Social virtual reality (VR) is increasingly becoming an emerging online social ecosystem where multiple users can interact with one another through VR head-mounted displays in 3D virtual spaces. The co-existence of minors and adults in social VR presents unique challenges and opportunities regarding how these two groups interact with each other in these shared virtual social spaces, which is a timely and understudied topic in HCI and CHI PLAY. In this paper, we report our findings of a participatory observation study to explore the interaction dynamics between minors and between minors and adults in social VR. Our findings contribute to a better understanding of young people's engagement with technology and point to future directions for designing safer and more socially satisfying social VR experiences for minors.

CCS CONCEPTS

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

KEYWORDS

Children, social VR, social virtual reality, social interaction, virtual reality, social dynamics, virtual worlds

ACM Reference Format:
Divine Maloney, Guo Freeman, and Andrew Robb. 2020. A Virtual Space for All: Exploring Children's Experience in Social Virtual Reality. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '20), November 2–4, 2020, Virtual Event, Canada.* ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3410404.3414268

1 INTRODUCTION

Social virtual reality (VR) is increasingly becoming an emerging online social ecosystem where multiple users can interact with one another through VR head-mounted displays in 3D virtual spaces [29, 30]. In these open-ended 3D virtual worlds, users engage in cultivating online social relationships, exploring diverse virtual places, experimenting self representation, [17]and enjoying immersive gaming. The diversity and richness of the activities afforded by social VR has attracted users of different age groups, and particularly a large amount of minors – the presence of minors across different social VR platforms has been noted due to either their relatively shorter avatars [7] and/or their higher pitched voices [24].

The co-existence of minors and adults in social VR presents unique challenges and opportunities regarding how these two groups interact with each other in these shared virtual social spaces. Of particular relevance to this paper is the variety of privacy and ethics concerns raised by problematic online interactions minors may have in social VR, including but not limited to interactions with online strangers, requests for personal information, and misunderstood communications [50]. Exploring how minors experience social VR and how they interact with adults in these shared social spaces is not only important to better understand the complicated social dynamics that are supported and facilitated by social VR, but also can inform the design of future social VR and broader HCI as safer online spaces.

However, prior research has revealed two limitations regarding studying minors and social VR. First, the majority of prior scholarship on minors and VR has focused on medical [1, 48, 58], experimental [51], or educational settings [22, 55]. Little work has explored children's use and experience of the increasingly popular commercial social VR platforms. Second, there is a lack of first-handed empirical evidence on how minors themselves understand and experience social VR. A recent study has demonstrated that minors are an inherent part of social VR experiences [24]. However, this work only interviewed adult social VR users about their perception of minors.

To address these limitations, in this paper we endeavor to explore the following research questions using a participatory observation approach [10, 32]:

RQ1: How do minors perceive and interact with other minors in social VR?

RQ2: How do adults and minors perceive and interact with one another in social VR?

This paper makes a number of contributions to HCI, CHI PLAY, and child-computer interaction. First, our focus on understanding the social dynamics and interactions of minors expands current literature on HCI and child-computer interaction relating to online digital spaces. Second, we offer first hand empirical data on what makes interactions in social VR unique and socially desirable for minors, especially compared to traditional virtual worlds (MMORPGs) and traditional gaming environments. This points to an emerging research agenda that has not been widely studied. Therefore, we contribute to addressing the two above-mentioned limitations in prior literature on children and VR. Third, we highlight potential

CHI PLAY '20, November 2–4, 2020, Virtual Event, Canada

ACM ISBN 978-1-4503-8074-4/20/11…$15.00
https://doi.org/10.1145/3410404.3414268

design implications that aim at addressing the safety concerns for younger users. This may inform the design of emerging social dynamics between minors and adults in future social VR and broader online social spaces.

2 RELATED WORK

Child-computer interaction has been a growing research agenda in HCI [37]. Such studies have focused on children's learning with technology [14, 15, 56], design concepts geared towards children [19, 38, 40], and methodologies for conducting research with children [25, 26, 36, 39]. In this work, we endeavor to further contribute to existing literature on child-computer interaction by exploring children's experience in an emerging novel sociotechincal system - social VR. In particular, our study is drawn on two strands of studies on child-computer interaction: children in virtual reality and children in virtual worlds.

2.1 Children and Virtual Reality

Investigation into children and VR has largely focused on two contexts: medicine and education. For example, previous studies have suggested that VR is effective for children to manage pain through gamification and the emergence of remote healthcare [1, 18, 48, 58]. However, it is important to note that these studies did not include any social aspect. Rather, they were experimental investigations with a sole user.

In the area of education, VR as a tool has been shown to help children develop cognitive skills and abilities. For example, Vogel et al. developed an application to teach the hearing-impaired [55] and Loiacono et al. created a game to enhance social skills with children with neurological disorders [22]. Other studies aimed at understanding how children learn and collaborate in VR. Roussos et al. created a narrative-based, immersive, constructionist/collaborative environment and yielded three design recommendations for how to create effective VR educational simulations for children: 1) focusing on deep learning problems, which require the rejection of inadequate and misleading models based on everyday experience; 2) the learning goal must be plausibly enhanced by the introduction of immersive VR technologies; and 3) VR-based learning environments must be informed by contemporary research in the learning sciences [44].

Collectively, this body of research has explored VR as a tool to assist children mainly in experimental settings. Recent work by Bailey et al. and Schmitz et al. demonstrates that minors respond differently to virtual reality as compared to traditional media [3, 45]. However, these studies focused on minors age four to six, and it is unknown how children at different developmental stages respond to VR. Additionally, few studies focus on what minors do and how they are perceived in VR, which raises various ethical concerns [51].

With the emergence and ease of accessibility to consumer social VR applications (e.g., AltspaceVR, RecRoom, VRChat), there is an urgent need to understand new social phenomena and challenges for children brought by commercial social VR applications.

2.2 Children and Virtual Worlds

In addition to VR, a body of research has also explored how children use virtual worlds. Virtual worlds in the form of Multi-User Domain Object Oriented (MOOs), and Massive multiplayer online role-playing game (MMORPGs), and open-ended digital social spaces have been used by children since the late 90s [11]. In recent years, many virtual worlds have been designed specifically for children. Examples include *Neopets, Barbie Girls, and Club Penguin*. These worlds tended to focus on playful designs and child-centric activities, including imitative role play, make-believe with objects, and make-believe with actions and situations [12, 20, 21, 27].

Like any other online platforms, unwanted activities such as harassment may still occur in these virtual worlds that were designed for children, which raises safety concerns for children who engage in these worlds. Nonetheless, they have been generally perceived as safer and preferred by parents as oppose to traditional online gaming (e.g., *World of Warcraft*). For example, Marsh mentioned parents saying *"I let my kids use Club Penguin and i think its perfectly safe"* [27]. Issues regarding identity construction have also emerged as a important research agenda regarding children and virtual worlds. For most children, engaging in a virtual world may be the first time when they can control an avatar. In this process, they have the opportunity to construct, re-construct, and learn how to perceive themselves and others in an online world [27].

However, the majority of prior research in this area focuses on virtual worlds where children interact with other children. Little is known about how mixed virtual environments where children and adults co-exist (e.g., social VR), and how such co-existence may shape children's experiences in virtual worlds.

3 METHODS

We took a participatory observation approach to collect data for this study [10, 32]. This work was approved by the University's Institutional Review Board (IRB) for research ethics. In participatory observations, the researcher takes part in the activities, interactions, and events of a group of people as one of the means to learn both the explicit and ambiguous aspects of their life routines and experiences [2, 10, 32]. In this sense, the observer is a genuine participant [2] who both engages in the environment and observes others' behaviors and interactions surrounding him/her. This method has been widely used in previous scholarship on online virtual worlds and MMORPGs [8, 9, 33]. To help identify minors in social VR, we adopted methods used in prior work such as voice [24], avatar height [7], and the context of the interaction to determine whether a user was minor or adult (e.g., if one calls the other a kid).

Research Site. All authors are experienced social VR users and have the knowledge and expertise required to study the situated practices, experiences of our subjects and communities. In this study, the first author engaged in three social VR platforms (AltspaceVR, RecRoom, and VRchat) and conducted participatory observation sessions on each platform for three months (February to April 2020). These platforms were chosen as our research sites for three reasons: they are three of the most popular, and most representative, social VR platforms; they are popular with both minors and adults; and the culture and affordances of each of these platforms differ greatly. Additionally, all platforms are free, making the barrier to entry low.

We briefly summarize the differences between these three platforms below.

AltspaceVR. In AltspaceVR, users have their own private space and can access to many public places. AltspaceVR is well known for the diverse events that it offers, ranging from open mic night, mediation classes, and programming classes.

RecRoom. RecRoom is considered most popular among minors while adults tend to prefer AltspaceVR [24]. The main activities in RecRoom are centered around games (e.g., paintball and basketball). Users can create their own private rooms. They can also venture into a central hub called the Rec Center and from there go into different rooms for gaming.

VRchat. VRchat, among the three, affords minimal activities but features uniquely designed rooms (e.g., spaceship, Japan Shrine) that attract various types of user. It offers the most sophisticated avatar customization compared to Recroom and AltspaceVR. VRchat is also ranked one of the most popular applications on the Steam game marketplace.

Participatory Observations. Observations generally took place in the evenings from 4-8 PM everyday as it was considered the peak time of using social VR. Observations were also conducted at weekends to access a more diverse user population. To conduct these observations, the first author created an account on each of the three platforms and attended platform specific events such as games, social activities, open events. He also spent time in open public spaces to examine leisurely behaviors and interactions. In total, he conducted 80 hours of observation. Screenshots, video recordings of observations/interactions, hand held voice recorded notes, and field notes were captured during periods of observation. The field notes were documented immediately after a specific observation session using a spreadsheet. The spreadsheet recorded the date and time of the observation, where the observation took place, and a detailed narration of the activities and interactions observed along with personal insights. Observed/recorded chat logs that were particularly relevant to our research were further transcribed for additional analysis.

Data Analysis. As we adopted a participatory observation method, the first author's observations and analysis as the main observer was what made this method and the collected data relevant and powerful [6]. According to McDonald et al.'s guidelines for qualitative analysis in CSCW and HCI practice [28], it is therefore important to take the main observer's experiences into account rather than seeking inter-rater reliability.

The collected data was analyzed through an iterative process of open coding [52], which focused on identifying themes emerging in minor-to-minor and adult-to-minor interactions in social VR. Our analytical procedures focused on eventually yielding concepts and themes (recurrent topics or meanings that represent a phenomena) rather than agreement – because even if coders agreed on codes, they may interpret the meaning of those codes differently [28]. The first author examined the collected data to gain a broader understanding of the common interactions among minors and other minors as well as between minors and adults. The first author then identified initial themes and common features related to minor-minor interaction and minor-adult interaction. All three authors collaboratively examined and reviewed these themes and sub-themes and refined them. Finally, all three authors collaboratively engaged in an iterative process to discuss, combine, and refine themes and concepts to generate a rich description synthesizing minor-minor interaction and minor-adult interaction in social VR.

4 FINDINGS

Using field notes, screenshots, and recorded videos from our observations, in this section we present our findings regarding minor-to-minor interaction and adult-to-minor interaction in social VR.

4.1 Minor to Minor Interaction: An Enjoyable Play Experience in Social VR

As described previously, minors were identified based on their relatively shorter avatars and/or particularly high pitched voices. We found that most minors seemed to enjoy social VR with other minors. Specifically, their interactions with other minors focused on 1) forming virtual intimacy and stronger emotional connections; 2) building rich social interactions beyond just gameplay; and 3) engaging in nuanced group behaviors. In addition to these overall positive experiences, minors also 4) dealt with harassment and bullying when interacting with other minors.

Virtual Intimacy and Emotional Connections. Similar to traditional online virtual worlds and MMORPGs, social VR allows for intimate connections between users through controlling the body of their avatar. However, unlike other virtual worlds, social VR affords immersive full body tracked avatars, establishing a direct "mirroring" between one's physical body and avatar body. Furthermore, it creates the potential for true "face-to-face" interactions experienced from a first-person perspective. The combination of these factors creates the potential for heightened emotions and feelings of presence, as compared to traditional online virtual worlds [35].

In our observations, we witnessed that minors benefited from using their bodies as a direct interface to communicate with each other. Through full body tracking, their interactions in social VR was similar to face to face communication in the offline world, making it easier and more natural for them to communicate with each other. Their expressions and actions in social VR generally could mirror those in the offline world. In addition, some minors seemed to enjoy communicating with each other through non-verbal methods (e.g., using body movements to communicate). In our observations, we frequently saw that minors used fist bumps, high-fives, poking, and touching on the shoulder to communicate with each other.

Through the similarity to face-to-face interaction and the affordance of rich non-verbal communication, social VR seemed to afford more natural and intimate interactions between minors. For example, we observed that minors tended to give each other virtual "hugs" as a way to display a sense of intimacy and closeness, as the following chat log shows: *Minor 1: my Mom says I have to log off now*
Minor 2: aw okay
Minor 1: wanna play tomorrow?
Minor 2: yea!
Minor 1: okay see ya
Minor 2: wait give me a hug!

Minors hug, and one exits the platform
(two minors on RecRoom)

In this example, these two minors demonstrated full awareness that social VR afforded certain intimate interactions such as hugging. They also understood that they could physically perform "hugs" using their immersive avatars. Rather than just saying goodbye, they intentionally chose to perform hug, which required them to physically perform the action of "hugging" in the offline world. For these minors, merely saying goodbye seemed inadequate when a virtually-embodied hug could instead be used to express feelings of closeness and intimacy. In this sense, digital communication and physical touch are synthesized together to facilitate minor to minor interaction.

Minors also employed their own ways of showing intimacy and emotional connections, which did not always follow traditional forms of intimate behavior (e.g., hugs and kisses). For example, fist bumping was a common way for minors to make friends and show close friendship (Figure 1). A fist bump in RecRoom allows two

Figure 1: Minors fist bumping to become friends on RecRoom

users for becoming official friends on the platform. After that, they could conduct specific activities together such as inviting each other to personal private spaces, receiving notifications when each other are online, and teletransporting to each other. After users became friends, interactions such as fist bumps and high fives were used to highlight spontaneous physical interaction and represent the establishment of friendship. While adults tended to use this method with caution, it was a popular way among minors to quickly build friendship and remain connected.

In another example, we observed that two minors were playing a simple game of "jump and catch" together in RecRoom:
Minor 1: I'm going to climb to the top and then jump off, then you catch me okay?
Minor 2: haha okay, i'll catch you
Minor 1: alright i'm going to jump!
Minor 2: jump jump!
Minor 1: ahhh (jumps)
Minor 2: see I caught ya!
Minor 1: that was fun! okay your turn!
(two minors on RecRoom)

One might not consider catching another person from a balcony as a form of intimacy. However, in our observation, these two minors seemed to regard it as a special way for children to demonstrate intimacy: to them, catching someone who jumped off a balcony required trust, interdependence, and teamwork. It was a children's game; but it also demonstrated intimacy and emotional closeness in children's ways. Because they were experiencing these interactions and activities in the immersive social VR environment, such activities and interactions were felt even more personal compared to those in traditional online games and virtual games.

Rich, Emergent Social Interactions Beyond Gameplay. Minors also seemed to enjoy the rich, emergent social interactions between each others. For them, social VR afforded a wide range of activities and experiences that enriched their online social lives, making it much more than merely a virtual place to play games. These interactions were mainly governed through the affordances of the specific platform. However, minors seemed to enjoy different types of interactions based on their maturity levels: ranging from (mature to less mature) older teenagers, young teenagers, and young children. Since there is no way to officially verify users' actual age in social VR, the criteria that we used to identify the approximate age of a minor included: the level of maturity shown in conversations, behavior, and interaction; their voices (e.g., an older teenage boy's voice may be different from a young boy's due to puberty), and what type of users (e.g., user who showed similar or different behaviors) whom they frequently interacted with.

Older teenagers were commonly seen in groups or clusters. Their interactions mainly focused on making crude and vulgar jokes to make other teenagers laugh, such as frequently commenting on one another's avatars or general topics of drugs, sex, alcohol, and recent events in the offline world (e.g., COV-19). Here is an example of their interactions: *"He deserves to die from the coronavirus by just looking like that [reference to his avatar]. That avatar is lame as f**k, who the f**k has a 1D avatar, haha"* (an older teenage boy on VRchat).

The avatar that this user referred to is shown at the right of Figure 2. It was a one dimensional cat avatar, which made many members in this teenage group laugh and entertained. For older teenagers, they enjoyed gaining the reputation of being an entertainer among their peers – the so-called *social clout*. The richness of their social interactions seems to stem from the ability to converse and interact as what they normally would in the offline world, as jeering is a common behavior among teens. Social VR also further allows them to access novel content and behaviors such as creating, customizing, and switching between immersive, full-body tracked avatars, which often lead to diverse social interactions and experiences for fun.

In our observations, young teenagers seemed to enjoy "play" more than older teenagers and young children. In fact, on RecRoom and AltspaceVR, we saw that young teenagers played the most games and heavily engaged in sharing content (e.g., avatar appearance). Their interactions focused on exploring the novelty of VR game play and bartering items. Figure 3 is an example of how three young teenagers bartered with one another for avatar items.
Minor 1: what's up with that silver chain?
Minor 2: I'll give it to you for some tokens?
Minor 3: No way you told me I could have it for my butterfly wings!
Minor 2: oh yeah i did...wait how many tokens?

Figure 2: Older Teenagers interacting together on VRchat

Figure 3: Young Teenagers interacting together on VRchat

Minor 1: hmmm not sure yet?
Minor 3: that is my chain, you told me i could have it!
(minors on RecRoom)

In this example, these minors were sitting in a virtual place with a cafeteria/lunch room setting. Very likely, this environment appeared to be similar to their offline social world (e.g., in a school lunchroom). Situating in such an environment, they seemed to enjoy exchanging their experiences of gameplay and in-game content (e.g., tokens, silver chain, and butterfly wings). For them, this became a unique interactive experience of blurring the boundaries of offline lives and online gameplay.

In contrast, young children seemed to focus on only interacting with other young children and exploring the technological affordances and interactive dynamics of the social VR platform together. In another interaction two minors on RecRoom grabbed a bottle filled with liquid. They then proceeded to throw the bottle as high in the air as they could and tried to catch it. After that, one said, *"pour the drink on me."* And the other poured the drink while the other pretended to drink (there were small brown dots that simulated the liquid leaving the bottle). In this case, these young children showed a strong curiosity to understand what they were capable of doing within the environment. In particular, they were happy to interact with and explore their surroundings with other children at their age rather than teenagers.

Nuanced Group Behaviors. Regardless of diverse maturity levels, we found that all minors used social VR as a collaborative learning environment and as a virtual place to share personal lives. Across all three social VR platforms, we observed that minors shared knowledge and openly collaborated with one another. For example, Figure 4 shows a popular event in AltspaceVR. At this event, users were siting in a theatre where they upvoted which 30 second video of a funny meme they would like to display on the big screen. This event attracted more minors than adults. In our observation, we witnessed that these minors frequently instructed and taught each other how to quickly interact with their specific VR device (e.g., Quest or Vive) to choose which meme would be shown on the screen in a openly collaborative manner.

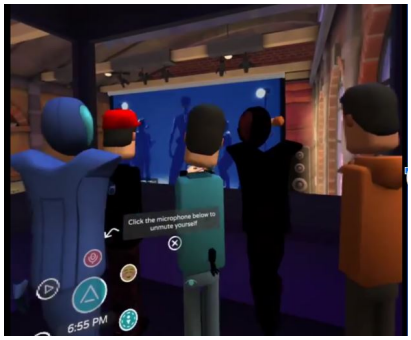

Figure 4: Minors watching Memes on AltspaceVR

In another observation, one minor on RecRoom was humming a popular American song titled "Roxanne." Within seconds, another minor nearby started humming the song. This quickly led to a group of eight minors singing the same song. Most of them were not in near physical proximity but instead walked over to join the group. Based on what we knew, this group did not know each other prior to singing that song together. Interestingly, for minors who were not familiar with the song, some of the singers in fact paused to introduce the title of the song and told them to "look it up" so they could sing along. This example highlights minors' nuanced group behaviors in social VR: such behaviors not only spontaneously emerged in interacting with online strangers but also were mediated and supported by the spatial audio in social VR as well as users' capabilities to localize the audio and sing/hum in real time.

It should be noted that minors' collaborative learning did not always involve entertainment. Rather, it included some more personal and in-depth aspects such as *exploration of identity*. It was very common for minors to dress their avatars alike and create a social VR clan (see Figure 5). We also observed that minors would explore aspects of identity such as gender together. For example, two male minors (we identified their gender via voice) chatted about their perceptions and understandings of gender roles in social VR:
Minor 1: We should switch our avatar to look like a girl.
Minor 2: Why? That's weird.
Minor 1: Because more people will talk to us!
Minor 2: Why would they talk to us?
Minor 1: Because everyone talks to girls more.
(Two male minors on AltspaceVR)

In this case, the two male minors shared with each other their own understandings of how gender played an important role in

social VR. For minor 1, he understood that a common social norm in social VR was *"everyone talks to girls more."* Therefore, he considered it completely reasonable to investigate use a female avatar while being a male and educated his peer (minor 2) about this norm. In contrast, minor 2 regarded gender switching as *"weird"* and wondered why such behavior was needed in social VR. Through this interaction, they both learned different perspectives of gender and gender switch in social VR.

Minors' nuanced group behaviors also included disclosing personal stories with one another and reflecting on significant global events (e.g., the current pandemic). For example, they were seen to share with one another how COV-19 was affecting themselves and their families. In these observations, they were open to sharing feelings of discomfort, uncertainty, and general angst about the pandemic, such as frustrations about being virtually home-schooled, having to share the computer or VR headset with their sibling, and not being able to go outside. Yet, they also mentioned positive aspects of the pandemic, including seeing others on the platform consistently and being able to spend more time in VR. For them, social VR became a valuable social space where they could still enjoy similar forms of regular everyday interactions together during a crisis.

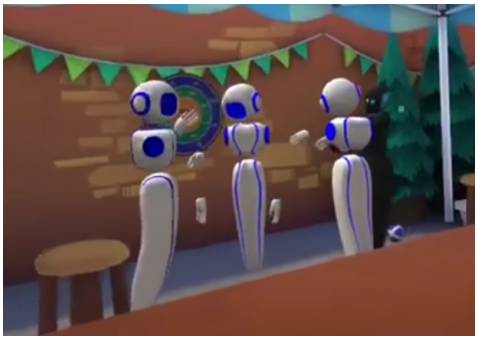

Figure 5: Minors switching to basic default avatars on AltspaceVR

Dealing with Harassment/Bullying. In our observations, minors' interactions with each other in social VR tended to be overall positive and enjoyable. However, like in traditional online virtual worlds and MMORPGs, we also observed harassment and bullying among minors on these platforms. It should be noted that we observed profanity, foul language, and derogatory comments such as *n***er, b**ch, h**, th*t.* However, these words were generally used by more mature minors and it was unclear if these words were meant to upset and offend other minors. In fact, we found that other terms such as *lame, loser, noob, squeaker* offend minors more than more explicit language mentioned above. Generally, two types of harassment/bullying often happened: harassment of older minors towards younger minors and harassment of young girls.

One example is how a younger minor interacted with a group of older minors in a VRchat virtual place (i.e., "Mirror Room") mainly for displaying and commenting on avatars. In this interaction, we observed that the younger minor was harassed because he was using an Oculus Quest that did not support appropriately viewing certain avatars in VRchat. Instead of displaying the avatar as a vivid 3D figure, it would show them as a generic robot with the avatar image on the center of the chest. A dialogue of the interaction is below:

Minor: check out my master chief avatar, isn't it cool.
*Older Minor 1: HA! your avatar is lame as f**k*
Older Minor 2: Yeah I bet you can't even see my avatar can you?
Minor: Uh no.. you have a robot..
Older Minor 1: probably using VRchat on a Quest...what a lame haha (Minors on VRchat)

In this interaction, the group of older minors were able to guess the age of the younger minor based on his voice. They then proceeded to harass him simply because of the VR device he was using. The insults toward the younger minor continued and eventually the younger user moved to the far end of the room and left. Later, other users in the room stepped in and commented, "*wow kids get bullied for not having a high tech headset. That's ridiculous.*" This case demonstrates the unpredictable challenges for younger social VR users – harassment may not only come from adults but also from their peers.

Female minors were also frequently targeted for harassment and bullying. In the campfire world in AltspaceVR, we observed that a group of male minors harassed a female minor because she was concentrating on interacting with another user rather than with this group. In this observation, we at first saw a pair of two minors, one male and one female, chatting with each other and laughing and joking. Then a group of male minors came up to them and wanted to chat with them. However, this pair of minors did not want to interact with the group. After realizing this, this group began to circle the girl, followed her, yelled at her, and made negative remarks about her avatar. Other users in the campfire world came to defend the female minor and the group of male minors eventually left. It was unclear to us whether the pair of two and the group of male minors knew each other before the incident. Yet, this case shows how easily female minors can face harassment and bullying in social VR.

Another similar observation also happened in AltspaceVR. In this case, female minors gained unwanted attention. We saw that a pair of two female minors were chatting in the theatre room. They planned to leave the room and go somewhere else together. One of them dropped a portal so they could both travel to the new area. However, a group of male minors saw the portal and said, *"Guys there's a girl over there and she just dropped a portal and wants someone to play with her. Come on guys, we need to go we need to go!"* Shortly after, one of the male minors in the group walked over to the female pair and said that he wanted to go with them. The female minors declined his request using body language but the male minor kept bothering them. Eventually, the female pair had to block him and leave.

In this case, the female minors clearly did not want the attention from the group of male minors or hang out with that group. Yet, even though they showed their unwillingness and directly rejected such request, the male minors still insisted on the unwanted behaviors. In this sense, female minors seem to be even more vulnerable in online social interactions than younger male minors in social VR.

4.2 Adult-to-Minor Interaction: A Complex Social Dynamic

The three social VR platforms where we conducted observations are open to anyone. Both minors and adults can create an account and engage in the virtual social spaces. Therefore, it is inevitable that these two groups would interact with each other in some manners. Compared to minor to minor interaction, we found that adult-to-minor interactions showed a more complex social dynamic. Both groups also seemed to have mixed sentiments about each other. Specifically, we identified four themes emerging in how adults and minors coexisted, interacted, and perceived each other in social VR: barriers, tensions, and frustration of co-existence; mutual learning; social distancing; and inappropriate content exposure.

Barriers, Tensions, and Frustration of Co-existence. Some adults considered that minors in social VR were annoying and disturbing, who undermined their own experience and enjoyment of social VR. In our observations, we constantly heard negative comments on interacting with minors in social VR, such as *"screaming, loud, and obnoxious."* One AltspaceVR user also complained when chatting with his friends: *"Dude kids are everywhere, I remember when Altspace used to be great but now its so annoying. Kids break everything and try to just get attention. I just come in here after work to chill. Its f***ing frustrating."* This quote well explained the potential tensions and frustration emerging in the co-existence of adults and minors in the same social VR platform. For this adult user, the goal of his interaction and engagement in social VR was to *"chill"* after work. In contrast, in his opinion, many minors tended to *"break everything"* and gain attention. Such conflicts of their social needs made him feel *"annoying"* and *"frustrating"*.

In fact, how minors sought out attention was one of the main reasons why many adults considered interacting with minors in social VR disturbing. As shown in Figure 6, a minor figured out how to change the floor height of his avatar to make himself above everyone. In our observation, this minor was trying to get attention from others and proceeded to interrupt conversations by floating above other users. Obviously, the impacted adult users did not appreciate such an interaction.

Figure 6: Minor floating in between two Adults

Examples like this often led adults to behave in ways to deter minors from interacting with them. In another observation in AltspaceVR, one adult user told a group of minors: *"Hey you better get out of here. They don't allow children in here so if the moderator finds out [pointing gesture in moderators direction] that you're in here, you're going to be banned from AltspaceVR. Do you want that? No? well,then go! Leave!"* This adult knew that there was no moderator present at that moment. However, he wanted to "scare" the minors away from hanging out in this space. For adult users like this, avoiding interacting or even co-existing with minors in the same virtual space was important.

Mutual Learning. However, not all adult users shared a negative perception of minors in social VR. Some seemed to enjoy actively interacting with minors. For example, in one observation (Figure 7), a minor was ignored by adult users on VRchat. Yet, one adult decided to initiate a conversation with the minor: *"Oh they don't want to talk to you. I'll talk to you. Where are you from?... i'm from [omitted]. What games do you like to play? I like to play..."* This interaction highlights that adults and minors could coexist in social VR and even engage in relationship building and learning about each other in some ways. Also, the way in which this interaction was initiated demonstrates that some adults perceive minors as equal participants on the platform, and that a minor should not be ignored because of their age.

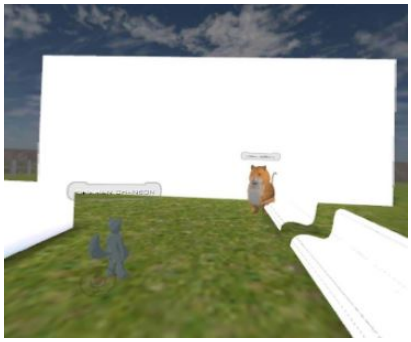

Figure 7: Minors and Adults on VRchat chatting

In particular, such interactions between adults and minors could lead to mutual learning. We observed *cultural learning* between minors and adults, especially when minors interacted with foreign adult users. In one observation, a minor was learning Japanese from a native of Japan; and in another observation, a minor was learning about cultural norms in Greece. These observations of cultural learning were open, inviting, and of interest of both the minors and adults. In both examples, the minors benefited from learning about a different culture and the adults benefited by sharing and practicing their English.

Such mutual learning could also happen in other contexts such as gaming. For example, an adult VRChat user talked about his experience with minors in our observation: *"Dude VRchat is so cool, and I understand why kids like it. Look at this cool skin some kid gave me! I wouldn't have this without him. Yeah kids can be annoying but we are all exploring so what's the big deal? Kids are going to be kids."* This adult user was given a customized Scooby Doo avatar by a minor, and he greatly appreciated this favor. For him, social VR was a novel interactive space where minors and adults should both have equal access to enjoy the environment and experiences.

His comment also highlights that adults could benefit from having minors around, such as learning from them about how to use the platform, avatar customization, and gaming.

In another example, when the first author was observing minors on RecRoom, he encountered a few challenges with the user interface of RecRoom. After spending more than 15 minutes trying to figure out a solution, two minors approached him, volunteered to help, and explained to him what he needed to do.

In this sense, the co-existence of adults and minors may still lead to forms of positive interactive experiences, which involve aspects of mutual learning such as sharing details about different cultures, languages, experiences, and content on the platform.

Social Distancing. We also found that different social VR platforms seemed to afford diverse social dynamics between adults and minors. For example, we noticed that minors tended to distance themselves from adults in RecRoom and adults seemed to distance themselves from minors on AltspaceVR, whereas on VRchat both groups mingled with one another. It should be noted that both groups on RecRoom and AltspaceVR would still interact with each other, such as making small talk or short interactions. Yet in our observations, these interactions were noticeably superficial and lacked in-depth communications, leading to our interpretation of social distancing.

One potential reason for social distancing of minors to adults on RecRoom isthe large amount of minors in the user base. Minors also generally prefer to interact with other minors, as we have shown in previous sections. Similarly, the majority users of AltspaceVR are adults, who also often interact with other adults. In our observations, one adult shared his opinion on social distancing from minors: *"It's like a bar atmosphere or massive social event. It's not that I ignore kids but I'm here to interact with more mature people. Interacting with kids requires more work because you have to be careful about what you say."* In this sense, social distancing seems to be a common norm in some social VR platforms to manage the co-existence of adults and minors – both groups need different social atmospheres, dynamics, and even languages in order to fully enjoy their social VR experiences.

Exposing to Inappropriate Content. Some adults did not censor themselves or acknowledge the ramifications of a minor overhearing a particular vulgar conversation or imitating grotesque behavior. The co-habitation of adults and minors brought about instances where mature content was discussed openly, which may expose minors to inappropriate content when interacting with adults. In our observation, two adults openly talked about becoming intoxicated in VR: *Adult 1: Bro did you bring your beer? are we drinking in VR right now?*
Adult 2: I am dude! It's one hell of a day and I wanna just keep chugging beers.
Adult 1: why not, like this is pretty chill.

In this conversation, the adults were discussing content that might not be suitable for younger ages. However, the challenge was that they might not be aware that minors were present nearby. In general, minors can be identified in social VR by their voice and height. If they choose not to speak, it would be difficult to identify them and height only provides evidence of a child making since there are no other mechanism available.

In other observations, there were instances of political hate speech and conversations involving sex. We observed one clear instance of sexual harassment between adults and a minor:
Minor: I'm trying to figure out how to show certain avatar, do you know how to do that?
Adult 1: Oh you're new to VRchat, oh you better watch out. There's a lot of stuff kids shouldn't see on here.
Adult 2: yeah all types of stuff!
Minor: like what?
Adult 1: hmm like VR rape. It's serious. I got raped the other day...haha (being sarcastic)
Minor: What's VR rape?
Adult 2: It happens when someone comes up to you really close and then (adult proceeds to hump and make sexually explicit movements on this child's avatar and then laughs).
Minor: oh this is weird...(moves backward and changes to a different topic)"

This example shows that minors could expose to inappropriate content (e.g., sex and rape) and behaviors (e.g., an adult made sexually explicit movements) when interacting with adults in social VR. Regardless the adults intentionally introduced such content or behaviors to minors or not, these minors unwillingly or unwittingly faced risks of harassment, sexual assaults, or negative social influences.

While verbal harassment was common between minors, we observed fewer instances of adults that intentionally harassed minors verbally.

In summary, though we did not encounter any adult-to-minor harassment in this study, these observations highlight three potential challenges for adult-to-minor interactions in social VR. First, the unpredictability of social VR interactions may lead to unwanted behaviors towards minors. Second, this novel immersive interaction space allows adults to exploit the naiveness of minors. Third, there is little to no consequence if adults expose minors to inappropriate content or conduct unwanted behaviors toward minors as they are cloaked with online anonymity.

5 DISCUSSION

To answer the two research questions that we proposed at the beginning of this paper, our findings have shown: 1) most minors seemed to enjoy their engagement in social VR with other minors, focusing on virtual intimacy, rich interpersonal interactions, and nuanced group behaviors despite risks of harassment/bullying (RQ1); and 2) adult to minor interactions demonstrated a more complex social dynamic, including barriers, tensions, and frustration of co-existence; mutual learning; social distancing; and possibilities for minors to be exposed to inappropriate content (RQ2). We now use these findings to discuss the implications of this work and extend our current knowledge of children's engagement with technology, especially their experience in social VR.

5.1 The Uniqueness of Minors' Experience in Social VR vs. Traditional Virtual Worlds & Media Platforms

As we described at the beginning of this paper, little to no work has investigated minors' experiences and interactions in Social

VR. How these emerging virtual spaces are increasingly shaping today's digital youth and children's social lives needs more research attention from the HCI and CHI PLAY communities. Especially, our findings have highlighted the uniqueness of minors' experience in social VR compared to traditional virtual worlds and media platforms.

Minors in Social VR vs. Traditional Virtual Worlds. Our study extends existing work on minors in online digital spaces. In particular, our findings highlight a number of similarities and differences between children's' experience in social VR and in traditional online games/virtual worlds.

One similarity is the wide range of activities that are offered in both types of virtual environments and high levels of engagement. In our observations, minors interacted with other minors in social VR by gaming, sharing content, and mimicking offline behaviors. Similar observations were also made in traditional virtual worlds [27, 47]. Yet, a uniqueness is that social VR seems to support the development of emotional and interpersonal connections among minors in an more immersive way. We are not asserting that minors cannot develop emotional connections in traditional virtual worlds. However, the similarities of social VR to the offline world appear to facilitate relationship building among minors in a natural way. Prior work has demonstrated that VR systems are capable of creating feelings of intimacy and other interpersonal connections between two users [13]. In our observations, minors tended to perceive their interactions with other minors as *real* even more. This phenomenon was observed by Valentine and Holloway [54] where children perceived the virtual world as of equal value to the offline world. In addition, Sharar et al. highlighted that minors aged 6-18 years old reported higher levels of presence and "realness" in the virtual environment compared to adults age 19-65 [49]. These may explain why most minors in our observations focused on virtual intimacy, rich interpersonal interactions, and nuanced group behaviors, and why they were visibly upset from bullying and harassment.

Our findings also reveal similar aspects of bullying and harassment found in social VR compared to traditional games and virtual worlds, especially those toward female users. Our observations echoed previous studies and showed that male minors tended to adhere to a masculine-dominated culture and social role [16]. Though bullying and harassment could happen between older and younger male minors, female minors seemed to be often harassed and bullied by male minors of all age groups.

However, despite the risk of harassment/bullying, engaging in social VR seems to be a generally positive experience for minors, especially in unusual times. For example, we found that minors relied on social VR as a way to maintain regular interaction and social lives in the current Cov-19 outbreak. This phenomenon, therefore, points to the need to further study how social VR, an emerging immersive social space, affect minors both in and outside the virtual environment.

Minors in Social VR vs. Traditional Media Platforms. One of the main differences between social VR space compared to traditional media platforms (e.g., TV and social networking sites) is the immersive virtual space and the full-body tracked virtual avatar. While the majority of scholarship regarding virtual avatars and immersive worlds has focused on their been powerful effects on adults' behaviors, perceptions, and cognition [4, 5, 34], little is known about how they affect minors and to what degree. In our observations, full-body tracked virtual avatars and immersive worlds seem to affect minors in various ways, including mirroring behaviors of the offline world, changes in emotional states, and perceptions of harm. These changes may due to the fact that minors are still developing their personality and understandings of self, the others, and the world, which may make them respond to VR differently compared to traditional media platforms [3, 45]. Prior work has also demonstrated that minors can struggle with digital representations when solving task as compared to what they perceived as watching directly [53]. This may explain why minors considered their behaviors, interactions, and experiences in social VR, a more natural and immersive virtual space, more similar to the those in the offline world compared to other traditional media platforms.

This also raises interesting questions about the impact of social VR on adolescent development and identity building. Prior work has shown that minors in virtual environments perceived virtual versions of themselves as their real identities and were more likely to create "false memories" [46]. In our study, minors tended to behave in ways as similar/realistic as in offline world. It is plausible that some of them may have difficulty differentiating from the offline and online world, which presents new challenges for developing more child friendly social VR technologies and platforms.

5.2 Understanding the Co-Existence of Minors and Adults in Online Social Spaces

A variety of similar behaviors and interactions commonly found in traditional gameplay was identified in our investigation. We observed that adults had mixed sentiments about co-existing and interacting with minors in social VR.

For example, some adult users enjoyed their interactions with minors for a variety of reasons, such as improving English, learning about a different culture, and gaining knowledge about content creation and gaming. Some even treated minors as equals in social VR, and would behave the same way as what they would towards other adults.

However, our work also highlighted adults' irritation and annoyance from interacting with minors. Some adults in our observations were noticeably upset because the presence of minors was prevalent and often disrupted the adults' social experience. Though minors' behaviors might result from their general curiosity of the virtual space, their behaviors were not always accepted as curiosity by adult users but as immaturity and annoyance. This often triggered tensions between the two groups. Such tensions, combined with the foci and affordances of specific platforms, can lead to a natural separation (e.g., social distancing) between adults and minors on a certain social VR platform. This observation, therefore, also implies that the design of the social VR platform can naturally discourage or facilitate interactions between group of people, which may be a useful lesson for designing and developing future social VR technologies.

In addition, we did not observe any verbal harassment between minors and adults. However, we did observe sexual harassment between a minor and adults, which ultimately led to a form of sexual assault with little to no consequences to the assaulter. It should be noted that out of the 80+ hours of observation, this type

of interaction was only observed once. Yet, it still raises concerns about the potential risks for minors to interact with adults and expose to adult content in social VR. It also leads to a number of questions and challenges for designing and developing a safe social VR platform for minors, such as: what are the consequences to adults who introduce undesirable behavior or content to minors in social VR? Who should monitor and mitigate these undesirable behaviors or content when social VR users come from different countries and adhere to laws of different governments? Should legal guardians/parents of the minor be informed of these risks, and will this lead to new considerations and regulations for minors' engagement in social VR?

5.3 Implications for Designing Future Social VR Platforms

Grounded on our findings and insights from prior work on the online safety of minors [23, 31, 41, 42, 57], we identify a few preliminary directions for designing child-friendly social VR platforms in the future.

Regular practice & implementation exiting VR. As we discussed earlier, minors seem to have difficulty differentiating between offline and the social VR world. Therefore, a useful potential design for minors would be acknowledging and practicing how to exit social VR (e.g., taking off the headset) when appropriate. In our observations, it was not always evident to minors that they could physically exit social VR just by taking the headset off. This may be in conflict with the interest of the social VR platforms. Yet, it may allow minors to better control their engagement in social VR with higher agency.

Experiencing social VR together with loved ones and friends. In our previous study [24], we found that parents and guardians experienced social VR platforms openly with their children. This seemed to help minors interpret and better manage unwanted and/or unfamiliar interactions. It also seemed to strengthen the relationship bond between parents/guardians and minors. In this sense, design features that encourage minors to experience social VR with their loved ones and friends would be helpful for protecting minors from risks in social VR and better deal with misinformation and unwanted experiences. Additionally, prior work by Ringland et al. has demonstrated that the involvement of parents or guardians in children's virtual experience helps children distinguish between "real" and "unreal" experiences [41].

Educating minors on digital literacy. Continuous education on social VR and broader immersive technologies is also needed for creating safe online social spaces for minors. Such technologies are increasingly embedded into young people's everyday social lives. In this sense, tutorial and training modules that are specifically designed for minors seem to be necessary. As VR itself has been commonly used for training of stressful situations [43], platform specific training that involves the safety of interactions could help mitigate potential risks.

Safety implications for minors in co-habitation with adults. The active engagement of both adults and minors in social VR and the active interaction between these two groups presents interesting challenges to design social VR as a virtual space for all. Above all, social VR platforms should strive for transparency around what types interactions are permitted. However, existing platforms do not provide sufficient information on this aspect. For example, AltspaceVR and RecRoom privacy policies state that all publicly available areas should be treated as public spaces. It is challenging for users, especially minors, to fully understand such information as the boundaries between private and public spaces online are often blurred. For VRchat, even less information regarding how to protect one's privacy is provided. A more straightforward and well-explained guideline that is appropriate to minors' reading and literacy levels is urgently needed.

In addition, as social VR is different from traditional virtual worlds and games, traditional methods to mitigate harassment (e.g., temporary ban of account) may not be effective. Instead, users who violate certain platform related policies can be required to take a immersive education training.

Furthermore, as Ringland et al. have shown, aiming to reduce risks often creates complications, such as prioritizing certain risk over others, increasing other risks, and infringing on a child's personal growth [42]. Therefore, social VR developers and designers should be cautious when creating safety measures for minors - in social VR, providing safety for both children and adults is a continually negotiated process and a balance between risk and autonomy in a given situation is much needed [42].

5.4 Limitations and Future Work

First, we acknowledge that observational methods have limitations, and we do not aim at drawing definite conclusions but rather highlight rich and insightful phenomena and practices emerging in observations. To mitigate this limitation, we adhered to the factors commonly associated with validity regarding participatory observation research, such as time, concentration of setting, developing familiarity/closeness with users, and diversity in social groups and activities. Second, we mainly identified minors in social VR via voice and height of their avatars. It is plausible that they were not actual minors. In addition, we differentiated young children, young teenagers, and older teenagers based on the main observer's subjective perceptions – e.g., the pitch and tone of users' voices. They could be incorrectly perceived since a high pitched voice did not always indicate a younger child. This work represents our first endeavor to explore children's experiences in social VR. We aim to use observational data to identify trends and behaviors for future investigations using interviews, surveys, or other methodologies. For example, one way to substantiate and confirm our findings in future work would be conducting in-depth interviews with minors and adults regarding their experiences and interactions in social VR.

Another area of future work would focus on what attracts minors to different platforms. We observed minors of different age groups, cultures, and backgrounds. Yet, it is not obvious why they chose to actively engage in one or multiple platforms. The gendered perspective of social VR is also interesting research area. For example, we observed that there were more female (both minor and adult) users on AltspaceVR compared to the other two platforms but we did not know why. The potential risks of harassment towards minors in social VR also needs further investigation.

5.5 Conclusions

Social VR is a novel digital space where users can interact, socialize, and gaming with one another in new and immersive ways. This space has attracted users of different age groups and maturity levels, leading to important questions regarding the interaction dynamics among these groups. Our study has identified four common themes regarding how minors interact with other minors in social VR: building virtual intimacy and stronger emotional bonds; experiencing rich social interactivity beyond gameplay; engaging in nuanced group behaviors; and managing harassment/bullying. We have also discovered the complicated social dynamics in adult-minor interaction in social VR, including: barriers, tensions, and frustrations of co-existing; mutual learning; social distancing; and the risk for minors to be exposed to inappropriate content. We believe that our focus on minors in social VR addresses two prior limitations in prior literature. We also hope that our findings contribute to a better understanding of young people's engagement with technology and point to future directions for designing safer and more socially satisfying social VR experiences for minors.

ACKNOWLEDGMENTS

We thank the anonymous reviewers and Microsoft for sponsoring our work.

REFERENCES

[1] Karen Arane, Amir Behboudi, and Ran D Goldman. 2017. Virtual reality for pain and anxiety management in children. *Canadian Family Physician* 63, 12 (2017), 932–934.
[2] Earl R Babbie. 2015. *The practice of social research.* Nelson Education.
[3] Jakki O Bailey, Jeremy N Bailenson, Jelena Obradović, and Naomi R Aguiar. 2019. Virtual reality's effect on children's inhibitory control, social compliance, and sharing. *Journal of Applied Developmental Psychology* 64 (2019), 101052.
[4] Domna Banakou, Parasuram D Hanumanthu, and Mel Slater. 2016. Virtual embodiment of white people in a black virtual body leads to a sustained reduction in their implicit racial bias. *Frontiers in human neuroscience* 10 (2016), 601.
[5] Domna Banakou, Sameer Kishore, and Mel Slater. 2018. Virtually being einstein results in an improvement in cognitive task performance and a decrease in age bias. *Frontiers in psychology* 9 (2018), 917.
[6] Louise Barkhuus and Chiara Rossitto. 2016. Acting with technology: rehearsing for mixed-media live performances. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. 864–875.
[7] Lindsay Blackwell, Nicole Ellison, Natasha Elliott-Deflo, and Raz Schwartz. 2019. Harassment in Social Virtual Reality: Challenges for Platform Governance. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (2019), 1–25.
[8] Tom Boellstorff. 2015. *Coming of age in Second Life: An anthropologist explores the virtually human.* Princeton University Press.
[9] Tom Boellstorff, Bonnie Nardi, Celia Pearce, and Tina L Taylor. 2012. *Ethnography and virtual worlds: A handbook of method.* Princeton University Press.
[10] Ann Bonner and Gerda Tolhurst. 2002. Insider-outsider perspectives of participant observation. *Nurse Researcher (through 2013)* 9, 4 (2002), 7.
[11] Amy Susan Bruckman. 1997. *MOOSE crossing: Construction, community and learning in a networked virtual world for kids.* Ph.D. Dissertation. Massachusetts Institute of Technology.
[12] Nicoletta Di Blas and Caterina Poggi. 2008. Can ICT support inclusion? Evidence from multi-user edutainment experiences based on 3D worlds. In *Proceedings of the 7th international conference on Interaction design and children*. 97–100.
[13] Trevor J Dodds, Betty J Mohler, and Heinrich H Bülthoff. 2011. Talk to the virtual hands: Self-animated avatars improve communication in head-mounted display virtual environments. *PloS one* 6, 10 (2011).
[14] Shalom M Fisch. 2005. Making educational computer games" educational". In *Proceedings of the 2005 conference on Interaction design and children*. 56–61.
[15] Louise P Flannery, Brian Silverman, Elizabeth R Kazakoff, Marina Umaschi Bers, Paula Bontá, and Mitchel Resnick. 2013. Designing ScratchJr: Support for early childhood learning through computer programming. In *Proceedings of the 12th International Conference on Interaction Design and Children*. 1–10.
[16] Jesse Fox and Wai Yen Tang. 2014. Sexism in online video games: The role of conformity to masculine norms and social dominance orientation. *Computers in Human Behavior* 33 (2014), 314–320.
[17] Guo Freeman, Samaneh Zamanifard, Divine Maloney, and Alexandra Adkins. 2020. My Body, My Avatar: How People Perceive Their Avatars in Social Virtual Reality. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–8.
[18] Jonathan Gershon, Elana Zimand, Melissa Pickering, Barbara Olasov Rothbaum, and Larry Hodges. 2004. A pilot and feasibility study of virtual reality as a distraction for children with cancer. *Journal of the American Academy of Child & Adolescent Psychiatry* 43, 10 (2004), 1243–1249.
[19] Ole Sejer Iversen and Christina Nielsen. 2003. Using digital cultural probes in design with children. In *Interaction Design And Children: Proceeding of the 2003 conference on Interaction design and children*, Vol. 1. Citeseer, 154–154.
[20] Yasmin Kafai, Deborah A Fields, Michael T Giang, Nina Fefferman, Jen Sun, Daniel Kunka, and Jacqueline Wong. 2017. Designing for Massive Engagement in a Tween Community: Participation, Prevention, and Philanthropy in a Virtual Epidemic. In *Proceedings of the 2017 Conference on Interaction Design and Children*. 365–370.
[21] Janet L Kolodner, Tamer Said, Kenneth Wright, and Amy Pallant. 2017. Drawn into Science Through Authentic Virtual Practice. In *Proceedings of the 2017 Conference on Interaction Design and Children*. 385–391.
[22] Tommaso Loiacono, Marco Trabucchi, Nicolò Messina, Vito Matarazzo, Franca Garzotto, and Eleonora Aida Beccaluva. 2018. Social MatchUP- a Memory-like Virtual Reality Game for the Enhancement of Social Skills in Children with Neurodevelopmental Disorders. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–6.
[23] Birgy Lorenz, Kaido Kikkas, and Mart Laanpere. 2012. Comparing Children's E-safety Strategies with Guidelines Offered by Adults. *Electronic Journal of e-Learning* 10, 3 (2012), 326–338.
[24] Divine Maloney, Guo Freeman, and Andrew Robb. 2020. It Is Complicated: Interacting with Children in Social Virtual Reality. In *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*. IEEE, 343–347.
[25] Panos Markopoulos, Mathilde Bekker, et al. 2002. How to compare usability testing methods with children participants. In *Interaction Design and Children*, Vol. 2. Citeseer.
[26] Panos Markopoulos, Janet Read, Johanna Hoÿsniemi, and Stuart MacFarlane. 2008. Child computer interaction: advances in methodological research.
[27] Jackie Marsh. 2010. Young children's play in online virtual worlds. *Journal of early childhood research* 8, 1 (2010), 23–39.
[28] Nora McDonald, Sarita Schoenebeck, and Andrea Forte. 2019. Reliability and Inter-rater Reliability in Qualitative Research: Norms and Guidelines for CSCW and HCI Practice. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (2019), 1–23.
[29] Joshua McVeigh-Schultz, Anya Kolesnichenko, and Katherine Isbister. 2019. Shaping Pro-Social Interaction in VR: An Emerging Design Framework. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–12.
[30] Joshua McVeigh-Schultz, Elena Márquez Segura, Nick Merrill, and Katherine Isbister. 2018. What's It Mean to" Be Social" in VR? Mapping the Social VR Design Ecology. In *Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems*. 289–294.
[31] Lisa Meloncon, Erin Haynes, Megan Varelmann, and Lisa Groh. 2010. Building a playground: General guidelines for creating educational Web sites for children. *Technical Communication* 57, 4 (2010), 398–415.
[32] Kathleen Musante and Billie R DeWalt. 2010. *Participant observation: A guide for fieldworkers.* Rowman Altamira.
[33] Bonnie Nardi. 2010. *My life as a night elf priest: An anthropological account of World of Warcraft.* University of Michigan Press.
[34] Tabitha C Peck, Sofia Seinfeld, Salvatore M Aglioti, and Mel Slater. 2013. Putting yourself in the skin of a black avatar reduces implicit racial bias. *Consciousness and cognition* 22, 3 (2013), 779–787.
[35] John Porter III, Matthew Boyer, and Andrew Robb. 2018. Guidelines on successfully porting non-immersive games to virtual reality: A case study in minecraft. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play*. 405–415.
[36] Janet Read and Kim Fine. 2005. Using survey methods for design and evaluation in child computer interaction. In *Workshop on Child Computer Interaction: Methodological Research at Interact.*
[37] Janet C Read and Mathilde M Bekker. 2011. The nature of child computer interaction. In *Proceedings of HCI 2011 The 25th BCS Conference on Human Computer Interaction 25*. 1–9.
[38] Janet C Read, Peggy Gregory, Stuart MacFarlane, Barbara McManus, Peter Gray, and Raj Patel. 2002. An investigation of participatory design with children-informant, balanced and facilitated design. In *Interaction design and Children*. Eindhoven, 53–64.
[39] Janet C Read and Stuart MacFarlane. 2006. Using the fun toolkit and other survey methods to gather opinions in child computer interaction. In *Proceedings of the 2006 conference on Interaction design and children*. 81–88.
[40] Mitchel Resnick and Brian Silverman. 2005. Some reflections on designing construction kits for kids. In *Proceedings of the 2005 conference on Interaction*

design and children. 117–122.

[41] Kathryn E Ringland. 2019. A place to play: the (dis) abled embodied experience for autistic children in online spaces. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–14.

[42] Kathryn E Ringland, Christine T Wolf, Lynn Dombrowski, and Gillian R Hayes. 2015. Making" Safe" Community-Centered Practices in a Virtual World Dedicated to Children with Autism. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. 1788–1800.

[43] Barbara Olasov Rothbaum, Larry Hodges, Renato Alarcon, David Ready, Fran Shahar, Ken Graap, Jarrel Pair, Philip Hebert, Dave Gotz, Brian Wills, et al. 1999. Virtual reality exposure therapy for PTSD Vietnam veterans: A case study. *Journal of Traumatic Stress: Official Publication of The International Society for Traumatic Stress Studies* 12, 2 (1999), 263–271.

[44] Maria Roussos, Andrew Johnson, Thomas Moher, Jason Leigh, Christina Vasilakis, and Craig Barnes. 1999. Learning and building together in an immersive virtual world. *Presence: Teleoperators & Virtual Environments* 8, 3 (1999), 247–263.

[45] Anastasia Schmitz, Richard Joiner, and Paul Golds. 2020. Is seeing believing? The effects of virtual reality on young children's understanding of possibility and impossibility. *Journal of Children and Media* 14, 2 (2020), 158–172.

[46] Kathryn Y Segovia and Jeremy N Bailenson. 2009. Virtually true: Children's acquisition of false memories in virtual reality. *Media Psychology* 12, 4 (2009), 371–393.

[47] Soonhwa Seok and Boaventura DaCosta. 2014. Distinguishing addiction from high engagement: An investigation into the social lives of adolescent and young adult massively multiplayer online game players. *Games and Culture* 9, 4 (2014), 227–254.

[48] Shahnaz Shahrbanian, Xiaoli Ma, Najaf Aghaei, Nicol Korner-Bitensky, Keivan Moshiri, and Maureen J Simmonds. 2012. Use of virtual reality (immersive vs. non immersive) for pain management in children and adults: A systematic review of evidence from randomized controlled trials. *Eur J Exp Biol* 2, 5 (2012), 1408–22.

[49] Sam R Sharar, Gretchen J Carrougher, Dana Nakamura, Hunter G Hoffman, David K Blough, and David R Patterson. 2007. Factors influencing the efficacy of virtual reality distraction analgesia during postburn physical therapy: preliminary results from 3 ongoing studies. *Archives of physical medicine and rehabilitation* 88, 12 (2007), S43–S49.

[50] David Smahel and Michelle F Wright. 2014. The meaning of online problematic situations for children: results of qualitative cross-cultural investigation in nine European countries. (2014).

[51] Erica Southgate, Shamus P Smith, and Jill Scevak. 2017. Asking ethical questions in research using immersive virtual and augmented reality technologies with children and youth. In *2017 IEEE virtual reality (VR)*. IEEE, 12–18.

[52] Anselm L Strauss. 1987. *Qualitative analysis for social scientists*. Cambridge university press.

[53] Georgette L Troseth and Judy S DeLoache. 1998. The medium can obscure the message: Young children's understanding of video. *Child development* 69, 4 (1998), 950–965.

[54] Gill Valentine and Sarah L Holloway. 2002. Cyberkids? Exploring Children's identities and social networks in On-line and Off-line worlds. *Annals of the association of American Geographers* 92, 2 (2002), 302–319.

[55] Jennifer Vogel, Clint Bowers, Cricket Meehan, Raegan Hoeft, and Kristy Bradley. 2004. Virtual reality for life skills education: Program evaluation. *Deafness & Education International* 6, 1 (2004), 39–50.

[56] David Weintrop and Uri Wilensky. 2015. To block or not to block, that is the question: students' perceptions of blocks-based programming. In *Proceedings of the 14th international conference on interaction design and children*. 199–208.

[57] Pamela J Wisniewski, Heng Xu, Mary Beth Rosson, and John M Carroll. 2014. Adolescent online safety: the" moral" of the story. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*. 1258–1271.

[58] Andrea Stevenson Won, Jakki Bailey, Jeremy Bailenson, Christine Tataru, Isabel A Yoon, and Brenda Golianu. 2017. Immersive virtual reality for pediatric pain. *Children* 4, 7 (2017), 52.