Human Proxies for Remote University Classroom Attendance

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ABSTRACT
Our research explores the idea of using a human proxy to attend a class on one's behalf where video streaming is used to share the class with the remote student. We explored this idea through an online survey and in-class participation. Survey results show that people favored 'top students' to represent them where gender and race played a much less important role. Students also highly valued a proxy who was also taking the class so they could discuss the course material. In class, students found the setup beneficial and highly valued the pair-wised learning that it afforded. Despite this, proxies found it difficult to concentrate in class and to be a surrogate for someone else at the same time. Together our results highlight the benefits and challenges with human proxies for classroom attendance and raise a series of design sensitivities that should be explored as part of future research.

Author Keywords
Human proxies; telepresence; video streaming; classrooms

ACM Classification Keywords
H5.3. Information interfaces and presentation: Group and Organization Interfaces – CSCW

INTRODUCTION
Rising tuition costs, an increasing slate of school offerings, and options for distance learning have prompted many students to pursue the benefits offered by distance learning [10,17]. Yet such online courses may easily lack the in-person interactions that many people find valuable for learning [17,39]. Given this challenge, we are now seeing a host of new technologies that offer support for telepresence, e.g., online discussion boards with video chat software and remote video presentation setups. There are also technologies that permit one to have a physical embodiment in the remote class such as a telepresence robot.

While telepresence robots offer a compelling scenario, they are still relatively expensive. Instead, we were interested in alternative setups that might include a physical embodiment and still be more affordable for the typical student. In this paper, we explore the idea of using human proxies or surrogates for remote classroom attendance. We were inspired by the use of surrogates in the television show, Arrested Development, where a man on house arrest uses a surrogate to be 'present' at work. In our case, a proxy attends class for a remote student, streams what is happening in the class to him or her via a wearable video streaming technology, and interacts in the class on the student's behalf. The potential benefit is that the student has an actual human presence in the classroom to represent herself. While this technology setup may seem futuristic, in reality it is now possible with present day technology such as relatively inexpensive wearable cameras (each costs about $100-200). Given the cost, students are more likely to have such cameras at their disposal compared to relatively expensive telepresence robots. What is not known is how human proxies may work in practice, what design limitations need to be addressed, and what unintended social consequences might occur when using proxies.

Our paper presents several contributions to the HCI community and, in particular, those exploring telepresence and remote embodiments whom we aim to sensitize to the unique opportunities and challenges brought forward with human proxies. First, we contribute an understanding of human proxy identity through an online survey with 33 university students who described their ideal human proxy. Findings show that students preferred human proxies that were strong students scholastically, favoring problem solvers and organized individuals. This suggests ways in which proxies might be made a reality in the ideal situation.

Second, we contribute an exploration of human proxies in actual classroom settings, which, to our knowledge, has never been done before. Through observations and interviews of student-proxy pairs, we learned that remote students were able to adequately participate in the class and engaged in valued pair-wise learning with a peer. On the other hand, proxies faced a number of challenges relating to camera work, embodiment, autonomy, and interactions.

Third, we articulate design opportunities and challenges for human proxies in classrooms. We describe the social and technical limitations as well as the social questions that still need to be explored. These suggest directions for future research. While we purposely did not explore learning effects in our research because we wanted to first focus on

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the social situations enabled through the technology, our work brings to light many intriguing questions about how proxies may affect learning processes and outcomes.

RELATED WORK

Video-Based Telepresence in the Workplace

The topic of telepresence has a longstanding research history. Early work on media spaces explored how audio and video feeds could be used to communicate availability information and support casual interactions between distance-separated co-workers [3,12,15,19,50]. The first media spaces connected common areas such as meeting rooms or kitchens and used relatively low-bandwidth to show what was happening at remote locations [3,12,19]. Follow-on work explored media spaces that were designed for office desks [8,14]. In much of this research, privacy was an important consideration [1,4]. Privacy issues typically related to one of solitude, confidentiality, or autonomy [4] and often increased in magnitude when a person was in a mixed context, e.g., telecommuting [37].

Mobile Telepresence

More recently, designs have explored mobile video, such as is the case in our human proxy work. For example, Porta-Person used a laptop-based embodiment that could be transported from one conference room to another through the help of a dedicated human "handler" [51]. Systems have included large, "life-sized" high-fidelity displays to provide virtual presence for the disabled or mobility impaired [31]. LiveSphere [35] provided headgear with six cameras to broadcast an entire scene around a person to remote users. Most similar to our work, Polly [27] provides mobile telepresence through the metaphor of a parrot sitting on a user's shoulder. Here a camera is attached to a stabilized gimbal. Similar to Polly, Misawa and Rekimoto [33] designed ChameleonMask where a human proxy wears a helmet containing a tablet attached to the front. Video of a remote user is streamed to the tablet for local users to see. A pilot study showed that interaction through the proxy worked reasonably well, yet they did not explore social situations to the same extent that we do in our studies.

Studies of mobile video conferencing have explored how wearable or handheld cameras can be used to connect people in settings such as wedding halls [32], restaurants [43], museums [43], malls [21,43], and outdoor parks [21,41,42]. Results showed that the camera holder faces challenges in orienting the camera and providing good views for remote viewers [21,32,42,43]. This can create a sense of social debt to the handler as well as a feeling of helplessness in the remote user who lacks control over remote views [43]. Remote viewers sometimes desire multiple viewing angles [32]. People are also conscious of the public visibility of conversations between remote users and the video handler [43].

Telepresence Robots in the Workplace

Telepresence robots have been designed and studied to allow remote workers to attend meetings with colleagues [49,51]. Despite these efforts, remote users often lack sufficient physical presence at remote locations and can easily begin to feel like second-class citizens causing them to become disengaged from the larger group [26]. The challenge is they are often unable to keep track of conversations and participate in the productive, highly-charged and sometimes chaotic ad-hoc meetings or side conversations that frequently take place [49]. Yet robotic telepresence has been found to provide better attentional information than traditional video conferencing [34].

Research has also shown the importance of wide field-of-view cameras and ranges of audio control from 'whispers' to conversationally-appropriate levels [22,23,25,40]. Video feedback of oneself is also important for self-appropriation [25,30,40,47], while robot height can imply persuasiveness [44]. Lee and Takayama [30] found that telepresence robots can create a sense of social connectedness by supporting casual interactions. The medical community has also been active in testing robotic telepresence systems. Studies have shown high levels of comfort and acceptance for telepresence robots used by doctors [46] though use with elderly patients has had mixed reactions [29].

Distance Learning

Research has also focused on distance learning and telepresence in classrooms or large lectures. Jancke et al. [20] designed TELEP to support presentations in a lecture-style setup. Video of remote audience members was available in a large grid for all to see and discussions took place in a chat room facility. PEBBLES connected children in a hospital to a school classroom [11]. Chen [5] designed a virtual auditorium to support learning that incorporates dialog between instructors and students through an audio link. Subsequent work involved the creation of a gesture-sensitive videoconferencing system where a study of it amongst small groups showed that low fidelity video does not adequately support floor control [6]. Visualizations of classroom participation were able to show 'the pulse' of the audience to instructors [7]. Shi et al. [45] designed a mixed presence classroom that projects views of remote students and supports annotations on projected slides.

To understand the awareness needs for telepresence classroom systems, Birnholtz et al. [2] studied instructors' practices in traditional classroom setups without remote students and suggest that telepresence systems for classrooms should provide both overview and detailed views of remote students. Other researchers have found that how "real" a remote person appears to local students has an impact on social interaction and participation [13,28,48], which are prerequisites for knowledge construction and collaborative learning [16,24].

Overall, we have not seen studies that explore the use of human proxies for remote university classroom attendance. As such, our goal was to build on the related work to understand how people would use a human proxy to support remote classroom attendance, how they would

interact with this person, who they would want as their proxy, and what social and technical limitations might exist.

ONLINE SURVEY ON PROXY IDENTITY

Identity is an important attribute when it comes to remote embodiments of oneself [9,36]. In avatar-based environments, it comes with a great number of decisions such as the selection of race, physical appearance, etc. [9,36]. With telepresence robots, it involves deciding how to ensure others recognize who you are [25,30,40]. For these reasons, we decided to first explore what type of person people would select as a human proxy, if given a choice for remote classroom participation. We were interested in learning what types of personality, race, gender, etc. students would want in their proxy, especially compared to their own identity. We created and deployed an online survey focused on these topic areas.

Survey Method

First, our survey described the type of human proxy scenario that students should imagine:

You are a university student and unable to go to class one day. Instead, you send a person to class on your behalf. We call this person a proxy or surrogate. The proxy lets you see and hear a live stream of the class by wearing a technology like Google Glass. You watch on your home computer or laptop. You are also able to participate in the class through your proxy. You can tell this person to ask questions, interact with certain people, etc. - whatever you are comfortable having this person do.

We also included two images to depict the setup. In Figure 1 (left), a blonde haired person is wearing a mobile camera attached to a pair of glasses to stream the classroom activities to the remote student. The remote student is at home in front of a computer and wearing an audio earpiece with microphone to illustrate that the two people can communicate with one another (Figure 1, right). The 'sketch-like' quality of the drawings was purposeful. We wanted survey respondents to comment on the experience rather than any particular hardware or software technology (or potential usability issues with it), which could emerge if they saw a more finalized system.

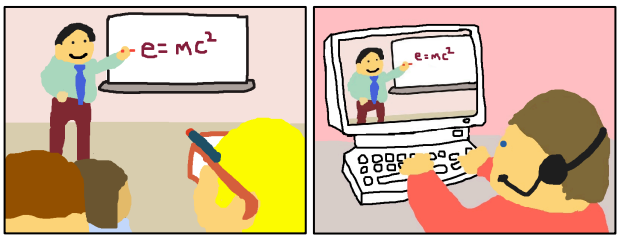

Figure 1. Drawings illustrating an example technology setup in the classroom (left) and student's home (right).

After reading the scenario and seeing the images, respondents answered our survey. The survey asked basic information about the respondent such as gender, age, race, and languages spoken. These answers were chosen from multiple-choice questions with possible answers. They then rated their technical savvy-ness and scholastic abilities using a 5-point Likert scale. We also asked questions from an abbreviated Myers-Briggs Type Indicator test. Myers-Briggs tests are questionnaires that respondents answer in order to determine their attitude towards behavioral attributes. After being scored, it categorizes people according to combinations of four behavioral dichotomies where a person matches one of the behaviors within each pair. Pairs consist of: introversion (I) vs. extroversion (E); sensing (S) vs. intuition (I); thinking (T) vs. feeling (F); and, judging (J) vs. perception (P). Respondents answered questions about each paired set of terms and are assigned a four-letter personality identifier. For example, "ESTP" represents a person that falls into the dichotomies of extroversion (E), sensing (S), thinking (T), and perception (P) where he or she would have strong personality traits in each area.

Next, our survey asked the same set of questions about the respondent's preferences for a human proxy. Through the same Myers-Briggs Type Indicator Test they selected the ideal behaviors of their proxy. They also chose their preferred gender, race, and languages spoken for the proxy. For example, we asked them, "What gender would you prefer for your proxy? Male, Female, or Doesn't Matter." We followed this up with a question of "Why did you choose this response?" Thus, for each of question, we asked them to explain why they chose a particular attribute. We also gave them options to select if an aspect of identity did not matter to them. Finally, we asked them about their reactions to the idea of using a human proxy to attend class remotely and how they saw this interaction occurring.

Survey Respondents

We received 33 responses to our survey. Respondents were comprised of 28 undergraduate and 5 graduate students who were taking courses within a university program focused on design/media arts. 26 people were 18-24 years old, six were 25-34, and one was 35-44. Only seven respondents were male, which is under representative of the program's roughly 50% split between men and women. Respondents varied heavily in their responses to the Myers-Briggs Indicator Test where between 1 and 4 people fell into each of the 16 possible behavior categories represented by the four letter combinations (e.g., ISTJ, ISFJ); thus, we had a large variety of personality types. All participants rated themselves as moderately to very tech savvy. All lived within a major urban area of North America that is highly multi-cultural. Their university program is equally multi-cultural with students of a variety of races.

Data Collection and Analysis

We used qualitative coding techniques to analyze responses to the open-ended questions in our survey and descriptive statistics to explore responses to closed-ended questions. Our analysis revealed several main themes that we describe

next in our results. Here we step through various aspects of identity including personality, gender, race, etc.

RESULTS

Personality

Only four respondents desired to have a proxy that was the same personality type as themselves. Other respondents picked a range of personality types with ESTJ (11 people) being the most popular followed by ISTJ (8) and ESTP (6). Thus, across the three most popular types of personalities, all contained the S and T identity components where S represents mastery of facts, knowledge of resources, and an appreciation of knowledge, and T represents the ability to analyze a situation for its strengths and weaknesses and problem solve. This shows that students would like their proxy to be a careful, analytical thinker. Within the top three personality types there are differences between whether a responded wanted an introvert (11 of 33) or an extrovert (22). This shows that extroversion is desired by a majority of respondents, yet introversion is valued by some.

Gender & Age

When it came to gender, a majority of respondents (22 of 33) felt that the gender of their proxy did not matter because the proxy would be acting on their behalf and gender would have no affect on this behavior. Seven respondents chose the same gender as themselves and four chose the opposite gender. Those who chose the same gender (both men and women) felt they would be able to communicate most easily with someone of the same sex.

A small number of respondents brought up perceived issues with particular genders. For example, three male respondents preferred to have a female proxy because they felt male proxies may be easily distracted by women in the class. Several female respondents brought up perceived interactional challenges with both genders, for example:

"For me personally, it's easier to communicate with male proxy since they talk straight forward and they give opinion straight forward." – P31

A small majority of respondents (17 of 33) favored a proxy that was in the same age range and university year as themselves, while five selected someone in the same age range but a higher university year. Respondents tended to choose people of the same age and university level (or higher) because they wanted have their proxy be someone they could relate to. Four people had no age/university level preference and six people had a mixture of responses. Respondents who were less concerned about age and university level felt that as long as the proxy could be trusted, varying ages/levels were less important.

Class Participation and Scholastic Levels

The majority of respondents (26 of 33) wanted the proxy to be another student in their class. They felt that the proxy would already know what was going on in the class as a result. This would make it easier for them to exchange thoughts with the proxy if they had a question about the course content. Other respondents felt that if there was a cost associated with such a proxy service (an idea brought up by participants, not us), it would be cheaper to have a proxy from within the class since it would be more convenient for this person to act as a proxy in this case. Seven respondents felt that the proxy should definitely not be a student in the class. Instead, they felt that the proxy's sole purpose was to 'be a proxy' and not a student as well.

The majority of respondents (26 of 33) felt that it mattered what kind of grades the proxy received as a student. They felt that grades were an important identifier of the proxy's ability to engage in a class and reflected what type of student they were. Thus, they wanted a proxy who did well in school. On the other hand, seven respondents did not feel that their proxy's grades were important because they felt the proxy was simply a surrogate for them.

Language and Race

All respondents wanted to ensure that their proxy spoke English fluently because all of their classes were taught in English. Respondents also felt it was very important that the proxy know their native language (e.g., Cantonese or Mandarin). This would allow the proxy to translate terms that the student did not understand. Most respondents (24 out of 33) did not have a preference for their proxy's race. What was most important was whether or not the proxy was paying attention in class.

"I would value their intellectual abilities and acuity. Race might play a role in our relationship but I would see this as positive because it would bring an "added value" to the proxy's presence by enriching our "dual" identity." – P9

On the other hand, four respondents felt that communication between themselves and the proxy would be better if they were of the same race. They thought they might share cultural knowledge that would help communication.

Proxy Expectations

When asked what their expectations were for their proxy, a large number of respondents talked about the proxy being able to follow their directions and instructions, be responsible, and pay attention. Smaller numbers talked about wanting the proxy to have good camera control, be able to start conversations on their behalf, be enthusiastic, and not draw too much attention to themselves. They also thought the proxy should periodically interact with the remote person to check if they were understanding the content of the class or repeat content that was missed.

"I would expect them to listen attentatively [sic] to my questions and discussions so they can deliver that to the class. I would expect them to pay attention to important information especially key information about exams. I would expect them to be able to multitask and still pay attention." – P21

SURVEY DISCUSSION

In general, respondents thought of a proxy as more of a friend or partner rather than someone they would explicitly 'control.' There is a chance that when people responded about gender and race that they recorded what they thought was socially acceptable rather than their true opinion. Overall, these findings suggest that if a human proxy service was available or students could ask their friends to fill this role, that there is a broad range of people that would be suitable to be a proxy. Yet if we look at scholastic competencies, we see a different picture. Respondents essentially wanted a human proxy that one might consider to be a 'top student.' The implication is that, given typical student grading (with a small number of high grades), there are likely a small number of individuals that would be considered as ideal human proxies. One may not easily be able to turn to a friend to ask for such a service. Instead, it could be much harder to find an ideal candidate, unless one was willing to compromise.

Our survey is intriguing as it begins to raise questions about what situations might actually arise in a classroom setting with proxies. For example, how will students *actually* interact with their proxy? Will they attempt to 'control' the proxy or will they allow him or her to engage based on their own free will? Many wanted an extrovert who would be good at talking with others, but would extroverted proxies perhaps gain too much autonomy and be too outgoing? Or would control remain with the remote student? We begin to explore such questions next in our study of classrooms.

CLASSROOM USAGE OF HUMAN PROXIES

Our second study explored what would actually happen in a classroom setting with human proxies. We deployed a basic technology setup in two university classes, one graduate and one undergraduate. The goal was to understand how remote students and proxies interact and behave, what works well with the human proxy setup, and what social and technical challenges still need to be overcome. We also wanted to expose any interesting social situations that might arise as a means to sensitive and suggest future direction for research on human proxies.

Participants

We recruited six pairs of students (twelve students in total) from two separate university classes to participate in our study. Recruitment occurred via advertisements in the classes. Table 1 shows information about our participants who are grouped according to each proxy-remote student pair. For example, UG1 (Row 1) was the proxy for UG2 (Row 2) who attended class remotely.

Participants selected their own proxy and could choose anyone they wanted. As it turned out, all chose someone else from the same class. Given this open selection criteria, we also had a mixture of males and females in each role as either the human proxy or the remote student. Participants ranged between 20 and 40 years of age with the majority in their early 20s. Students varied by their personality type in terms of being introverted or extroverted. We did not notice any specific strategies for choosing a partner for the study, aside from choosing someone in the same class. While our previous study showed specific identity and personality attributes as being important for a proxy, when it came to participating in this study, we observed that students quickly asked a friend if he or she would participate with them. This is possibly because it was a study but it could also represent more naturally occurring situations where, in practice, people prefer friends over other identity attributes.

Class	ID	Gender	Role	Personality
Undergrad	UG1	Male	Proxy	Extrovert
Undergrad	UG2	Female	Remote	Introvert
Undergrad	UG3	Female	Proxy	Introvert
Undergrad	UG4	Male	Remote	Extrovert
Undergrad	UG5	Male	Proxy	Introvert
Undergrad	UG6	Female	Remote	Extrovert
Undergrad	UG7	Male	Proxy	Extrovert
Undergrad	UG8	Female	Remote	Introvert
Graduate	G1	Male	Proxy	Introvert
Graduate	G2	Female	Remote	Extrovert
Graduate	G3	Female	Proxy	Extrovert
Graduate	G4	Female	Remote	Introvert

Table 1. Student-proxy pairs in our study.

The first eight participants were students in an undergraduate design course that contained a three-hour class. The first hour was devoted to covering lecture materials using a 'flipped classroom' model, which focused on discussion and questions about course material. The remaining two hours were comprised of design activities and crits. The remaining four participants were students in a graduate course on collaborative technologies. It too contained a single three-hour class. The first hour of this class was seminar-based and involved discussions of papers that students had read before class. The remaining two hours were comprised of design activities, discussions, and informal presentations by students.

Method

Participants pre-selected which class they wanted to do the study in from a selection of six weeks in the term. We purposely had them pick from weeks that included typical class activities, as opposed to weeks containing an exam/quiz or large formal presentation. When the participants' selected day came, the human proxy arrived at class fifteen minutes early and we helped them setup our technology probe. It contained a wearable bag (as a shoulder strap) with a smartphone holder attached to it, as shown in Figure 2. In the holder we placed an iPod Touch (5^{th} generation) with a front facing 1.2 MP camera capable of HD video (720 p) at up to 30 frames per second. A similar wearable setup was previously used in other mobile video communications research [43]. The iPod Touch streamed audio/video to the remote student using Skype. As can be seen in Figure 2, the camera is at chest level. We pilot tested with various locations including the head (a

camera attached to a hat) and different chest areas. The selected location was not overly obtrusive and the camera angle changed easily when the proxy moved his body.

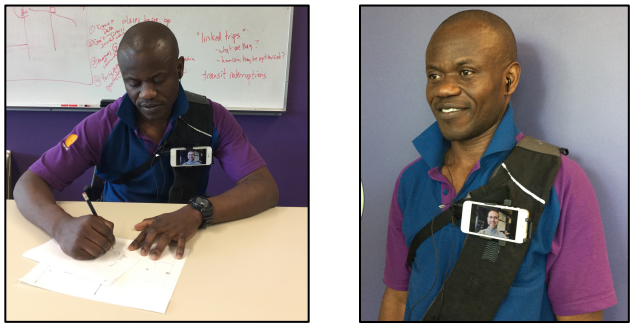

Figure 2. A human proxy wearing the technology setup.

At the remote location, students used their own computer. The human proxies used an earbud attached to the iPod Touch in order to talk to the remote student. Participants were told the goal of the human proxy setup was to allow the remote student to see class and participate in it. Beyond this, we allowed participants to choose how they would use the technology and how they would interact as a pair.

In order to speak to others in the class, the remote student had to tell the proxy what to say. We had deliberately not let remote users talk directly through the system (e.g, via the device's speaker) because we felt it may be difficult in a classroom setting without having a broader contextual understanding of what was happening (e.g., frequent interruptions). We thought this understanding would come from the proxy. We also thought that this type of audio might be indicative of situations where students use wearable cameras in a classroom with a proxy on their own accord (given the low cost of cameras and ease of setup) and, perhaps, unbeknownst to the instructor.

During the class, we observed the proxy's interaction with classmates and the instructors and also paid attention to his or her classroom behaviors. After the class, we conducted individual interviews with the human proxy and the remote student to understand their perspectives. We asked them questions about how they interacted using the technology setup, what worked well about it, what did not work well, and what they thought should be done to improve the situation. For example, we asked human proxies, "How did the remote student let you know what s/he wanted you to do?" and "Did this work effectively?" For remote students, we asked similar questions but from their perspective. Interviews lasted between 20 and 45 minutes.

Students in the undergraduate class received a small amount of bonus credit (1%) in the course for participating. Students in the graduate class did not receive any additional credit. Thus, the motivation for a person to be a proxy was at most for course bonus credit, though we expect that students were partly motivated because they saw it as a favor to the remote student. The remote student received the additional benefit of not having to travel to campus.

Data Collection and Analysis

We audio recorded all interviews and kept notes on our classroom observations. We then fully transcribed all interview audio and conducted a series of qualitative data coding activities on the transcriptions, including open, axial, and selective coding. We used our observations to help interpret and guide our coding. The coding drew out main themes related to the benefits of a human proxy, issues around location and privacy, interaction behaviors between the human proxy and the remote student, camera work by the human proxy, and successes and challenges with the remote student's embodiment. In the next section, we step through each of these themes.

THE BENEFITS OF REMOTE PARTICIPATION

Participants generally enjoyed the experience of using a human proxy for classroom attendance. This included both the remote student as well as the student acting as the proxy. Most commented that it was very beneficial for those who might be sick or faced mobility challenges. In fact, two of our participants happened to be sick on the day of their study participation and would have normally not come to class as a result. Other participants talked about the benefits of not having to commute to school, which sometimes took between 45 minutes and an hour via public transportation. One remote student felt human proxies were a good way to overcome shyness in classroom settings.

We asked participants how they felt the experience compared to situations involving Skype and a laptop. Participants overall felt that the proxy experience added benefits beyond just a Skype call alone. The comment most often made was that the proxy added additional mobility beyond a typical video chat call (e.g., via Skype on a laptop). Several proxies commented that they enjoyed having a very close personal connection with another student. In this way, they shared the classroom experience together in a more intimate way than was typical.

G4, Remote Student: "Yeah, I think it was more mobile. Being attached to someone when they broke up into groups, I went with them, and it felt comforting. Like if you're just on a computer, you would feel disconnected. It was nice because I'm friends with <my proxy>, it was nice talking to her one-on-one. It felt really comfortable…more personal than if I was just put up on a big screen on Skype."

Thus, as can be seen, remote attendance had a number of benefits for both proxies and the remote students. But, of course, there were also limitations and challenges that both parties faced and we describe them in the following sections as starting points for design considerations.

LOCATION AND PRIVACY

We had given remote participants the option to connect to class from a location of their choosing and all chose their home bedrooms. This was because it was the most

comfortable location for them and they could close the door to avoid hearing sounds from other people that might be around. It also meant 'zero' travel time to get to campus.

UG4, Remote Student: "To be honest, I woke up about half an hour ago at that time, so that's why I was at my home in my room, and that's where my computer and everything is, too. Very comfortable. It's like I was just at home and I just woke up so I don't have to prepare myself or anything."

Some participants considered going to another location, such as a coffee shop, because they thought they may be able to concentrate better there or that it may appear more professional. However, potential background noise prevented this along with the additional effort to leave their home.

We asked remote participants about their privacy and if they were concerned about it, given that they were in their home bedroom. None raised any concerns. They also were generally not concerned about how they looked on camera. Participants described being in their pajamas or having not 'gotten ready' yet for the day. In only one instance did a remote participant talk about changing the view of her camera to not capture herself. When she left her computer area, she would turn her camera to face her cat.

On the classroom side, proxies tended to sit at the front of the classroom in the first available row of seats. They found it easiest for the remote student to hear the instructor from this location after testing out various positions. It also allowed the remote student to easily see a whiteboard on the wall, which sometimes contained writing. At times this location was socially awkward for the proxy because it may not be his or her 'usual' sitting location causing the student to change seating patterns. Students generally tend to sit in the same area each class, though seating is not restricted. They also do not tend to sit at the front of the room. Proxies who did not sit at the front of the room ended up receiving complaints from the remote students about sound quality.

G1, Proxy: "What do I feel about the location? It is awkward because I am the only person in the front row. I have no other choice because if I sit in the back row, due to the limitation of the iPod, <remote student> couldn't see the board, so I have to be in the front."

PROXY-STUDENT INTERACTIONS

The main activity that proxies engaged in was camera work in an effort to properly direct the camera at locations the remote student should be able to see. Because the camera was attached to the proxy's chest, proxies had to orient their bodies towards what was being shown in class or who was talking. Some proxies were very good at this and our observations in class showed that they were often conscious of where the camera was pointed. At times this was awkward because it involved rotating one's chest rather than just their head. Some proxy-student pairs worked collaboratively together to get the best possible view for the remote student. Other remote students did not discuss the camera view because they did not want to 'bother' the proxy, or the view was 'good enough.' Some proxies were less concerned and did not take additional efforts to ensure the view was a good one. Sometimes this led to the remote student seeing awkward or irrelevant views.

Many human proxies said that being a proxy was a challenging task as they had to pay attention to the class itself as well as the desires of the remote student they were representing. Some proxies even felt additional anxiety or worry that they may not be giving the remote student the best possible experience. Because of this, many would go to great efforts to listen to the remote student and ensure the experience was good.

G1, Proxy: "It's hard work. Hard work. Yeah, I need to listen to her first. I need to translate that effectively and clearly and accurately. It's difficult. In that sense, I feel disengaged if there's a very complex idea."

In our setup, remote students had to tell the proxy what to say to others in the classroom. There was no direct audio link for the remote student to speak to the class. This became challenging when complex ideas needed to be communicated. Such interactions often became slow and tedious as the remote student relayed to the proxy what he or she wanted to say.

UG4, Remote Student: "I would actually give her some commands. I would say, "Oh, I've got a question. Can you put your hand up?" kind of thing. Or I would ask her, "Can you ask this for me?" kind of thing."

At times it was difficult for the proxy to hear what the remote student was saying because of other noise in the classroom, such as the instructor speaking or students talking amongst themselves. This meant that interactions between the proxy and the remote student often had to be carefully timed for a point when others were not talking. The proxy faced the additional challenge of sometimes not being able to speak aloud to the remote student to coordinate interactions because of classroom social norms, e.g., not talking aloud when the instructor was speaking.

Some students found workarounds where they would use text chat in Skype or text messaging to talk with the remote student or proxy. This backchannel worked well for proxy-to-student conversations, but it meant that the proxy was limited to mostly sitting down so that they could be at their laptop or in a state where they could easily text message back and forth. During group activities, the remote student could engage in discussion through the proxy, however, it was difficult to do physical activities such as sketching or drawing their ideas.

Sometimes proxies became distracted by classroom happenings and did not hear what the remote student was asking them to do because they were listening to the class or interacting with a local student. Proxies did not always participate on behalf of the remote student exactly as they

would have liked. Instead, proxies sometimes filtered interactions with other students. This occurred by either ignoring what the remote student was saying, or by changing its tone or content slightly. Both proxies and students realized that sometimes the proxy could be distracted by other happenings in the classroom and not hear or pay attention to the remote student, this created a sense of plausible deniability as to whether or not the proxy heard an instruction from the remote student. Thus, it could be easily ignored if the proxy did not want to do or say what had been asked.

UG7, Proxy: "I don't want to say exactly what <remote student> said ... Maybe <our partner's> feelings would have been hurt, I don't know."

We also saw other instances where proxies started to develop a deeper sense of autonomy and wanted to interact on their own, rather than as a representative of the remote student. For example, one proxy was a member of a different team (for assignments) than the remote student. When it came time to do activities with team members during the studio lab, tensions emerged between the remote student and the proxy. Each wanted to interact with his or her own team members. The proxy ended up going to be with his team rather than the remote student's and the remote student had to engage with her teammates using an instant messaging channel instead of using the proxy. In this case, the person with the 'stronger' personality (the proxy) ended up getting what he wanted.

EMBODIMENT

Remote students were embodied using a relatively small device. This made it so they were not obtrusively large, yet it also meant that it was difficult for students and the instructor to see the remote student at a distance in the classroom. The remote student's face was much smaller than local student's face and, thus, more difficult to notice. To attract attention to the remote student if they wanted to say something, proxies often performed overt hand gestures. For example, we observed that proxies would sometimes make pointing gestures to the display on their chest when the remote person wanted to say something or when they wanted to be introduced or noticed. This worked some of the time, but could easily not be noticed if the gestures were not large enough.

UG7, Proxy: "I guess I pointed at <remote student> a few times when ..... when people were kind of wondering what I was doing talking to myself or something. Or if I like went up to the teams, I'm like, "Hey say hi to <remote student>," or something. And <remote student> would wave and they would wave."

Several remote students felt that they were not noticed in the classroom because of the small display on the proxy's chest. This was advantageous for those who wanted to remain more discreet. Others wanted to have a larger presence in the classroom setting than the proxy setup afforded. In these cases, many participants talked about having a speaker for their own voice so they could talk aloud, rather than just through the proxy. Here they wanted two options: 1) to be able to talk directly to just the proxy for side conversations and instructions, and 2) to be able to talk aloud to others in the room on an as-needed basis.

G4, Remote Student: "I think, having the ability to speak for myself through maybe a small speaker on the phone than I wouldn't have to be communicating my ideas through someone else's interpretation of what I said. I'd feel more, like I was actually personally contributing to the class."

EXPERIENCING THE CLASS

Remote participants generally felt that they were able to participate effectively in the class through their proxy.

UG4, Remote Student: "I was able to learn effectively because I can hear the lecturer and I can see the lecturer, what he's talking about. I could see the examples. That I find out to be pretty effective…. Aside from the fact that I cannot [directly] interact with other students, otherwise learning direct from the lecturer himself, it's actually just fine. I have no problem with it."

Some participants talked about not wanting to bother the proxy too often with questions. They felt this might compromise *the proxy's* learning. Thus, some were generally concerned about their impact on the other person and his or her ability to pay attention in class.

On the other hand, proxies faced large issues in regards to their own participation and engagement in classroom learning. First, proxies did indeed find it difficult to listen to the remote participant while simultaneously hearing the course instructor. When the remote student was not talking to them, they also had to think about what camera work might be needed to provide a better experience for the remote student.

G3, Proxy: "The idea is interesting, but it was bothering me more than I was benefit from. Being in a classroom and paying attention to someone who is not present. Paying attention to two different locations was more distracting than beneficial. There would be times when she says something and I don't hear it well, or I don't understand, so I have to go back and forth between her and me. I can't follow the content of the class, because I can't tell, let's say to slow down or just to wait for me. So then there were a few critical points where I missed the comment from the class or what someone else said."

DISCUSSION

The goal of our research was to better understand an emerging telepresence opportunity by learning through one type of human proxy setup such that we could sensitize researchers and designers to the types of questions and issues one ought to think about in this design space. Thus, we wanted to use our studies as a means to think critically about the design space. We now discuss our results and

detail a series of more speculative thoughts in relation to human proxy design and usage.

Paired Learning

The strongest benefit that we saw in the human proxy experience we studied was the unique learning experience it created. Remote students became engaged in paired learning with their proxy where they would talk with each other, discuss the course content, and help each other out. This was a clear benefit and many remote and proxy students talked about this as their most enjoyable part of the experience. Our survey on identity also reflects this idea where most participants very clearly wanted a proxy who was someone that they could learn *with* and *not through* during their classroom experience. This suggests new opportunities for distance learning as well as how one thinks about remote telepresence and embodiment.

Embodiments such as telepresence robots and laptops place students directly in the class where they represent themselves through the associated computer hardware. This is beneficial for having autonomy over one's actions, yet it means that remote students might feel isolated from others in the class. Thus, while one may imagine that having to interact through a proxy would create many negatives, and it certainly did, it also revealed the potential for opportunities to learn course material in a more intimate fashion with a peer. This type of experience is not normally found in setups that utilize telepresence robots or more traditional video conferencing solutions (e.g., Skype from a laptop). Of course, it also raises questions about how one should think about student learning from an educational perspective. Is such paired learning truly effective? How can student learning be assessed? If, for example, a proxy adds to the discussion in the class and earns some form of participation grade, should the credit go to the proxy or the remote student and how does one truly know where the contribution came from? Such questions already exist for courses that include team-based assignments, yet human proxies raise these issues again in different ways.

Technical Challenges

The human proxy setup we explored certainly created challenges. These included issues with camera work, poor microphone distance, and issues in seeing far away objects. Similar problems have been reported in other contexts [43] and, in particular, with telepresence robots [22,23,25, 40,49]. Design suggestions have included using multiple fixed cameras, direct sharing of meeting slides, and more advanced audio and video setups [22,23,25,40,49]. We advocate that similar solutions may also work for human proxies in classroom settings.

Our proxy setup also created disadvantages for the remote student who did not have autonomous control over their own mobility or speech like they might receive if they were using a telepresence robot instead. This problem has also been articulated in other contexts (e.g., outdoor activities with families [18], proxies at museums and restaurants [43]). We had also thought that remote students might be able to physically interact in class during design activities through their proxy. Such interactions might expose advantages for the use of human proxies as compared to commercial telepresence robots, which currently do not generally have arms. However, the use of proxies for physical activities was not as easy as we had hoped because of the need for detailed instructions between students. Thus, the potential is there but design improvements need to be made for it to be realized.

Social Situations and Questions

Our research also raises intriguing social questions that should be thought about by telepresence designers and researchers, and even potentially instructors of courses where students may use proxies in the future.

First, there are questions around identity and the effects of who one picks to be a proxy. If people do in fact want an ideal proxy who is scholastically strong, and are willing to choose such a person over a friend, there are questions about the effects of a 'stranger' within the classroom setting. It is not clear in these cases if and how the proxy might alter or even potentially disrupt the social dynamics of the classroom and what impact the proxy may have on the relationships between the remote student and her peers. The desire to choose an ideal human proxy could also lead to companies that provide proxy services. Would such proxies be required to 'blend in' with the normal look and interaction style of the class's students, or would the person have to appear and act in a more professional manner (e.g., wearing a suit), akin to business-like expectations that might come along with a paid service? On the other hand, if a student did indeed choose to have a friend be his proxy, what effect might the proxy have on the friendship if the person turned out to not be scholastically strong and this began affecting the remote student's learning?

Second, there are questions around what is socially appropriate in a classroom and if proxies or remote students might disrupt the current classroom social norms. Our participants told us that they wanted a proxy who would understand the normal procedures and behaviors of a post-secondary environment. But who is responsible for ensuring such behaviors are adhered to? Is it the remote student or the proxy? The majority of participants in our classroom study told us that they wanted a mechanism to talk aloud in the classroom without the aid of the proxy. Yet what happens if such interactions are poorly timed because the remote student does not understand the current classroom context and if it is a good time to speak? Is this the fault of the remote student, or should the proxy be held responsible for not informing the student of when and how to talk directly to the class? All of the remote students in our study connected from their bedrooms but some mused about connecting from a more public location like a coffee shop. We might imagine that some would actually do this in practice if proxies were in more widespread use. This

raises interesting questions about how the general public might react to seeing and hearing a person engaging with a proxy. For example, would bystanders feel it was socially appropriate for a person to be told what to do by someone who was remote? What social protocols exist around such behaviors and how might they change over time?

Third, our study raised questions about the autonomy of human proxies. From the proxy's perspective, they often found it difficult to perform in the dual role of both a proxy and a student. If they are a student in the class, they may easily decide to focus on their own learning at some stage and begin to neglect the remote student. In our study, some proxies filtered conversations and some ignored certain requests from the remote student. This raises questions around how remote students might be able to deal with such situations. Do social protocols suffice, or should there be 'override' mechanisms designed into the technology that allow remote students to gain back some control over their classroom experience? For example, they may be given the chance to talk directly to those around them rather than through the proxy. Would such control mechanisms then, in turn, unnecessarily infringe on the needs of the proxy?

Fourth, there are questions around scalability. Our study focused on a single proxy, but one could imagine the potential for multiple proxies to be in a single classroom. Multiple proxies could come with the benefit of supporting multiple remote students or they could offer multiple different viewpoints for a single student, if the remote student is able to 'move' between proxies. This also raises further issues about identity and embodiment.

It is highly likely that the use of human proxies in classroom settings is not a complete replacement for attending class. One would not likely want an entire class to consist of proxies, for example, or for students to participate in an entire course through a proxy. Given our experience in trying it out in classroom settings, we feel that it is a system best utilized by a small handful of students, rather than large groups, and in one-off situations such as when someone is sick. However, given the ability for students to easily utilize a proxy (only a smartphone is really needed), one could imagine increased usage of proxies. There is even the potential for surreptitious use of human proxies where instructors do not know proxies are present or that students are 'streaming into class.' This contrasts telepresence robots, which are quite noticeable as compared to human proxy setups. In the latter case, a wearable camera could be easily hidden and not even noticed by instructors. This raises implications around the design of wearable cameras and the feedback mechanisms that might let the class and instructor know they are being streamed. This should be explored in future research.

Limitations

Our explorations of human proxies looked at specific types of classroom setups and did not explore large lecture or theatre-style classes. Further research is needed to understand how our results might generalize or not to these settings. It may be the case that because they do not typically have hands-on design activities, the advantages of a human proxy might diminish. It would also likely be more difficult for a remote student to talk to a proxy via an audio channel because they would feel the need to be quiet during the lecture. We also only explored one type of proxy setup. Future research should explore the use of different embodiment types, including possibly larger device displays. Proxy selection in our classroom study was likely limited in that students were more focused on picking a proxy out of convenience rather than someone who was ideal. Our survey showed that people had an ideal proxy that they would like but in practice they may be less selective. People's usage and selection of proxies may easily change over time as they grow accustomed to the experience and technology. Usage may also change once a period of novelty wears off. Thus, our results should be validated as a part of longer-term research. Lastly, we chose a technology design approach to understand human proxies in classrooms as opposed to an educational approach that might deeply assess the learning potentials or pitfalls of human proxies. This should also be focused on in follow-up research.

CONCLUSION

The use of human proxies to perform tasks for people who are remote is now a possibility given recent advancements in inexpensive mobile video streaming technologies. However, this area of technology usage is relatively unexplored. We chose to study how such technologies might be used for remote classroom attendance, with an emphasis on identity, interactions, embodiment, and privacy. Our results showed that people wanted a specific type of person when it came to proxy use in classroom settings, but this did not focus heavily on attributes such as race or gender. Instead, many idealized traits centered on the proxy's ability to participate in classroom activities such as scholastic abilities, the ability to be outgoing, aptitude, and the language spoken in the classroom. Students also faced challenges with interaction, embodiments, and camera work, which suggest design opportunities for these spaces. Overall, these results show promise for the use of human proxies for remote classroom attendance yet they also have sensitized us and hopefully other researchers and designers to the social and technical challenges that would need to be addressed as a part of future design work.

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REFERENCES

1. Victoria Bellotti and Abigail Sellen.1993. Design for Privacy in Ubiquitous Computing Environments, Proceedings of the Third European Conference on

Computer-Supported Cooperative Work (ECSCW'93), Kluwer Academic Publishers, Milan, pp. 77-92.

2. Jeremy Birnholtz, Clarissa Mak, Saul Greenberg, and Ron Baecker. 2008. Attention by proxy? issues in audience awareness for webcasts to distributed groups. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08). ACM, New York, NY, USA, 103-106. DOI=10.1145/1357054.1357071
3. Sara A. Bly, Steve R. Harrison, and Susan Irwin. 1993. Media spaces: bringing people together in a video, audio, and computing environment. Commun. ACM 36, 1 (January 1993), 28-46. DOI=10.1145/151233.151235
4. Michael Boyle, Carman Neustaedter, and Saul Greenberg. 2009. Privacy Factors in Video-based Media Spaces, Media Space: 20+ Years of Mediated Life, Springer.
5. Milton Chen. 2001. Design of a virtual auditorium. In Proceedings of the ninth ACM international conference on Multimedia (MULTIMEDIA '01). ACM, New York, NY, USA, 19-28. DOI=10.1145/500141.500147
6. Milton Chen. 2002. Achieving effective floor control with a low-bandwidth gesture-sensitive videoconferencing system. In Proceedings of the tenth ACM international conference on Multimedia (MULTIMEDIA '02). ACM, New York, NY, USA, 476-483. DOI=10.1145/641007.641109
7. Milton Chen. 2003. Visualizing the pulse of a classroom. In Proceedings of the eleventh ACM international conference on Multimedia (MULTIMEDIA '03). ACM, New York, NY, USA, 555-561. DOI=10.1145/957013.957130
8. Paul Dourish and Sara Bly. 1992. Portholes: supporting awareness in a distributed work group. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '92), Penny Bauersfeld, John Bennett, and Gene Lynch (Eds.). ACM, New York, NY, USA, 541-547. DOI=10.1145/142750.142982
9. Nicolas Ducheneaut, Ming-Hui Wen, Nicholas Yee, and Greg Wadley. 2009. Body and mind: a study of avatar personalization in three virtual worlds. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '09). ACM, New York, NY, USA, 1151-1160. DOI=10.1145/1518701.1518877
10. Ulf-Daniel Ehlers. 2013. Open Learning Cultures: A Guide to Quality, Evaluation, and Assessment for Future Learning. New York: Springer.
11. Deborah Fels, Judith K. Waalen, Shumin Zhai, and Patrice Weiss. Telepresence under exceptional circumstances: Enriching the connection to school for sick children. In Proceedings of Interact, 2001, 617-624.
12. Robert S. Fish, Robert E. Kraut, and Barbara L. Chalfonte. 1990. The VideoWindow system in informal communication. In Proceedings of the 1990 ACM conference on Computer-supported cooperative work (CSCW '90). ACM, New York, NY, USA, 1-11. DOI=10.1145/99332.99335
13. Gina Garramone, Allen C. Harris, and Ronald Anderson. 1986. Uses of political computer bulletin boards. Journal of Broadcasting & Electronic Media, 30, 325–339.
14. Saul Greenberg and Michael Rounding. 2001. The notification collage: posting information to public and personal displays. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '01). ACM, New York, NY, USA, 514-521. DOI=10.1145/365024.365339
15. Steve Harrison. 2009. S. Media Space: 20+ Years of Mediated Life, Springer.
16. Starr Roxanne Hiltz. 1994. The Virtual Classroom: Learning Without Limits Via Computer Networks. Ablex Publishing Corp., Norwood, NJ, USA.
17. H, Hu. 2013. MOOC Migration. Diverse: Issues in Higher Education, 30, 4, 10-11.
18. Kori Inkpen, Brett Taylor, Sasa Junuzovic, John Tang, and Gina Venolia. 2013. Experiences2Go: sharing kids' activities outside the home with remote family members. In Proceedings of the 2013 conference on Computer supported cooperative work (CSCW '13). ACM, New York, NY, USA, 1329-1340. DOI=10.1145/2441776.2441926
19. Gavin Jancke, Gina Danielle Venolia, Jonathan Grudin, J. J. Cadiz, and Anoop Gupta. 2001. Linking public spaces: technical and social issues. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '01). ACM, New York, NY, USA, 530-537. DOI=10.1145/365024.365352
20. Gavin Jancke, Jonathan Grudin, and Anoop Gupta. 2000. Presenting to local and remote audiences: design and use of the TELEP system. In Proceedings of the SIGCHI conference on Human Factors in Computing Systems (CHI '00). ACM, New York, NY, USA, 384-391. DOI=10.1145/332040.332461
21. Brennan Jones, Anna Witcraft, Scott Bateman, Carman Neustaedter, and Anthony Tang. 2015. Mechanics of Camera Work in Mobile Video Collaboration. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15). ACM, New York, NY, USA, 957-966. DOI=10.1145/2702123.2702345
22. Norman P. Jouppi. 2002. First steps towards mutually-immersive mobile telepresence. In Proceedings of the

2002 ACM conference on Computer supported cooperative work (CSCW '02). ACM, New York, NY, USA, 354-363. DOI=10.1145/587078.587128

23. Norman P. Jouppi, Subu Iyer, Stan Thomas, and April Slayden. 2004. BiReality: mutually-immersive telepresence. In Proceedings of the 12th annual ACM international conference on Multimedia (MULTIMEDIA '04). ACM, New York, NY, USA, 860-867. DOI=10.1145/1027527.1027725
24. Gregory Kearsley. 1995. The nature and value of interaction in distance learning, ACSDE Research Monograph No. 12, University Park, PA: Pennsylvania State University, American Center for the Study of Distance Education, 83092.
25. Atsunobu Kimura, Masayuki Ihara, Minoru Kobayashi, Yoshitsugu Manabe, and Kunihiro Chihara. 2007. Visual feedback: its effect on teleconferencing. In Proceedings of the 12th international conference on Human-computer interaction: applications and services (HCI'07), Julie A. Jacko (Ed.). Springer-Verlag, Berlin, Heidelberg, 591-600.
26. Eunyee Koh. 2010. Conferencing room for telepresence with remote participants. In Proceedings of the 16th ACM international conference on Supporting group work (GROUP '10). ACM, New York, NY, USA, 309-310. DOI=10.1145/1880071.1880124
27. Sven Kratz, Don Kimber, Weiqing Su, Gwen Gordon, and Don Severns. 2014. Polly: "being there" through the parrot and a guide. In Proceedings of the 16th international conference on Human-computer interaction with mobile devices & services (MobileHCI '14). ACM, New York, NY, USA, 625-630. DOI=10.1145/2628363.2628430
28. Karel Kreijns, Paul Kirschner, Wim Jochems, and Hans van Buuren. 2011. Measuring perceived social presence in distributed learning groups. Education and Information Technologies, 16, 4, 365-381.
29. Anicca Kristoffersson, Silvia Coradeschi, Amy Loutfi, and Kerstin Severinson-Eklundh. 2011. An Exploratory Study of Health Professionals' Attitudes about Robotic Telepresence Technology. *Journal of Technology in Human Services*, 29, 263-283.
30. Min Kyung Lee and Leila Takayama. 2011. "Now, i have a body": uses and social norms for mobile remote presence in the workplace. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11). ACM, New York, NY, USA, 33-42. DOI=10.1145/1978942.1978950
31. Jason Leigh, Maggie Rawlings, Javier Girado, Greg Dawe, Ray Fang, Alan Verlo, Muhammad-Ali Khan, Alan Cruz, Dana Plepys, Daniel Sandin, and Thomas Defanti. 2000. AccessBot: an Enabling Technology for Telepresence. Proceedings of the 10th Internet Society Conference, INET.
32. Michael Massimi and Carman Neustaedter. 2014. Moving from talking heads to newlyweds: exploring video chat use during major life events. In Proceedings of the 2014 conference on Designing interactive systems (DIS '14). ACM, New York, NY, USA, 43-52. DOI=10.1145/2598510.2598570
33. Kana Misawa and Jun Rekimoto. 2015. ChameleonMask: Embodied Physical and Social Telepresence using Human Surrogates. In Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '15). ACM, New York, NY, USA, 401-411. DOI=10.1145/2702613.2732506
34. Tomoyuki Morita, Kenji Mase, Yasushi Hirano, and Shoji Kajita. 2007. Reciprocal attentive communication in remote meeting with a humanoid robot. In Proceedings of the 9th international conference on Multimodal interfaces (ICMI '07). ACM, New York, NY, USA, 228-235. DOI=10.1145/1322192.1322232
35. Shohei Nagai, Shunichi Kasahara, and Jun Rekimoto. 2015. LiveSphere: Sharing the Surrounding Visual Environment for Immersive Experience in Remote Collaboration. In Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '15). ACM, New York, NY, USA, 113-116. DOI=10.1145/2677199.2680549
36. Carman Neustaedter and Elena Fedorovskaya. 2009. Presenting identity in a virtual world through avatar appearances. In *Proceedings of Graphics Interface 2009* (GI '09). Canadian Information Processing Society, Toronto, Ont., Canada, Canada, 183-190.
37. Carman Neustaedter and Saul Greenberg. 2003. The Design of a Context-Aware Home Media Space for Balancing Privacy and Awareness, In Proceedings of the Fifth International Conference on Ubiquitous Computing (UbiComp 2003), Springer.
38. Carman Neustaedter, Carolyn Pang, Azadeh Forghani, Erick Oduor, Serena Hillman, Tejinder K. Judge, Michael Massimi, and Saul Greenberg. 2015. Sharing Domestic Life through Long-Term Video Connections. ACM Trans. Comput.-Hum. Interact. 22, 1, Article 3 (February 2015), 29 pages. DOI=10.1145/2696869
39. Scott L. Newstok. 2013. A Plea for "Close Learning." *Liberal Education*. 99, 4, 16-19.
40. Andreas Paepcke, Bianca Soto, Leila Takayama, Frank Koenig, and Blaise Gassend. 2011. Yelling in the hall: using sidetone to address a problem with mobile remote presence systems. In Proceedings of the 24th annual ACM symposium on User interface software and technology (UIST '11). ACM, New York, NY, USA, 107-116. DOI=10.1145/2047196.2047209

41. Jason Procyk, Carman Neustaedter, Carolyn Pang, Anthony Tang, and Tejinder K. Judge. 2014. Shared geocaching over distance with mobile video streaming. In Proceedings of the companion publication of the 17th ACM conference on Computer supported cooperative work & social computing (CSCW Companion '14). ACM, New York, NY, USA, 293-296. DOI=10.1145/2556420.2557635

42. Jason Procyk, Carman Neustaedter, Carolyn Pang, Anthony Tang, and Tejinder K. Judge. 2014. Exploring video streaming in public settings: shared geocaching over distance using mobile video chat. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14). ACM, New York, NY, USA, 2163-2172. DOI=10.1145/2556288.2557198

43. Irene Rae, Gina Venolia, John C. Tang, and David Molnar. 2015. A Framework for Understanding and Designing Telepresence. In Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15). ACM, New York, NY, USA, 1552-1566. DOI=10.1145/2675133.2675141

44. Irene Rae, Leila Takayama, and Bilge Mutlu. 2013. The influence of height in robot-mediated communication. In Proceedings of the 8th ACM/IEEE international conference on Human-robot interaction (HRI '13). IEEE Press, Piscataway, NJ, USA, 1-8.

45. Yuanchun Shi, Weikai Xie, Guangyou Xu, Runting Shi, Enyi Chen, Yanhua Mao, and Fang Liu. 2003. The Smart Classroom: Merging Technologies for Seamless Tele-Education. Pervasive Computing IEEE, 2, 2, 47-55.

46. J. Sucher, S. Todd, S. Jones, T. Throckmorton, K. Turner, and F. Moore. 2011. Robotic telepresence: a helpful adjunct that is viewed favorably by critically ill surgical patients. *The American Journal of Surgery*, 202, 6, 843–847.

47. Leila Takayama and Helen Harris. 2013. Presentation of (telepresent) self: on the double-edged effects of mirrors. In *Proceedings of the 8th ACM/IEEE international conference on Human-robot interaction* (HRI '13). IEEE Press, Piscataway, NJ, USA, 381-388.

48. Chih-Hsiung Tu. 2000. On-line learning migration: from social learning theory to social presence theory in a CMC environment. Journal of Network and Computer Applications, 23(1), 27–37.

49. Gina Venolia, John Tang, Ruy Cervantes, Sara Bly, George Robertson, Bongshin Lee, and Kori Inkpen. 2010. Embodied social proxy: mediating interpersonal connection in hub-and-satellite teams. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10). ACM, New York, NY, USA, 1049-1058. DOI=10.1145/1753326.1753482

50. Steve Whittaker, David Frohlich, and Owen Daly-Jones. 1994. Informal workplace communication: what is it like and how might we support it?. In Conference Companion on Human Factors in Computing Systems (CHI '94), Catherine Plaisant (Ed.). ACM, New York, NY, USA, 208-. DOI=10.1145/259963.260328

51. Nicole Yankelovich, Nigel Simpson, Jonathan Kaplan, and Joe Provino. 2007. Porta-person: telepresence for the connected conference room. In CHI '07 Extended Abstracts on Human Factors in Computing Systems (CHI EA '07). ACM, New York, NY, USA, 2789-2794. DOI=10.1145/1240866.1241080