"I Felt Like I Was in a Fishbowl": Lived Experience with Telepresence and Non-Visible Disabilities in Higher Education

Hanlin Zhang
Knowledge Lab
University College London
London, United Kingdom
hanlin.zhang.20@ucl.ac.uk

Yifan Feng
Knowledge Lab
University College London
London, United Kingdom
UCL Interaction Centre
University College London
London, United Kingdom
yifanfeng4@acm.org

Adam Walker
Knowledge Lab
University College London
London, United Kingdom
adam.walker.23@alumni.ucl.ac.uk

Jennifer A. Rode
Knowledge Lab
University College London
London, United Kingdom
jen@acm.org

Abstract

Telepresence robots are promising tools for enabling remote and embodied classroom participation. While existing research has primarily investigated students with physical disabilities in K–12 contexts, little is known about their use by students with non-visible disabilities such as neurodivergence (e.g., autism, ADHD) and mental health conditions in higher education. To explore this gap, we conducted a 10-week ethnography with disabled college students using four brands of telepresence robots, focusing on accessibility challenges and adaptive strategies introduced by telepresence. Our findings reveal several barriers, including audio distortion, sensory overload, spatial sensitivity, and anxiety tied to loss of control that affect neurodivergent students and those who have mental health-related disabilities. However, with thoughtful training, empathetic technical support, and inclusive pedagogical practices, many of these barriers can be mitigated. Finally, we propose design recommendations for both robotic design and instructional practices to improve telepresence robots' usability and usefulness for students with disabilities.

CCS Concepts

• **Computer systems organization → Robotics**; • **Human-centered computing → Empirical studies in collaborative and social computing**; **Collaborative and social computing design and evaluation methods**; • **Social and professional topics → People with disabilities**.

Keywords

Telepresence, Non-visible Disability, Neurodiversity, Mental Health, Higher Education

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1 Introduction

Telepresence robots have increasingly been used in education contexts as a means of enhancing participation, enabling remote access for students who cannot physically attend classes due to a range of factors such as medical conditions, disabilities or temporary illness [28]. Unlike traditional telepresence solutions such as video conferencing, telepresence robots offer a more embodied and interactive experience, enabling users to move through physical spaces, express themselves through intonation and gesture, and engage socially with instructors and peers. These capabilities make robotic telepresence particularly compelling for supporting access in education settings. Current research on telepresence robots has primarily focused on school contexts, particularly with young learners with physical disabilities or chronic illness [57, 79]. Few studies have explored how telepresence robots function in higher education contexts, which often involve more complex social dynamics, greater expectations for autonomous participation, and less structured classroom settings. Moreover, much less attention has been paid to how telepresence robots might serve students with non-visible disabilities, particularly students who have mental health-related disabilities or who are neurodivergent. These students often face unique, less visible participation barriers that are not easily addressed by existing access solutions.

The broader HCI field has shown increasing interest in assistive technologies use and designed for neurodivergent students, including those with autism spectrum (ASD) and attention deficit hyperactivity disorder (ADHD). However, assistive technologies are often presented as "normalizing" users [55], or in other words, in keeping with the medical model of disability [66], technology is assumed to remove indicators of disability to ensure people pass as "normal". In this paper, we echo discussions in HCI and assistive technology on "take a critical look at prevailing discourses on disability...like the medical model" [4, p. 4], particularly for research on individuals with neurodivergence and non-visible disabilities [6], and instead wish to adopt a social model of disability to frame the use of telepresence. This is in keeping with Rode's prior work [64, p. 1], which discusses how disability and telepresence robots interact:

> The telepresence robot did not "fix me" as is often implicated with the medical model of disability [75], or augment my experience to make it more palatable to the able-bodied majority. Instead, it allowed me to make conscious trade-offs between the affordances of my corporeal body and an emergent cyborg-self in the context of a degenerative auto-immune disease.

By drawing on this understanding and research gaps, we conducted a pilot study exploring the experiences of telepresence robots used by students with non-visible disabilities such as neurodivergence, mental health-related, and diabetics in higher education contexts. Specifically, we examined the accessibility support and challenges these students face when using telepresence robots, aiming to reveal the often-overlooked barriers they encounter. This paper makes **three key contributions:** 1) this is the first ethnographic study to explore how telepresence robots are used by students with non-visible disabilities in higher education; 2) it offers a social model–oriented critique of telepresence as an assistive technology, challenging dominant normalizing discourses; and 3) it provides both robotic design and pedagogical recommendations to collectively enhance meaningful participation for these students, contributing to more inclusive educational practices. To achieve this, we conducted a 10-week ethnography with observation, interviews, and a survey to gather rich and in-depth insights into the disabled students' learning and social experience mediated by telepresence robots. Through reflexive thematic analysis of field-notes, interview transcripts, and weekly survey responses, we present actionable design recommendations for telepresence robot manufacturers, as well as pedagogical recommendations for university educators, with the goal of fostering more inclusive and accessible learning environments for all students.

2 Related Work

2.1 Technologies for Accessibility

A substantial body of HCI research has examined the development and deployment of a range of assistive technologies to enhance accessibility for individuals with a wide range of disabilities, including physical [53, 72], sensory[59, 65], cognitive [20, 46], and mental health-related conditions [62]. For users with physical or communication impairments, technologies such as speech recognition systems [5] and alternative input devices [3] have been shown to facilitate more independent interaction with environments. For blind and low-vision users, screen readers and screen magnifiers provide critical access to text-based content [22, 73], while closed captioning, hearing aid-compatible systems, and automatic text simplification support d/Deaf and hard-of-hearing individuals in navigating audiovisual materials [1, 58]. These technologies are primarily aimed at mitigating access barriers in communication, education, and professional contexts, with growing attention to their integration into mainstream platforms and services.

While the existing literature mentioned before has focused on assistive technologies designed to support individual access needs across various contexts, there is a growing interest in how emerging technologies can facilitate inclusion in more collective and social environments. Among these, telepresence robots have gained traction as a promising tool for enabling remote participation, particularly in educational settings. The following section reviews current research on the use of telepresence in education, with a specific focus on its potential and limitations in supporting accessibility for students with disabilities.

2.1.1 *Technologies to Support Neurodivergent People.*

Research in HCI and assistive technology has increasingly focused on developing tools to support neurodivergent individuals, encompassing conditions such as autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD) [6] and their usages in higher education [74]. Much of the HCI research examines the role of assistive and educational technologies in supporting autistic children, primarily through the lens of the medical model [66], which views disability as something that needs to be fixed or managed through medical treatment or assistive technology [55]. For example, augmentative and alternative communication (AAC) devices, including speech-generating devices (SGDs) and mobile applications, have been widely used to assist non-speaking autistic individuals in expressing their thoughts and needs, thereby facilitating more effective communication and social interaction [32, 68]. Social robots have been designed to support autistic children in learning social cues, with studies showing their potential to facilitate engagement and reduce anxiety in social interactions [19, 45]. Virtual reality (VR) environments have also been explored for emotional and social skills training, offering controlled, repeatable, and customizable scenarios that help autistic individuals navigate social situations [31, 40, 87]. That said, scholars (e.g., [82, 84]) critique the dominant focus of current research on using technology to enforce normative goals for individuals with autism, and instead emphasize the importance of supporting autistic people's self-determination and autonomy over correction or normalization.

For individuals with ADHD, technology-based interventions focus on supporting executive functioning, time management, and attention regulation. Digital tools such as gamified cognitive training apps (e.g., Cogmed) and attention-enhancing wearables (e.g., smartwatches with vibration reminders) have been studied as potential aids in improving focus and reducing impulsivity [43]. Studies suggest that adaptive digital learning environments that provide real-time feedback and personalized scaffolding can improve task engagement and motivation for individuals with ADHD [41]. However, many technology-based interventions are shaped by neuronormative research aims and primarily focus on mitigating behaviors perceived as disruptive, rather than addressing the lived experiences or structural barriers faced by neurodivergent individuals [69].

Much of this research mentioned above reflects the medical model of disability, which seeks to "correct" or "compensate" for neurodivergence rather than embracing neurodiversity as a natural variation of human cognition. Morgado-Ramírez and colleagues [7, 55] critique this tendency in HCI, arguing that most technologies for neurodivergent individuals are designed within a deficit-oriented paradigm rather than aligning with the social model of disability, which emphasizes societal and environmental adaptations to support neurodivergent individuals. Therefore, more research is needed to shift the focus from deficit-based interventions toward approaches that prioritize autonomy, agency, and inclusivity, ensuring that assistive technologies are designed to accommodate diverse cognitive styles.

2.1.2 Technologies to Support Mental Health. Morgado-Ramírez's critique that research about neurodivergence in HCI relies on the medical model [55], can be extended to research on technologies to support mental health. One of the most widely studied technological interventions for mental health is mobile health (mHealth) applications, which provide self-guided cognitive behavioral therapy (CBT), mood tracking, and mindfulness exercises [11, 21, 49]. Research has demonstrated that such applications can complement traditional therapeutic approaches by offering real-time coping strategies and enhancing self-management of mental health symptoms [11, 49]. AI-driven chatbots, such as Woebot and Wysa, have also emerged as digital mental health companions, providing conversational support based on CBT principles to assist users in managing stress and anxiety [21]. Among the various mental health conditions, PTSD has received significant attention in technology-assisted interventions. PTSD is a psychiatric disorder that can develop following exposure to traumatic events and is characterized by intrusive memories, emotional distress, and hyperarousal. Virtual reality exposure therapy (VRET) has emerged as a promising tool for PTSD treatment by providing immersive, controlled environments in which individuals can confront and gradually desensitize themselves to trauma-related stimuli [35, 44]. This technology allows for the customization of traumatic scenarios, enhancing engagement and increasing the realism of exposure.

While these technologies offer accessible and scalable mental health interventions, their reliance on the medical model may limit their effectiveness in fostering long-term mental well-being. A more holistic, user-centered approach with the social model of mental health could enhance digital interventions by addressing systemic barriers, promoting peer support, and recognizing the role of socio-environmental factors in mental health outcomes. Therefore, this research adopts the social model of disabilities to study technology, particularly telepresence robots for students with a range of mental health and neurodivergences in higher education.

2.2 Telepresence for Inclusive Education

Telepresence robots have gained widespread recognition and adoption in educational settings, particularly in higher education. Studies of telepresence robots in higher education usually focus on the strengths and weaknesses of using these robots for the social presence of students [51], instructional design and teaching practices [10, 25, 37, 61], perception and acceptance [50]. Elmimouni et al. [28], building on Williams [83] have studied whether telepresence robots can be considered "disabled" in higher education by examining their functional limitations and the social dynamics around their use. This research shows that while the robots are not inherently disabled, their restricted sensory and mobility capabilities require users and classmates to adopt compensatory strategies similar to the lived experience of disabled people. They make numerous recommendations for best practices in teaching with robots and argue that these best practices are akin to best teaching practices with disabled students. As such, they propose a strategic allyship between disabled students and robot users.

Increasingly, discussions around telepresence robots in educational settings have shifted toward issues of equity and accessibility. For example, these robots have been used to support young students with chronic illnesses, enabling them to maintain a sense of normalcy in their relationships with instructors and peers [57, 79]. Similarly, telepresence robots have facilitated academic progress for hospitalized children, helping them stay engaged with their studies [80]. Nevertheless, much of the existing research focuses on students with physical disabilities, with limited attention given to those with cognitive differences, such as mental health challenges and neurodivergence. Furthermore, these studies primarily explore the use of telepresence robots in school settings rather than higher education. This gap underscores the need for further research on how telepresence robots can support neurodivergent students and those with mental health conditions in higher education contexts.

2.3 Theory around Telepresence

There are some studies conducted in contexts outside the classrooms which have theoretical findings relevant to telepresence robots in education for disabled students. For instance, Lee and Takayama [48, p. 41] established how remote workers engage in rich informal communication and build social connections by negotiating new social norms around courtesy. Further, they introduced the notion of embodiment where the robot "is (ontologically)—a person". Tree et al. [76] in a lab study of mock interviews half using telepresence interviews introduce the concept of psychological distance, which they define as "how close people feel to each other". While their statistical evidence is not especially strong, it motivates their conclusion that telepresence robots produce greater psychological distance. Finally, Boudouraki and colleagues [13, 14] ethnomethodologically explore telepresence robots in a global technology company. They find that telepresence robots were underutilized because knowledge workers were already well-equipped for hybrid work, perceived limited added value in the robots, and found them poorly suited to their distributed workflows [14]. Importantly, they frame this discussion in terms of Heidegger, Goffman, and Sacks to discuss how telepresence robots are often othered, despite politeness practices, failing in their goal of "being ordinary". All of this theory–around embodiment, courtesy, psychological distance, and the goal of being ordinary is foundational to this work, but workplaces and offices are not schools [13]. Thus, this paper is critical in determine how these practices play out in a academic context with disabled students in a context with radically different power dynamics and objectives.

2.4 Ethnography of Disability and Accessibility in HCI

Ethnography is an anthropological practice that emerged in the early 20th century, primarily characterized by the researcher's immersion in the "field" [2, 24, 38]. In HCI, ethnographic methods were initially adopted to address the limitations of early user-centered approaches that overlooked the broader contexts of technology use [9, 38, 39]. Over time, HCI researchers have expanded the focus from individual user-system interactions to larger socio-technical systems and cultural settings, using ethnography not only to inform design decisions but also to develop interpretive understandings of people and practices [8, 29]. This shift reflects a move toward understanding the complexity of lived experiences, relational dynamics, and the situated nature of technology insights rarely accessible through other methods.

More recently, ethnography, particularly autoethnography, has been increasingly used to investigate accessibility [34, 36]. Glazko et al. [34] present a three-month autoethnography involving researchers with disabilities to explore how generative AI (GAI) tools support or hinder accessibility for meeting personal access needs and making content accessible for others. Through a collaborative three-person autoethnography, Jain et al. [36] offer a longitudinal reflection on their experiences in graduate school as disabled individuals, emphasizing the complexities and challenges they faced when formal accommodations fell short and the adaptive strategies they employed in response. Together, these studies emphasize the importance of lived experience and socio-technical nuance in designing inclusive educational and technological environments. Therefore, this research adopts an ethnographic approach to critically examine how accessibility is practiced, negotiated, and sometimes disrupted in the everyday use of telepresence robots by neurodivergent students and those with mental health related disabilities in higher education.

3 Method

We conducted an ethnographic study in an anthropological fashion [9, 24, 63, 78] of the last author's 10-week-long master's course (an elective research method class that used a seminar format) at the University College London (Ethical Approval ID #REC1766). This methodology positioned the researchers not as pure observers, but as active participants in the classroom where telepresence robots were operated, enabling the ethnographers to discuss their relationship with their informants and establish rapport [63, 78] and "inspire[ing] fruitful design collaborations and understandings of technology use" [81, p. 2733]. In our study, the last author was both a researcher and the course instructor. Our participant observation prompted reflection on the power dynamics of a professor studying their own students, ensuring that participant observation and interview aligned closely with best practices. Similarly, other team members who served as teaching assistants, guest lecturers, or technical support staff were encouraged to reflect on their roles and presence impacting participants' telepresence robots use and data collection. By fostering a reflective and transparent engagement, we were able to build stronger rapport with students with disabilities, supporting them to share more nuanced insights into the accessibility challenges they faced.

3.1 Participants, Positionality Statement, and Reflectivity

3.1.1 Participants. We recruited ten participants (5 females, 5 males, 0 "prefer not to say") from a total of twelve mixed-ability students enrolled in the last author's postgraduate class (an elective module). Prior to the first teaching session, students were informed via email that they had the option to utilize telepresence robots along with the standard Zoom meetings to join class if they were unable to attend in person due to illness or other reasons, or if they were registered for the distance learning route. Participation in the study was entirely voluntary and did not impact their final grades. Later in the course, we confirmed that the voluntary nature of participation had been clearly communicated during recruitment. Participants were asked if they would like to see a draft of the paper to confirm that the paper represented them appropriately, and we conducted member checking with all participants who opted in. All participants with mental health conditions wanted to member check.

Like Elmimouni et al. [28], we considered that a mixed-ability classroom setting was more appropriate to explore opportunities and challenges for inclusive education, as they said, *"given the lack of data on best practices for teaching with telepresence in the classroom for students with or without disability, despite our interest in using telepresence to support disabled students, we did not feel it was ethical to start research with exclusively disabled participants"* [28, p. 6]. We hold the same view that data from all ten participants has an important bearing on identifying effective support strategies for students with disabilities.

In this paper, we primarily focus on college student's telepresence experiences with regard to non-visible disabilities such as neurodivergence, mental health conditions, and diabetics, from five participants. To ensure participants' privacy and anonymity and respect their choices, particularly given the small sample, we have opted to avoid including additional demographic information [1]. Though this decision supports confidentiality, it also means certain demographic nuances (e.g., exact age or overlapping disabilities) are not fully detailed, limiting the granularity of our analyses. However, we outline participants' telepresence use and duration of each session in Table 1 and students' attendance in Table 2.

3.1.2 Positionality and Reflexivity. While we studied a mixed-ability class, over half of the research team members were identified as disabled and/or neurodivergent, a proportion that well exceeds our institutional norms. We believe that this unique composition influenced participant recruitment and our ability to develop a deep rapport with our participants. For example, the last author, who was the professor of the class (and also the project PI), is a well-known public disability advocate and formerly had a senior leadership role in EDI at the university. It is well known amongst the students that they are neurodivergent (ADD and dyslexic), have low vision and a physical disability, and intermittently walk with a cane. While they do not publicly disclose their mental health

[1] Providing demographics specifics such as gender and race, and when combined with disability, could potentially compromise participants' anonymity especially at our own institution. Thus, we made a joint decision between the research team and our participants, as some might seek a PhD in our field, and prefer to keep their disability characteristics confidential.

Table 1: Robot uses by participant numbers across 10-week class, each 2-hour long. *=Connection lasted 5 minutes before battery died. **=Two robots available.

Week	Beam+	Double 3**	Beam Pro	Ohmni Pro
1	1	2	–	–
2	1	2	1	–
3	–	1	–	–
4	–	2	–	–
5	–	2	–	–
6	–	–	1	–
7	–	–	1	–
8	–	–	1	1
9	–	–	–	1*
10	1	–	–	–

Table 2: On-site and Off-site students' attendance and participant-observers by week.

Week	On-site	Off-site	Robot Users	Total Stud.	Total P-Obs.
1	4	3	3	7	6
2	3	5	4	8	5
3	7	2	1	9	5
4	5	2	2	7	6
5	5	3	2	8	6
6	6	1	1	7	6
7	4	4	1	8	7
8	4	6	3	10	6
9	5	3	1	8	3
10	5	4	1	9	4

status, they did share that they had been diagnosed with depression and PTSD with participants in individual interviews to encourage rapport and reassure them that the research was conducted in a non-judgmental and inclusive environment. Similarly, one research assistant (RA2) who was enrolled in the same study program as the studied class disclosed their neurodivergent conditions (i.e., ASD & ADHD) prior to the study. Another research assistant (RA1) was a PhD student who also has ADHD and had been treated for depression, though this was less well-known to the students but known to the research team. The remaining members, while not neurodivergent or disabled, were established as allies by working closely with a majority-disabled research group. Thus, most authors had an established positionality as disabled and/or neurodivergent, and we had established a connection with the majority of the students in the study.

Consequently, we believe that our group's positionality impacted the class makeup and research participation. Although we do not have direct access to the disability status of all students enrolled in this class, our university's Student Statistics report [77] indicates that 17.45% of students self-reported disabilities, including 5.95% with mental health-related conditions, 6.22% with neurodivergent conditions, and 3.48% with physical and long-term or multiple disabilities. Our research found that the proportion of disabled students in this study was significantly higher than university averages: three students identified as having mental health conditions, one identified as having ASD and ADHD, one as having ADHD, and one as having a medical disability. Thus, half of our students had at least one reported disability and/or neurodivergence with some experiencing disabilities from multiple categories [2]. Given our unique demographics, we wonder what factors may have contributed to our distinctive study population. We understand that the course content (e.g., the focus on ethnography in researching inclusive digital technology design), or the fact that it was the only elective module offered during the study term, may have played a role. That said, we also wonder if students who were disabled and/or neurodivergent might have been drawn to the class to have the chance to work with a disabled professor. These might explain why our study population might not reflect the typical student demographics at our university.

We also acknowledge that our positionality likely impacted our ability to establish rapport. Prior work discusses positionality statements as "performative" [52] and highlighted the potential harm of forcing minoritized researchers to disclose personal information in unsafe circumstances [67]. Elsewhere, however, Rode [63] has discussed how anthropologists unlike their positivist colleagues do not strive to maintain interpretive omnipotence [18]. Understanding how we achieved rapport is crucial for our methodology: *"Discussion of rapport is to ethnographies what discussion of choice of statistical techniques is to an experimental paper—it is a critical aspect of the reflexive ethnographer craft and a core part of their method"* [63, p.127]. Therefore, we argue that our positionality statement is methodologically appropriate, being necessary rather than performative, as it is critical to understanding both how we recruited a sample so atypical of our university demographics and how we generated sufficient rapport to encourage such open participation.

3.2 Apparatus: Telepresence Robots

We utilized multiple brands of telepresence robots in this class reflecting their availability in our lab (see Figure 1). The variety of robots reflected practical "bring your own device" (BYOD) scenarios often encountered in classrooms, where support for multiple device brands is typical [26].

Figure 1: Our study's telepresence robots. From left are two Double 3 robots, Beam+, Ohmni Pro (arrived in Week 8/10), and Beam Pro

All robots shared core functionalities, allowing remote users to move around campus and zoom their cameras to participate in learning and social activities. However, each robot offered unique

[2]Although some students had multiple disabilities, only five students self-identified as having disabilities.

additional features and physical designs that may affect remote (driver) and local participants' experience. First, the screens of both Beam models (Beam+ and Beam Pro) were static, while the Double 3 robots featured height-adjustable screens, and the Ohmni Pro allowed the display to pivot vertically. Second, in terms of scale, the Beam Pro closely matched human proportions, whereas the remaining four robots presented the user slightly smaller than human size. Third, all robots could display brief text, such as user names, but only the Double 3 could display websites. Lastly, collision detection capabilities across robots differed. This feature allowed users to determine whether a robot could physically contact classroom objects or people. Collisions might occur accidentally, such as bumping a classmate's chair, or intentionally, illustrated by a student who attempted to play tag. While collision detection could enhance safety, it also restricted navigation through narrow classroom spaces, such as aisles between chairs. The Double 3 featured built-in collision detection combined with AI navigation assistance, enabling users to move by simply clicking a destination and letting the AI handle navigation. The Beam Pro had permanently activated collision detection, whereas the Beam+ and Ohmni Pro robots provided users the option to toggle this feature on or off.

3.3 Procedure and Settings

Participants were required to complete a brief safety training session with one of our research assistants before using a robot in class, regardless of their prior experience with telepresence robots. In an effort to mitigate potential risks, particularly for Blind individuals and those with service dogs, we included training materials instructing telepresence users to stop, say "hello" (in case the person was hearing), and wait for a cane user or someone with a service dog to pass. After the training, students were instructed to select a robot prior to the class each week based on their personal preferences and availability. This flexibility enabled both remote users and local participants to exhibit genuine reactions and develop spontaneous strategies toward different brands of telepresence robots operating in the room. We deliberately allowed unstructured use in the classroom as it was consistent with our ethnographic method and it allowed us to study organic strategies for social and learning engagement. Furthermore, we did not inform local participants about how to interact with the telepresence operations. However, we did mention to local participants to refer to robot users by their names rather than as "the robots" as per Elmimouni's recommendation [27]. Additionally, since the teaching materials for this class were accessible on our university's Moodle (a Learning Management System (LMS)), we did not make any further accommodations and maintained a standard learning environment for all participants.

Each teaching session lasted approximately 2 hours, including a 10-15 minute short break. During these sessions, participants actively and freely operated the telepresence robots, engaging in a variety of teaching and social activities. This seminar-style class focused on the theories and practices of ethnographic methods in HCI & Educational Technology and was designed for small-scale, interactive participation. It required substantial student input, including discussions, debates, and presentations. The format facilitated telepresence use and remote participation, enabling students to maneuver their telepresence robots closer to tables for staff- or student-led discussions, and to reorient the robot's position and camera for multimedia presentations on classroom screens. During the study breaks, remote participants navigated around the room to socialize with their on-campus peers and research team members. To better understand potential user interactions, Table 2 provides an overview of student attendance, including the number of face-to-face students, the total number of remote attendees, those participating via telepresence robots, and observers. At least one telepresence robot was used in every week's session to support students' learning and social activities (see Table 1 for specific brand deployed in the class). On average, approximately four to five students attended in person each week, and one to two students participated using telepresence robots, with an additional five participant-observers present in the class. This typical attendance pattern created a rich environment for capturing a wide range of user interactions and experiences. Collectively, these conditions enabled a robust exploration and utilization of telepresence robots in the classroom setting, supporting the validity of our ethnographic approach to user research.

Figure 2: Study location and classroom layout

3.4 Data Collection

Our data collection focused on participants' interactions with/through telepresence robots within the classroom (see Figure 2). This involved participant observation [3] and taking ethnographic field-notes across the 10-week course (2 hours per week), one weekly 7-question survey, one optional participatory design (PD) session (60 minutes) midway through the class for both remote users and local participants, and one semi-structured post-study interview per participant (60 minutes for remote users and 30 minutes for local participants).

In total, 46 sets of field-notes were produced by seven members on the research project (see Table 2), totaling 291 pages of "thick description" [33]. Everyone on the project team engaged in participant observation including three research assistants (RAs) who were took notes while providing technical support; one student from the class who produced auto-ethnographic notes as part of her dissertation; the professor and one teaching assistant (TA) who balanced teaching responsibilities with note-taking; and a senior faculty member who attended selected classes, providing supplementary field-notes focused specifically on educational pedagogy. Each week, at least four team members sat in the classroom with robots and took notes, ensuring comprehensive observational coverage and minimizing gaps in the data. The consistent presence of

[3] All remote participants operated the telepresence robots from locations outside the classroom, spanning three overseas countries and other regions within our study country; and none of our observers operated the robots from within the classroom.

a designated field-note taker ensured detailed documentation of class activities and telepresence use. We deliberately chose ethnographic field-notes over visual recordings (photos and videos) for research purposes to protect participant privacy and minimize classroom distractions. Although the class capture system automatically recorded sessions for student use, adhering to ethical guidelines, these recordings were not utilized in this research.

To further enrich data collection, the last author also conducted one PD session and individual interviews. Half of the participants (5/10) joined the PD session to provide interim feedback regarding telepresence operation and general user experiences in class. Additionally, five remote users (drivers) and two local participants participated in the semi-structured interviews. One local participant and one remote user requested to conduct their interviews in Chinese, which our multilingual team accommodated by assigning a team member as a translator. All participatory design and interview sessions were audio-recorded and transcribed into English to enable data analysis by the entire research team. For this paper, we primarily report findings from post-study interviews, which included disability-focused questions designed to prompt both remote users and local participants to reflect on their classroom interactions through and with telepresence robots. We also draw on relevant weekly survey data, observational data and reflective field-notes to support our discussion. As data collection occurred in parallel, additional findings not focused on disability will be discussed in separate publications.

3.5 Data Analysis

We employed Reflexive Thematic Analysis (RTA) [15–17] with a focus on instances related to disability and telepresence. Throughout this process, the first and last authors engaged in regular discussions, drawing upon our positionality and "lived experience" as disability scholars with/out disability. By openly acknowledging our positionality and practicing reflexivity, we interpreted participants' experiences and perceptions of interacting with and through telepresence robots with context-specific insights. Additionally, our dual roles as researchers and teaching staff uniquely positioned us to uncover experiences and perceptions that might otherwise have been overlooked or perceived differently during our teaching activities. This allowed us to present design implications for both telepresence technology and inclusive education.

In the following section, we present two types of data: disabled students' reflections on their own disabilities and experiences with telepresence robots; and non-disabled students' perceptions of their disabled peers' interactions with telepresence and categorize them in themes and sub-themes. Informed by disability justice research in HCI [4, 71, 85], we respect participants' "lived experience" and their disability identities and accordingly, we organize our findings into three categories reflecting three distinct types of disabilities our participants self-identified with: neurodivergence, mental health issues, and medical disabilities. As Räsänen and Nyce [60] points out, anthropology (and ethnography) contributes a unique analytic lens through an integrated contextual analysis, offering socio-cultural insights into specific user interactions and technology design. Following its conventions, we integrate data presentation and discussion, providing an in-depth analysis of disabled users' telepresence experiences.

4 Findings and Discussion Regarding Neurodivergent Participants

4.1 Robot Users with Neurodivergence

We had one student with an unspecified "neurodivergence", and another with ASD who had ADHD. Both of them demonstrated hyper-sensitivity to sound and audio, and spatial sensitivity when using telepresence robots. In this section we discuss this data, but also in keeping with ethnographic practice, we also include passages from our RA with ASD's field-notes as they reflexively discuss how their positionality as someone with Autism impacted their engagement with students using robots.

4.1.1 Hyper-sensitivity to Noise and Audio Distortions for Neurodivergent Students. The student with ASD framed their challenges in terms of hypersensitivity to noise. For instance, when using Beam+ noted that they *"had difficulties with audio fixing on random aspects of the class, but the conversation was difficult to hear"* (Field-notes, Week 2). The participant later described the audio as *"very poor to the extent I could not hear anything, so I connected on Zoom. Also, generally, the audio captures way more things like clicking and typing. Others talking... it is like autism sound hypersensitivity"* (Survey, Week 2). They continued discussing their experience in the interview, that processing interacted with their neurodivergence, *"[it] like utterly like killed me from the inside. Sometimes, it was hard to focus because I could hear every detail of everything happening around me of other people like clicking on their keyboards or doing things... sound hypersensitivity on steroids"* (Field-notes, Week 4). The other neurodivergent student made a similar comment, *"as someone who has always had the privilege of attending class in-person, I have never really dealt with the pains of poor audio-visuals. I already struggle with attention and sensory issues in in-person classes, and this extra layer of difficulty left me feeling overstimulated"* (Field-notes, Week 4). This audio distortion was also noted by students who did not identify as disabled, for instance, one remarked that he could, *"hear the door louder than [RA3], who was talking to him at the time, which affected his ability to focus on the conversation with [RA3]"* (Field-notes, Week 2), and mentioned that *"even small sounds like doors opening can be amplified, making it hard to hold a conversation while others are speaking"* (Survey, Week 2). RA2 remarked on this in his field-notes,

> [The student with autism] also mentioned that... [they] also had difficulties with audio fixing on random aspects of the class, but the conversation was difficult to hear. Thinking about this in more depth could be considered similar to autism sensory issues, where people get easily focused on other sounds or phenomena when trying to focus on talking. This could suggest that, much like classrooms for autistic students, classes for telepresence robots may benefit

> from having reduced sound stimulation, further suggesting that telepresence robots and students could have similar considerations (Field-notes,Week 2).

Our data suggests that the audio distortions was a consistent issue across different robot brands. Consequently, we are particularly concerned that neurodivergent students with audio sensitivity might find these challenges a substantial barrier to engagement with their education.

This suggests despite the social benefits, telepresence robots also pose challenges, especially for participants with ASD due to sensory hypersensitivities. Participants' difficulties engaging in conversation due to noise, mirror the challenges faced by individuals with autism, who often struggle with overstimulation in noisy environments [86] and where certain sounds are perceived as amplified [70]. We found that neurotypical students have experiences similar with hypersensitivities as well. This is in keeping with Williams [83]'s argument that all robot users experience disability regardless of whether they have first-hand lived experience with disability. Our findings mirrored those of Elmimouni et al. [28], which show this theory applied to telepresence as well. Ultimately, for all students, regardless of disability, given prior research [47, 56] about how environmental noise can serve as a source of distraction, more understanding is needed before telepresence robots can safely and effectively be deployed in classrooms about how they impact and/or benefit individuals, especially those with ASD.

4.1.2 Spatial Sensitivity with Robots. Spatial sensitivity was remarked on by both the participant and the researcher who had autism. The participant who was being interviewed remotely commented,

> But I, I do remember, like if you get a bit too close the robot... it can feel pretty weird because sometimes I'm not sure maybe if other people feel this, maybe it's the autism, but I really do feel like I'm part, I am the robot sometimes, which causes a lot of issues. So if someone does get too close, it just feels it's not something that would ever happen in real life to like, like they wouldn't come up to my face, right? Like to listen to me and put their ears like right next to the camera.

The participant gestured, putting their hand up to the camera. In the interview, we clarified that people were literally putting their ear up to the robot when they struggled to hear them, and as such invading their personal space.

Similarly, the research assistant who had ASD also wrote about the impact of his spatial sensitivity in his field-notes. He commented on his wariness regarding the robot's proximity: *"One aspect of my autism is that I don't like people touching or being too close to me—it is interesting that I also felt like that with telepresence robots"* (Field-notes, Week 1).

This response highlights a potentially overlooked dimension of telepresence: the spatial and embodied implications of remote presence technologies for neurodivergent users. These individuals (one student enrolled in the class and one student researcher) both experienced a visceral reaction to the robot's position in the classroom as if it were an extension of their own body. This suggests that spatial boundaries and interpersonal distance, which are already significant considerations for many autistic individuals, can be activated even in mediated, virtual forms of presence. Thus, we recommend that future work must explore this in greater depth.

4.2 Support for Robot Users with Neurodivergence

4.2.1 Training to Flexible Participation for Neurodivergent Students. Our findings indicate that students with ADHD and autism benefit from flexible participation. We note the student with ADHD found themselves needing to log out and log back in to take a break when overwhelmed when using the robot. Rather than viewing such temporary disconnections as technical malfunctions, teachers must understand that this may reflect the user's self-regulation needs. Therefore, training for teaching staff should explicitly address this possibility, encouraging teachers to support students' needs to "step away" without penalty, reinforcing a positive and humanizing culture for users.

Furthermore, considering the arguments that robots simulate aspects of neurodiversity, it may be beneficial to provide further training to users of telepresence robots to get them used to the hypersensitivity generated by the robots. Mathews et al. [54] consider auditory training can help students with autism recognize and process speech in noisy environments and manage conversations. Therefore, training provides the potential to expose learners who are neurodivergent to audio hypersensitivity and train them to cope and hold conversations, which will enhance their opportunities for socialization when using telepresence robots.

4.2.2 Training to Support Predictability and Physical Navigation for Neurodivergent Students. Our data also shows that students with ASD benefited from environments that support planning and predictability. A participant with disclosed neurodivergence emphasized the importance of predictability: *"I typically like to plan almost everything. I'm a big planner, so when I kind of can tie up my expectations accordingly, I think it helps to alleviate some of the stress"*. This view can be considered common in neurodivergence, with Bewley and George [12] considering individuals with autism need advanced notice of changes in conditions so they can know what to expect and prepare for them.

Therefore, training is essential to create a more predictable and supportive environment for students with neurodivergence. Structured training sessions can proactively inform students about the potential challenges they may encounter when using telepresence robots, such as processing auditory input or dealing with sensory overload. By setting realistic expectations and providing strategies to manage these issues, training can help alleviate anxiety and promote a sense of control, factors that are particularly important for students with autism and ADHD.

Apart from the predictability of noise, the predictability of physical navigation is also important. During their closing interview, one participant who declared Autism and ADHD discussed they experienced difficulties maneuvering around the class due to challenges with the classroom layout, stating, *"Uh cables. So yeah, if you remember the podium thing, I once had to go around all the other way because I can't just step over a cable, right? Maybe I could have driven* *over it. I didn't wanna risk it."* This showcases their difficulty moving around the class due to their uncertainness about a perceived obstacle. Furthermore, they discussed the challenges of moving around narrow spaces, stating, *"I guess chairs, like, of course, the narrow width, it's quite hard to sometimes maneuver around them. So it would be kind of awkward."* The participant considered a way to handle these issues may be for learners to get more experience navigating the telepresence robots in this space before the lesson: *"Training could be improved by setting up a scenario that mirrors the real classroom environment, with obstacles like chairs and desks instead of using cones. It would help people get a feel for navigating."* This highlights the importance of incorporating spatial familiarization into telepresence training, which helps students understand the room layout and obstacles to prepare for this change of attendance. This is in line with Bewley and George [12]'s suggestion of giving students a chance to prepare for change. Doing this will provide students with autism a predictable learning environment [30], respecting a general preference for being prepared as an ASD mitigation strategy [12]. Thus, providing training for students to familiarize the environments is crucial to reduce uncertainty, thereby supporting smoother transitions and greater confidence when using telepresence robots.

5 Findings and Discussion Regarding Mental Health

5.1 Robot Users with Mental Health Conditions

Three participants shared with the research team that they had mental health conditions. One of them was a distance learning student and regularly used the robot, while the other two were in-person students one of whom drove the robot once when they were feeling unwell, and one who did not drive but was in class with students driving robots.. **Participants expressed extreme concerns about ensuring their data remained unidentifiable, even to their classmates who might read this paper. To protect their identities, we will dispense from using the participant naming scheme used in other publications and instead refer to them simply by Student A, B, and C. Further, given the small sample size we will not include gender or other identifying information to help further protect identity.** While we do not endorse a medical model of disability, we present participants' framing of their mental health condition as they did, including diagnoses. Student A shared during the interview, *"So my neurodivergences are anxiety and PTSD."* Whereas Student B shared, *"I've been diagnosed with both depression and PTSD and anxiety."* Finally, Student C framed it as, *"My condition... is called 'Polycystic Ovary Syndrome (PCOS)'. In addition to that, I also have some anxiety and depression, which were caused by the long-term academic pressure I experienced during high school."* All of these participants discussed how their mental health impacted their use of robots for the worse.

5.1.1 *Anxiety and Loss of Control.*

Student A during the interview framed their issues with the robots as stemming from anxiety and not PTSD.

> *Student A:* My PTSD again is very situationally specific, and it in a context that has absolutely nothing to do or whatever have anything to do with with the robots themselves.
> *Researcher:* So it's an anxiety thing?
> *Student A:* Totally.

They framed the issue as a loss of control,

> I kind of a big [...] contention between me and my anxiety is this kind of need for control. And I think in the moments that I was operating the telepresence, I didn't have the control that I wanted. And in that case, I think it made me more anxious than usual (Student A).

Student A clarified during the interview that their issues were with driving the robot themselves, rather than having robots in the classroom, *"I would say having them in the classroom was positive, even if my personal experience with them was not."*. They then described the source of this lack of control and feeling overwhelmed as follows,

> I felt like I was in a fishbowl for the majority of the class. When I'm telling you it was so frustrating because it would be like I could hear one sentence. I couldn't hear the next sentence. Things would kind of go in and out. The fishbowl effect really happened a lot, visually or audio, more audio, but visually my screen would get super, super, super pixelated (Student A).

Beyond this, Student A expressed concern about their classmates' and professor's perception of them when using the robot, and felt that when using the robots, they had violated their own expectations of how to follow social norms. They also struggled using the robot, describing themselves as *"frustrated and overwhelmed"* so much and they said, *"I didn't enjoy my experience and I can be honest about that fact, but I didn't enjoy it to [...] the extent that I would never use them again"* (Student A). Yet, they still left the door open to their future use, saying, *"I don't see myself being closed off to the robots forever"*, for them, robots had enough benefits to consider using again.

5.1.2 *Discomfort Attributed to PTSD.*

In contrast to Student A, Student B did frame their issues in terms of PTSD saying, *"The PTSD side of stuff is why I don't like people being behind me is why I like having a kind of exit to stuff, and so it's also about the kind of like size of like I don't like big things being like very close to me and that way though."* Consequently, Student B reported trying to avoid their *"triggers"*, whether human or mediated via a telepresence robot:

> In general, I don't like people being close behind me, regardless of whether they are using a telepresence robot of their walking around with their own body. Or, I don't know, like I will always sit so that I have a kind of either my back to the wall or kind of like a clean line to the exit. I will like I'm generally quite careful on that stuff and I do get kind of like, ah, every now and again. So I don't think it's necessarily something that is directly linked to the telepresence robot. And there's, like, some people in real life that (Student B).

Student B did not like people behind them and was mindful of whether the door was blocked as having a clear way to exit a room. Both solutions allowed the participant to avoid potential harms, and are examples of hypervigilance practices experienced by people with PTSD [42]. Thus, what is interesting here is that these hypervigilance practices extended to computer-mediated communication with the telepresence robot. They also mentioned it was difficult to tell who was using which robot from behind, especially on the Double robots of which we had two, and that this made them feel *"weird"*. This is also a shared experience with Student C. In the interview, they commented,

> if someone already has a tendency toward anxiety or depression, using the telepresence robot might make them feel more irritable or anxious. This is because the robot's field of view is generally quite dark and limited. I feel like the robot's view doesn't take up the full screen—it's only part of the screen.... the view probably only occupies about three-quarters of my screen, making it quite restricted (Student C).

It is important to note that Student C was using a Beam Pro robot, which includes a full-screen feature; however, the user chose not to utilize it. Fortunately, despite some discomfort, both Student B and Student C did not experience the same level of discomfort reported by Student A.

5.2 Support for Robot Users' Mental Health Challenges

Prior research, such as [13] highlight challenges and anxiety with regards to self-presentation in general populations, but this research's contribution is to explore how these issues are made manifest with regards to disabled populations in educational. Our analysis shows that people with mental health challenges can continue to use robots, and users' mental health can be supported with a mixture of training and tech support.

5.2.1 Empathetic Technical Support. We recognized that Student A can use telepresence robots appropriately when provided with timely emotional and technical support by one of our RAs, who was also the student's classmate. Student A described this as,

> [The RA] like made the gesture to come and sit by me physically, and he texted me and said, hey, like, I know you're having a tough time. It was actually really sweet. He's like, hey, you're having a tough time. Like I'm gonna come sit by you. And I was like ohh my God, I'm feeling so overwhelmed that it's so humanizing to know it was probably so nice because I was so stressed. And I was like, my classmates are so kind. But he was like, I'm just gonna sit by you. And if you need anything like you tell me. And that's something that you would expect from your friends from your cohort. And I received the same treatment. So I would say even though my robot itself, the technological difficulties that I was having made me feel excluded, my classmates did a really good job to make me feel good (Student A).

In this instance, using text as a back-channel support, the RA confirmed that they should move next to the participant using the robot. In doing so, the physical proximity ameliorated the situation. This underscores the importance of humanizing support to help students manage anxiety and feel included when suffering technological difficulties when using telepresence robots.

5.2.2 Training and Classroom Support. Student A had clear ideas on how to mitigate their experiences through training. First, they discuss the need for teaching empathy to students collocated with robots, *"I would say just having training that emphasizes empathy, kind of teaching the students how to understand the robots and the ways the multifaceted ways that they navigate, the fact that it's difficult."* Second, Student A felt that *"When I was driving my training just kind of went out the window,"* but highlighted that training should have included the ability to participate in a *"regular class for like, 10 or 15 minutes as a practice before you really needed it also would have also probably would have appreciated that just to kind of like test drive it without having any kind of expectations."*. This suggests the importance of decoupling the training experience from a higher-stakes activity, a graded class, and instead, users should first practice attending via robot on a lower-stakes activity such as an optional research lecture.

Student B did not offer any mental health-specific suggestions for how their interactions with robots could be improved, but their data does have clear implications. The name of the person using the robot should be clearly labeled on the back. Further, training should explicitly discuss robots in the context of anxiety and PTSD. Users should be told that robots have been known to startle people with these mental health challenges, and telepresence robot use may be inappropriate with users whose PTSD or anxiety are not well controlled. In situations with strong power dynamics, such as classrooms, it is imperative that these discussions be handled candidly and sensitively.

Finally, Student C called for improving *"limited and dim visuals, potential sound issues or connection drops"* as otherwise they worried it would worsen feelings of *"anxiety, irritation and discomfort"*. This suggests that issues with networking must be addressed to ensure higher quality connections, and robot users must be trained how to use the full screen feature. Using full screen, however, would necessitate an extra screen for notetaking, viewing online course readings, and participating in any learning management system, in our case, Zoom and Moodle.

Ultimately, our data suggests that in many circumstances, individuals with mental health conditions can appropriately use telepresence robots, but care is required. Training must address how mental health conditions can impact use. Extra screens might help users' sense of immersion. Care plans should be put in place to respond to adverse incidents. Finally, space must be made for discussion of reasonable accommodations, and robots may not be appropriate for all environments.

6 Supporting Users with Other Non-Visible Disabilities

In addition to discussing the telepresence experience with regards to neurodivergence and mental health conditions, we also found data on other non-visible disabilities important to this research to enrich our approaches to facilitating technology-mediated learning and fostering inclusive education. The participant was the most enthusiastic telepresence user, attending class via telepresence robots for 5/10 weeks (they were a teacher and missed some classes due to parent-teacher conferences). This participant was a distance learner and also a "type 1" diabetic, and by the end of the study, they identified as disabled (though initially, they did not realize that UK law included diabetes as a disability, a topic that came up organically in class). They participated from overseas, where it was four hours later, such that the two-hour class time overlapped typical dinner hours. As this was a time they typically ate, it made managing their blood sugar more challenging. The participant spoke about how the robot helped them manage their disability, specifically their blood sugar level, *"I found it being extremely useful. Being on a telepresence robot, you know, as a type one diabetic because it's certain points... I possibly was going low and I was then able to...eat my food."* They discussed how before they might have just had to join the teaching session late, because

> I don't necessarily feel comfortable taking out my sandwich and eating around others in person. And that's just me as a person in my own workplace, when I have my lunch, I like to be, you know away from others whilst eating. I don't unless everyone else is eating. I feel uncomfortable eating with me alone and other people are not eating.

Consequently, the participant's preference while eating was to log out of the robot, and to simply stay logged on to Zoom with the video off. They clarified they preferred having a robot in the classroom at this time as opposed to just turning off the camera on Zoom saying, *"I just felt comfortable"*. This suggests that simply having the robot there, even while logged off gave the user an increased feeling of presence and embodied classroom participation, even ironically while temporarily logged out of the robot to eat and only listening on Zoom. We believe this is because the robot served as a larger physical marker of presence than a rectangle on other videoconferencing apps. While Rode [64]'s research discusses how disabled people can use robots to augment disability intentionally, this participant's data was interesting as an example of how robots can be used as a way to avoid drawing attention to one's disability. Prior work highlighted courtesy as as key tensions for the design of telepresence robots [27], and our user's data suggest that how disabled people use telepresence to present their identity and respond to courtesy norms are a critical area of study to ensure telepresence robots are usable by people with a range of abilities.

7 Design Implications

While some issues raised by our participants, such as networking challenges, can be addressed through regular software updates and hardware improvements, others may require further design explorations for both telepresence robots and training materials. Thus, we propose the following recommendations to inform further work, aiming to engage with both technical and non-technical solutions to foster disability-inclusive teleoperation in educational contexts and improve the experience of disabled college students. We acknowledge others may have made similar recommendations for non-disabled populations, but this work is unique in that we highlight the design needs for disabled populations. For instance, while Lee and Takayama [48] highlighted the need for users to be able to identify robots from behind and the side, this finding takes on greater significance when engaging with participants with PTSD.

7.1 Telepresence Robots

- Adaptive Audio and Noise Processing: Our data shows that audio distortions, as well as, picking up background noise more than conversation are key factors affecting the experiences of neurodivergent users. We recommend implementing adaptive audio channels with intelligent audio signal processing techniques to help provide directed sound input and regulate auditory feedback to improve effective technology-mediated communication.
- Rear Display Screen: Adding a second rear-facing screen display as a digital name badge on the back of the robotic head could provide more visual cues and information. It could remind local participants of the driver's information, and provide awareness for people viewing the robot from behind that the robot had an active user. This could also help mitigate anxiety issues caused by uncertainty and the effort required to recall information.

7.2 Best Practices & Instructional Design

- Classroom Management: Optimizing the physical environment is important for all users. Managing sound stimulation is crucial; active efforts such as reducing background noise in the classroom or designing a low-volume space with sound paneling for telepresence-mediated interaction can help minimize distractions and improve the on-task attention of neurodivergent users. This will benefit users without disabilities as well.
- Special Training for Remote Users: First, training materials should include strategies and guidance focused on managing hypersensitivities and attention spans in telepresence-mediated environments, particularly on engaging with the various functionalities and affordances of telepresence robots. Second, in educational settings, it is beneficial to provide training on multitasking, toggling between apps (driving, note-taking, adjusting microphone and video settings, reading course materials, and classroom text chat), and minimizing and maximizing screens. This training would allow them to more closely simulate the experiences of in-person participation.
- Special Training Programs for Local Participants: First, informing local students to provide emotional support and building a supportive classroom environment are crucial. This involves fostering an inclusive atmosphere that acknowledges and accommodates the emotional and social needs of remote participants. Second, instructing local students to consult with and establish clear spatial boundaries for telepresence users is essential (to create mutually agreed interpersonal space). This helps neurodivergent users mitigate the stimulation of embodied experiences mediated by telepresence, allowing them to feel more comfortable during interactions and communication, as if they were in co-located contexts.

These suggestions aim to collectively enrich the technology-mediated learning experience of disabled students, thus opening up new and inclusive educational opportunities enabled by telepresence technologies.

8 Conclusion and Future Work

Telepresence robots present promising possibilities for inclusive learning and social experiences in classroom. Our research shows how telepresence may inadvertently create barriers for individuals who are neurodivergent or experience mental health and other non-visible disabilities. In this study, we conducted a 10-week ethnographic investigation in a postgraduate course taught by the last author, examining how students used telepresence robots to participate in classroom learning and social activities. Our findings offer novel insights into the intersection of disability, telepresence technology, and higher education. Based on our user interviews and field-notes, we highlight the need for additional support structures to ensure disabled students feel comfortable and empowered when using and interacting with robots. These include training for managing audio and sound, emotional and technical support during robot operation, and proactive classroom preparation for telepresence robot use. Building on these insights, we offer design recommendations for both telepresence technologies and educational practices to help create more inclusive learning environments for disabled students.

That said, we acknowledge limitations of an ethnography. To understand its limitations, it is critical to apply the appropriate epistemological lens to the research. Many things that are often perceived as limitations in other HCI methods are viewed as desirable and intrinsic in ethnography. It is fair to say this is a single-site context which focuses on one elective course at one institution, and that this shapes our findings in ways that likely reflect the pedagogical style, disability policies, and culture of this particular setting. Rather than aiming for broad generalizability, our study offers richly contextualized insights that others may compare to or contrast with their own environments. As we engaged in participant-observation, we could not minimize reactivity [18], so instead, we engaged in keeping with best anthropological practice by discussing our positionality reflexively [23, 63, 78] and how it impacted both the data we collected and its interpretation. This is methodologically appropriate for ethnography, with its own epistemologies. Future research as detailed below, will clarify how these insights might transfer elsewhere. Regardless, this study's key finding that students with disabilities have unique challenges with telepresence, which must be addressed in design, is not impacted by these limitations.

As a pilot study, we plan to conduct future work to include aspects that were missed in this study. One significant omission from our data is the lack of physically disabled, D/(d)eaf and/or Hard of Hearing, or Blind users. These groups were not enrolled in this class and are generally underrepresented at our university [77]. Consequently, despite training our participants on how to interact with Blind people and people with service dogs in telepresence-mediated environments, they did not have the opportunity to test this protocol during our study. Additional research is needed to evaluate the appropriateness and effectiveness of these safety practices and to further explore how to make telepresence robots safe around and accessible for these populations.

Our study mainly focuses on interactions that occurred in classrooms. Further research is required to explore other university spaces outside the classroom, such as lobbies, computer clusters, libraries, campus bars, and lunchrooms. These work can help understand whether particular social norms or group power dynamics in these settings may also affect disabled users' experience. Furthermore, another two areas emerged during our study that warrant further exploration. First, a comparative analysis of the different telepresence robot designs, particularly how they meet the needs of both disabled and non-disabled users, is needed, enabling a more inclusive and comprehensive evaluation. Second, it is important to examine how the physical presence of robots in an active learning classroom provided meaningfully different educational experiences from Zoom presence.

Ultimately, our data suggest that the unbridled enthusiasm for telepresence robots must be checked by an understanding of how they impact disabled students. To date, this is the first ethnographic study with disabled college students, and it suggests that real harm could be done. Our data suggest PTSD, anxiety, and overstimulation due to ASD could be intensified due to telepresence operation. On the flip side, these telepresence robots allow flexibility to manage physical disability as we learned with our student's diabetes, supporting prior published research [64].

What is more troubling, as we verified from our interviews, was that these students' challenges were unknown to their classmates. We worry that many classrooms would result in students suffering these indignities in silence. The open question is, of course, if the robots enabled the students to mask their disabilities or if they would be doing so anyway regardless of their mode of attendance. We do not view masking as something desirable; rather, it is a response to stigmas surrounding disability. Regardless, our data does not show that our participants were masking intentionally. The students with autism and diabetes were out about their disabilities, and thus did not mask. The students with mental health challenges did not share their diagnosis with their classmates. We do not know if this was masking or merely that it did not come up. Perhaps they merely wanted to protect their privacy or were influenced by the socio-cultural norms practiced in the country where the study was conducted? Consequently, we are hesitant to theorize in terms of masking, given that this was not our participants' framing, and doing so would overly medicalize and stigmatize disability. This does, however, highlight the need for additional research to understand choices and agency with regards to presentation of disabled identity when communication is mediated through a telepresence robot.

Much additional research is required to explore the multitude of disabilities and their intersectionality. Further, we need to identify training practices and teaching methods to support students with disabilities. Finally, there is a need to develop learning management systems that incorporate moving the robots, note-taking, viewing course documents, and simplified camera and microphone management. Ultimately, telepresence shows promise for students with a host of disabilities, but the hardware and software need to be developed in concert with people with disabilities to ensure it is not another technology that marginalizes.

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