VOLUME 23 ISSUE 4

The International Journal of

Technologies in Learning

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ABSTRACTING AND INDEXING
For a full list of databases in which this journal is indexed, please visit http://thelearner.com/journals/collection.

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THE INTERNATIONAL JOURNAL OF TECHNOLOGIES IN LEARNING
www.thelearner.com
ISSN: 2327-0144 (Print)
ISSN: 2327-2686 (Online)
doi:10.18848/2327-0144/CGP (Journal)

First published by Common Ground Publishing in 2016
University of Illinois Research Park
2001 South First Street, Suite 202
Champaign, IL 61820 USA
Ph: +1-217-328-0405
www.commongroundpublishing.com

The International Journal of Technologies in Learning is a peer-reviewed, scholarly journal.

Common Ground Publishing is a member of Crossref.

Virtual Inclusion via Telepresence Robots in the Classroom: An Exploratory Case Study

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Abstract: Every year, large numbers of students are not able to attend school due to illness. Extended absence from the classroom has negative and overlapping educational and social consequences as students may fall behind in instruction, feel isolated from their peers, and experience loneliness and depression. School districts sometimes provide individual tutors who make occasional home visits but such tutoring cannot substitute for regular participation in the classroom environment. Telepresence robots may provide a way for students to remain connected to their schools, classmates, teachers, and maintain or develop critical social relationships via virtual inclusion. A total of sixty-one participants were included in this study. Semi-structured interviews were conducted with five homebound children, five parents, ten teachers, thirty-five classmates, and six school/district administrators. While the robots were deployed, one home observation, two classroom observations and two focus group sessions were conducted. This study is a small-scale exploratory case study that examined the use of robots to attend school and how schools integrated homebound students via robots into traditional classrooms. Three themes emerged from the coding and analysis of the data: 1) anthropomorphism for social acceptance and normalcy, 2) overcoming isolation to meet socio-emotional needs, and 3) new experiences that generated talk of an academic future.

Keywords: Telepresence, Education, Inclusion, Human-Computer Interaction, Human-Robot Interaction

Introduction

Advancements in the medical field are improving the prognosis for many childhood illnesses, and cutting edge technological advancements in pediatric medicine have allowed for reclassification of diseases once considered fatal or terminal (e.g., cancer, heart disease, kidney disease) to be categorized as chronic illnesses (Sexson and Madan-Swain 1993). Chronic illness, as operationalized by Perrin and colleagues (1993), is a disease lasting, or expecting to last, at least three months and demonstrating some impact on the child, such as functional impairment or a greater than expected need for medical attention given a child's age. For this study, a functional impairment experienced by all participants with chronic illness was physical segregation that caused severe academic disruption (i.e., a significant break in academic attendance) and social isolation from peers. In this article, the term "homebound" is used for children who are not able to attend school due to symptoms, treatments, or recovery from illness.

Even though attending school with peers and close friends constitutes the bulk of their daily lives, when some children are diagnosed with a chronic illness (e.g., cancer, heart failure), they are suddenly removed from a social context that constitutes four to six hours of their daily lives. Traditional services afforded by our educational systems to children with chronic illness have not changed much, if at all, over the past eighty years (Holmes, Klerman, and Gabrielson 1970) with the first documented use of homebound educational services in the US occurring in the 1930s as a service for pregnant students in New Haven, Connecticut ("Instructions for the Home Teacher," n.d.). Packets of papers and make-up work are sent home with siblings or family members and, depending on the school system, homebound services may be offered that typically consist of four to five hours of at-home instruction per week.

The International Journal of Technologies in Learning
Volume 23, Issue 4, 2016, www.thelearner.com

ISSN: 2327-0144 (Print), ISSN: 2327-2686 (Online)

Technology

Innovative approaches to this problem have been limited by the availability of alternative methods for including these children in traditional schools. Until recently, the technology has not been readily available to offer alternative methods for dealing with academic disruption due to medical conditions—there simply has not been a way to expose these students to social interactions with teachers and peers without great risk to the students' health. While valuable work has been conducted on the challenges of geographical distance on teamwork (Olson, Olson, and Venolia 2009) and the contributions of video conferencing systems (Venolia et al. 2010), mobile robotic telepresence systems have added mobility to the equation. For children with chronic illness, studies have also examined the use of texting, email, and social networking sites as technologies to remain connected with their peers (Liu, Inkpen, and Pratt 2015) and for children with severe learning disabilities the use of telepresence robots has been studied as a way to create a bridge between mainstream and special education classrooms (Sheehy and Green 2011). However, to our knowledge, there have not been any formal studies on the use of telepresence robots by children with chronic illness for virtual inclusion in real-world mainstream classrooms.

Virtual Inclusion

In this article, the term "virtual inclusion" is used to characterize an educational practice that allows a student to attend school through a mobile robotic telepresence system in such a way that the student is able to interact with classmates, teachers, and other school personnel as if the student were physically present. Virtual inclusion is possible through the concept of telepresence, as operationalized by Kim and Biocca (1997) and others (Gerrig 1993; Minsky 1980), which refers to the user's compelling sense of being in a mediated space and not where the physical body is located. Allowing the student to pilot or navigate a physical presence in an educational environment is a significant component of virtual inclusion for the homebound student and the classmates. For classmates, earlier studies with a teleoperated robot have shown that children treated it as a living thing and displayed more engagement than adults with the robot (Scheeff et al. 2002). For the homebound student (i.e., operator), Nakanishi and colleagues (2009) found that a physical presence, when combined with movement, enhances the perception of a social link for the operator. This increased level of engagement with the robot and social link for the homebound student provides the critical support necessary for virtual inclusion.

Telepresence

Figure 1: VGo telepresence robot

To understand virtual inclusion via robot, it is important to understand how telepresence robots operate (Figure 1). Telepresence robots aim to provide social interaction between humans (Kristoffersson, Coradeschi, and Loutfi 2013). Telepresence robots are not traditional videoconferencing or telepresence solutions where two or more people meet using specially equipped rooms or computers. In a school setting, a telepresence robot allows for virtual inclusion by enabling the student to be in virtual attendance (i.e., included) in a distant location (i.e., the classroom/school) and have the freedom to move around as if s/he were physically there. The robotic unit has a screen to project the student's face, is mobile, and is remote controlled by the student—the student controls the robot from home, the hospital, or while traveling as long as there is wifi connectivity (Figure 2). After the robot is placed in the classroom and the homebound student logs onto the system, the student can see, hear, talk, interact, "raise a hand" (via flashing lights), and have access to any location in the classroom and school similar to that of a student in a wheelchair. The unit is recharged every night and provides a two-way, secure, real-time connection for the student that typically lasts most of the school day.

Figure 2: Child at home controlling robot at school

Methodology

To investigate real-world experiences with virtual inclusion, the research team sought a school setting where these robots were distributed by school/district based on student need and not family or community support. The robots require financial resources and students whose parents are able to afford robots or whose communities come together to help purchase a robot for a child may also receive above average social and academic supports that contribute to the success of the robot for academic and social benefits. The research team wanted to explore a level playing field where students received the robots regardless of income level, family background, or social supports. A public school system that had five robots distributed to students with various chronic illnesses was used for this study.

This study sought to explore and understand the phenomena of children with chronic illness using robots to attend school in real-world traditional classrooms. As such, this study was qualitative and exploratory. As a qualitative study, findings resulted from the study of these real-world settings where the "phenomenon of interest unfold naturally" (Patton 2002). As an exploratory case study, the study examined the academic and social contexts of virtual inclusion as well as gained insight into the practice of virtual inclusion via telepresence robots in the classroom and its implications for future research. The study sought to explore the following research questions:

1. How is the robot used in classrooms by homebound students, their teachers, and classmates?
2. What appear to be the effects of robot use on the homebound students, classmates, teachers, and families?
3. Is classroom inclusion via telepresence robot financially and functionally feasible?

Participants

A small-scale exploratory case study was conducted with over twenty hours of interviews, six hours of observations, and two focus groups. A total of sixty-one participants shared their experiences during this study: five homebound children, five parents, ten teachers, thirty-five classmates, and six school and district administrators (Table 1). The children with chronic illness in this study had a range of chronic illnesses including an immunodeficiency disorder (1), cancer (3), and heart failure (1) and were currently using, or had previously used, robots for virtual inclusion. The age range of the children was six to sixteen years old with four male students and one female student. In order to conduct a holistic, in-depth study, data was collected from the children with chronic illness, and their parents/guardians, classmates, teachers, and school administrators.

Table 1: Participants (N = 61)

Homebound Student Name	Relationship	Sex	Grade When Interviewed	Condition	Interview Location
Samuel		M	5th	Heart	Restaurant (en route to hospital)
	Mother	F	—	—	
	Classmates	—	5th	—	Classroom
	Teacher A	F	—	—	Classroom
	Teacher B	F	—	—	
	Teacher C	F	—	—	
	Principal	F	—	—	School Office
	District Administrator	F	—	—	District Office
Daniel		M	6th	Cancer	Hospital
	Mother	F	—	—	
	Teacher A	F	—	—	School Office
	Teacher B	F	—	—	
	Administrator	M	—	—	
	Principal	M	—	—	School Office
Eileen		F	9th	Cancer	Home
	Mother	F	—	—	
	Teacher	F	—	—	Classroom
David		M	3rd	Immunodeficiency Disorder	Home
	Mother	F	—	—	
	Teacher A	F	—	—	
	Teacher B	F	—	—	
	Teacher C	F	—	—	
Nathan		M	2nd	Cancer	Home
	Mother	F	—	—	
	Classmates	—	2nd		Classroom
	Teacher	F	—	—	Classroom
	Principal	F	—	—	School Office
	Regional Administrator	M	—	—	Automobile

Recruitment

Participants were recruited at a district-level technology center through the Technology Programs Manager who made the initial contact with the parents of homebound children who were using or had used one of the district's telepresence robots for virtual inclusion. If the parents expressed an interest in participating in the study, their contact information was provided to the research team via email. After parents and students agreed to participate in the study, the Technology Programs Manager proceeded to contact teachers and administrators of participating families and the contact information of willing teachers and administrators was also shared with the research team via email.

Interviews

All interviews were semi-structured and lasted twenty to sixty minutes. Interview topics included motivation for using the robot, technical aspects of robot use, academic experiences while using the robot, social experiences while using the robot, child's well-being, and general experiences with educational homebound services when applicable. Interviews took place in multiple sites with child/parent interviews taking place in homes, a restaurant (a child was traveling to the hospital), and hospitals. Interviews with teachers and administrators took place on school or district campuses except for one administrator interview, which took place in a vehicle while he was driving, as per his request.

Observations and Focus Groups

Observations took place in one home where the child was controlling the robot and in two classrooms where the robot was deployed and active in the classroom. These observations lasted forty-five to ninety minutes with one of these observations taking place in Nathan's classroom and the other, on a different day and location, in Samuel's classroom. Samuel was in school (via robot) for the classroom observation but was traveling to the hospital on the day his home observation was scheduled. Observation notes were recorded and analyzed on the same day they took place. Immediately after classroom observations, focus groups were conducted with the classmates. Focus groups lasted seven to twenty-five minutes and discussions were limited to four questions on the classmates' attitudes and perceptions of attending school with a robot. Open responses were allowed for each question with an average of two to three minutes allowed per response to each question. Home and classroom observations were not possible for three cases due to the following reasons: Eileen had returned her robot at the time of the interview, Daniel was receiving treatment at the time of interview, and David did not attend school on the day of the interview.

Analysis

To increase trustworthiness in the data and confirm validity of the processes, Yin's (1994) recommendation to use multiple sources of data was followed. Triangulation, protocols that are used to ensure accuracy and alternative explanations (Stake 1995), of the data was accomplished by asking similar interview questions of different study participants (children, parents, professionals), by collecting data from different sources (children with chronic illness, parents, teachers, classmates, and school administrators), and by using different methods (interviews, observations, focus groups, field notes). It was expected that the concepts and themes related to the virtual inclusion experiences of the participants would emerge from the multiple sources of data through inductive content analysis, open coding, and the constant comparative method recommended by Glaser and Strauss (1967). Interviews, observation field notes, and classmate focus groups were recorded, transcribed, and coded to identify patterns, similarities, and dissimilarities across the five cases.

Miles and Huberman (1994) state that coding is analysis, while others (Basit 2003) attest that coding and analysis are not synonymous. For this study, coding was viewed as a crucial aspect of analysis, and data were coded both during and after collection as an analytic tactic. Codes were developed as the data were coded and, as recommended by Hatch (2002), patterns were viewed not just as stable regularities but also as varying forms. Patterns and themes were characterized by similarity, frequency, and correspondence. The data also underwent several cycles of coding to generate relevant categories, concepts, and themes.

Initial coding was performed on transcripts and different parts of the data (i.e., text) following Glaser and Strauss' (1967) description of open coding where tentative labels are applied to sections of data and these labels are later classified under common concepts or categories as the data undergoes multiple rounds of coding. A list of the code words for each transcript was compiled and compared across the individual cases. This allowed for checks to ensure that a code was used consistently throughout the transcripts. During these steps, notes were taken and recorded of emerging codes, the ideas they represented, and relationships between codes. The themes and concepts that emerged from the analysis were repeatedly compared with the transcripts to ensure their validity. The constant revision of the material allowed for some codes to be subsumed under broader and more abstract categories.

Findings

This process resulted in highlighting three themes critical to understanding the social and academic reality of virtual inclusion for these participants—anthropomorphism for social acceptance and normalcy, overcoming isolation to meet socio-emotional needs, and new experiences that generated talk of an academic future. This process also supported self-determination theory (i.e., a child's fundamental need for competence, relatedness, and autonomy) (Deci and Ryan 1985) as a potential framework for future studies.

Anthropomorphism for Social Acceptance and Normalcy

Anthropomorphism refers to attributing human-like characteristics to non-human agents (Guthrie 1997), and several studies support the idea that human interaction with computers is fundamentally social in nature (Nass, Steuer, and Tauber 1994; Takeuchi and Katagiri 1999). Previous research has shown that users tend to treat computers and robots as if they were humans without even being aware of it (Luczak, Roetting, and Schmidt 2003) and that users also apply human social categories to computers as well as to robots and they do so relatively automatically (Reeves and Nass 1996; Nass and Moon 2000). Throughout this study, students and teachers began to view the robot as the student after the initial introductory period and frequent references were made to the robot "attending school," "playing in the gym," "falling down," "singing in the choir," etc.

Social Acceptance and Normalcy

Anthropomorphism of the robot was a key contributor to establishing a sense of normalcy for all homebound students interviewed. It allowed for the homebound student to interact with classmates, maintain or establish social connections to their school community, and receive care and support from their friends. The anthropomorphization of the robot and the subsequent acceptance of the robot as a regular member of the classroom seemed to vary between schools. Most schools reported an excited introduction phase followed by a settling of attention and eventual normalcy of the robotic presence.

For Samuel, all three of his teachers felt that the ascription of human qualities to the robot seemed to happen easily for his fifth grade classmates. His teachers reported that the robot was accepted as Samuel almost immediately and that,

> Teacher 1: They call it "Samuel."
> Teacher 2: It's "Samuel."
> Interviewer: So they don't differentiate between the robot and "Samuel"?
> Teacher 2: Yeah … It is one person. They don't think anything different.

Surprisingly, the removal of human qualities seemed to happen just as effortlessly by Samuel's classmates. After attending school for several weeks as a robot, Samuel was cleared by his physician to attend school for picture day as long as he wore a facemask while not being photographed. He was able to finally meet his new friends in person and his teacher reported that Samuel and his friends got along just like they did when Samuel was in class via the robot. His classmates so easily accepted Samuel in person that when it came time to take the class picture, they did not want the robot in the picture.

> Teacher 2: Yeah, the other day, we had class pictures and so Samuel's mom brought him here and in the class picture was Samuel and the robot and the kids were like, "Why are they both in there?" (chuckle)
> Teacher 3: So, you know, it was ... "Why does he take two spots?"
> Teacher 1: Yeah (chuckle). "That's one person … why is he having them both?" And so, they were confused by the fact that they both were going to be in the picture.

The robot lost its value and identity when Samuel was physically present—there was no need to ascribe human qualities to the robot because the actual human it represented was physically present in the room. However, after Samuel went home, he came back to school via the robot that same day and his homeroom teacher recalls that the transition was seamless and class activities resumed as normal.

The ascription of human qualities to the robots was consistent across all five cases with each teacher interviewed making at least one mention of students treating the robot as a "regular" student. Nathan's teacher reported that "You may not have noticed, but when we're walking down the hall coming back from book fair, they just ran over and just (laughter) like the robot's a normal, (laughter) a kid." It was also common across all five cases that students referred to the robots by the name of the homebound student. Daniel's teacher commented that, "It was always Daniel. It was never the robot. It was always Daniel. They would say in the mornings, 'Is Daniel going to be in class today?" She continued, "The very first day we had the robot in the classroom, it was like Daniel was back … And so we immediately identified, you know, with just him and it was a more of a—I would say an emotional tie to him rather than like an academic tie."

This emotional tie and connectedness that teachers and classmates felt towards the student via the robotic presence was consistent in all five cases; however, Eileen also had the experience of attending a class where she did not feel her classmates treated the robot as a "normal" student. Eileen was the only female student in the study as well as the only high school student. Studies have shown that user gender affects people's reactions toward artificial intelligence robots (Crowell et al. 2009), but there has not been enough research on gender and social acceptance of telepresence robots to evaluate whether being female contributed significantly to Eileen's experience.

For most of the students, the robot either remained in the same classroom or traveled with the same group of students between classes. This increased exposure and interaction with the robot may have contributed to acceptance of the robot for the other students. Eileen reported that she used her robot to attend various classes composed of different students throughout the day.

Her experience with normalcy as a student varied from that of the other students in the study, but it is not clear whether this variance was due to her gender or due to the level of anthropomorphism and normalcy allocated to the robot by classmates since most of her classmates were exposed to the robot for only one class period during the day.

This difference in normalcy surfaced when Eileen was asked about her favorite class. She named world geography and when asked to explain why that was her favorite class, her response focused on how other students treated her.

> Eileen: Well, it's just the people in that class didn't treat me like I was a robot … so I liked it … and like in my first period, every single person would stare at me and like crack up laughing if I ran into something … and then like they never got used to it.
> Mother: And in that world geography class, they would pick on—you know—they would pick on her, but be like, "Come on Eileen! What are you doing?" You know, like treated her like a normal person…

The social connection Eileen felt in her world geography class and that other homebound students felt in their classrooms seemed to allow them to enjoy their classes and motivate them to attend school via robot. They were able to experience a social connection even though they were embodied in a mobile robot. The importance of this social connection is supported by self-determination theory and relevant research has shown that students have three categories of needs: to feel competent, to feel socially attached, and to have autonomous control in their lives (Deci and Ryan 1985; Connell and Wellborn 1991).

While the use of telepresence robots may help students academically by allowing them to participate in classroom lectures and activities, the academic benefits of this form of inclusion may be influenced by the social acceptance of the robot as a classmate. Research by Tsui and colleagues (2011) stresses the importance of informal interactions with telepresence robots in order to improve the effectiveness of robot use during formal interactions. For younger students who attend school for most of the day with the robot and have increased opportunities for informal interactions, acceptance and anthropomorphization of the robot may happen more readily than for students who only see the robot for one class period of the day. In this study, social attachment to classmates and a sense of normalcy seemed to be related to the level of anthropomorphism allocated to the robot by classmates.

Negative Behaviors

Anthropomorphization and social acceptance of the robot allowed for most of the students in this study to experience a sense of normalcy and a return to traditional school experiences. However, traditional school experiences are not always positive, and there were a few examples of negative actions from peers towards the student via the robot.

Negative actions differ from acts of bullying in that, according to Olweus (1991), "A person is being bullied when he or she is exposed, repeatedly and over time, to negative actions on the part of one or more other persons" and "negative action is when someone intentionally inflicts, or attempts to inflict, injury or discomfort upon another." Olweus (1991) also stresses that in order to use the term "bullying" there should be an imbalance in strength (an asymmetric power relationship). Bullying of the robot was reported for one student through two separate physical incidents and negative action was reported for one other student through one verbal incident. The reported bullying and negative actions had differential effects, possibly due to gender or age.

One student who experienced a negative action, Eileen, eventually returned her robot to the service center and resumed homebound services for all her classes. She stated that she "didn't like all the attention" that the robot received and reported that a male student asked about her, "Like, what is that, a vacuum cleaner?" She did not think the student was being intentionally negative but she did not like the attention she received as a robot. She eventually made the decision to return her robot to the service center. Being called a vacuum cleaner ultimately motivated her to return the robot with the hope of returning to school the following semester as self-described, "Eileen the human."

Samuel also experienced negative verbal behavior but his experience was different in that it also included negative physical behavior on more than one occasion. However, he did not return his robot and was actively using the robot at the time of the interview. The first incidence of bullying occurred when he "ate" lunch with his friends (i.e., he "sat" the robot at a lunch table with his friends and ate his lunch at home while his friends ate their lunch at school). One of his teachers described the bullying incident and reported that Samuel was eating lunch with his friends when another student walked up and smeared ketchup on Samuel's face/screen. According to the teacher, Samuel was also taunted with "Why don't you go tell your mama?? Go tell your mama right now…" while his screen was being smeared with ketchup. Samuel did not need to tell his mama because she was home and witnessed the entire incident via Samuel's laptop but he also did not tell his teacher about the bullying. Samuel's teacher remembers that, "he came back from lunch with his lights on and I said, 'Yes?' and he said, 'I need you to wipe off my lens.' And so, you know, I took a tissue and cleaned off his lens and I said, 'Ok, is that better?' And he said, 'Yes.'"

The teacher was unaware of the bullying until Samuel's mother called the school and reported it. When the teacher was asked how she felt about the bullying incident, she matter-of-factly replied, "Yeah, I was like well he's getting the full deal right here. The whole shebang … the good and the bad." This incidence of bullying did not discourage Samuel from attending school via the robot but instead his friends became his "bodyguards" to protect him during lunch. When the teacher was asked for her views on these social interactions, both good and bad, she reflected on something his mother had told her, "His mom told me one time what a blessing it [the robot] was because he was literally … very depressed for the past two years." She continued with her thoughts on Samuel's depression and experiences of being isolated for two academic years versus attending school via robot, "I think that the benefit … whether it works great or not, just the benefit of him getting to be around other kids when he wouldn't normally get to be around kids is priceless."

Neither Samuel nor his mother reported the first bullying incident during their interviews, but they did describe other negative behavior from a classmate, Mike. Mike would put his hand in front of Samuel's screen to prevent him from seeing. Even after Samuel's mother asked Mike (through the robot) to stop doing that, Mike denied doing it and continued this behavior until an adult at the school noticed what was happening and put a stop to it.

Samuel's attitude towards the bullying and lack of discouragement from it may stem from his mother's perceptions of these behaviors. During our interview, she commented, "I said, you know, it's just going to happen … when … going to lunch … there's not the teacher or the aide … there's not as much adult supervision. So that tends to be when things happen or when they take him back to the classroom or they're going to recess, you know, because (thoughtful pause) they're ten."

Even though bullying is traditionally viewed as a negative experience, Samuel's teacher and his mother seemed to accept the negative behavior as an unfortunate but normal part of the school experience and typical of being ten years old. When asked to describe the most positive aspect of using the robot, Samuel's mother expressed,

> Mother: Um, like I said, just a sense of normalcy. I mean, he just—he feels more like a ten-year-old kid. You know, he's back to complaining about having homework. He's back to—you know, the things that most ten-year-olds do … talking about his friends…
> Interviewer**:** Complaining about them?
> Mother**:** And darn Mike! (laughter) Um, and he's a nice boy. He's a ten-year old boy is what it is.

For Samuel, the negative experiences also allowed for subsequent positive experiences while embodied in the robot. His friends rallying around him and assigning themselves as his bodyguards followed having ketchup smeared on his screen. Having the annoyance of a classmate block his screen gave him something to discuss during our interview while he rolled his eyes, threw his hands up in mock frustration, and laughed with his mother at Mike denying that he was the one blocking the screen. As Samuel described his school experiences, it was clear that he felt a strong social connection to his school and to his friends.

Overcoming Isolation to Meet Socio-emotional Needs

Maintaining a social connection to peers has not traditionally been an aspect of home instruction services. Most of the students in this study felt isolated from their peers when they could no longer physically attend school and interact with their friends. This exclusion from school left some students with feelings of loneliness, depression, and isolation. The homebound students did not mention feeling depressed while receiving home instruction before the robot, but parents and teachers made references to the students experiencing "depression" and displaying a "lack of interest" when it came to completing school work through homebound instruction.

The educational experiences of the children in this study had a common thread—the use of the robot to remain socially connected. While some parents, teachers, and administrators focused on the academic benefits and better utilization of school resources via the robot, the children had a different focus (Table 2). When asked what they liked most about using the robot, all of the homebound children interviewed responded with a variation of "I get to see my friends." When asked what they liked least about using the robot, the responses varied greatly from "nothing really" to connectivity issues, to wishing the robot had arms.

Table 2: What Students Liked Most and Liked Least about Using a Robot

	Liked Most…	**Liked Least…**
Daniel	Seeing my friends	Not physically being there
Nathan	Everyone's nice to you	That I crashed a lot…it keeps coming on and off, on and off. So like we can't do the activity that we were doing…
Eileen	Just talking to my friends	The attention
Samuel	Getting to have a lot of fun with my friends	That it doesn't have arms. Because sometimes…I'll get locked in the room and I can't unlock the door or open it.
David	Mm, you can see your friends	Nothing really

The students' responses to what they liked most about using the robot had a consistent theme of remaining socially connected to their friends and reflected the enjoyment they experienced from being able to maintain that connection. Even though the responses to what they liked least about the robots were not consistent, most of the responses still reflected on their perceived level of social connection. Nathan's response expressed frustration when that connection was severed due to the technical aspects of the robot, Samuel wished he could still open doors to join his classmates, and Daniel wished he could physically attend school again. Eileen did not like the attention she received while embodied in the robot and while her response reflects a social connection she did not enjoy, it is worth noting that she followed this response with the incident of the boy asking if she was a "vacuum cleaner." What she liked least about using the robot is also what caused her to stop using the robot. Her virtual inclusion experience was shaped by the social interactions she received while embodied in the robot.

Homebound Instruction

Students with chronic illness have one consistent option to remain academically connected to their school—homebound instruction. The few students who were allowed the option of the robot had varied experiences with homebound instruction and virtual inclusion. These experiences ranged from a third grader who had never attended a traditional school before using a robot to a second grader who transitioned from a traditional student to virtual inclusion without ever using homebound services.

Samuel used homebound services for two academic years and was then able to use the robot the following school year. When I asked his mother to describe her child's experience with virtual inclusion, she stated that she was initially concerned that her son would not be able to attend a full day of school. His energy level and interest in school had dropped off dramatically and she believed he would be able to attend school for maybe thirty minutes to one hour a day. She attributed Samuel's energy level and lack of interest in schoolwork to his medical condition.

Once Samuel received the robot, his interest and energy increased and he attended a full day of school (six hours) the first day he used the robot. His mother commented, "And once he got the robot, I mean, I never in a million years expected him to be able to go to school all day … I just did not expect it. And he went the first day and went all day…" Until she witnessed Samuel's increased energy and instant engagement in school activities, his mother had not realized that her son might have been experiencing depression as a result of his isolation from school and peers.

> Mother: There were a lot of things that I didn't think he could, you know, with the progression of the heart condition, we kind of thought that he was just able—his ability to do things was lessening, I guess. There were a lot of things I didn't think he could do and I was attributing it physically. I didn't think he could do what he can now as far as stamina to attend all day. Which I think was maybe a little more of depression.

Samuel transitioned seamlessly from four hours of instruction per week to six to seven hours per day, five days a week. After receiving the robot, Samuel was not only motivated to do well in his regular classes but also auditioned for and made it into the school choir via robot. According to a school administrator, Samuel's music teacher was hesitant about allowing him to audition via robot. After the audition, the teacher reported back to the administrator that Samuel made it into the choir and that "He has the voice of an angel." She only heard Samuel sing via the robot.

Daniel also experienced homebound services and virtual inclusion. He experienced homebound services for one semester shortly after his family relocated to a new school district. Unfortunately, his family's relocation occurred shortly before he was diagnosed with cancer. Even though a robot was available for Daniel to use during his first semester of sixth grade, the new school district did not support use of the robot and, instead, provided traditional homebound services. He and his family were greatly dissatisfied with the homebound services and when Daniel was questioned about his experience with homebound services, he sighed and quietly replied, "I failed."

After a semester of homebound services and the negative experience of failing academically, Daniel's family decided to move back to his prior neighborhood where his former school district and teachers agreed to use the robot. After using the robot to attend school for the second semester of sixth grade, and with the full support and help of his teachers, Daniel was able to remain in grade and his mother expressed deep appreciation for the willingness of the school district and the teachers to try this new form of technology for her son. She felt that "If it weren't for the robot and the school, you know, welcoming it and helping him and everything, he would have failed sixth grade." His mother was very grateful that her son had achieved some academic success with the robot. However, when Daniel expressed what he liked most about using the robot, he did not mention academics. He responded, "Just being there, to be there during lessons and stuff and seeing your friends talking to you … and socialize."

Daniel enjoyed socializing with friends and seemed to feel increased motivation to keep up with his schoolwork when he was using the robot versus when he was utilizing homebound services but the use of the robot did not completely remove feelings of isolation. When his mother expressed appreciation for the ease of robot use and how Daniel was able to use it unsupervised, Daniel expressed continued feelings of loneliness.

> Mother: He stays home, and there's times I gotta work and he's home by himself and he does everything by himself. He logs on, he—you know, he goes to school … It's very easy to function…
> Daniel: I don't like staying alone.

The robot was Daniel's main form of human contact during the school day, but it was not enough to remove feelings of loneliness. When questioned further about the robot and asked if there were any negative aspects about using the robot, Daniel replied, "No, I don't think so. Other than not physically being there." Daniel did not enjoy being home alone and he missed not being able to physically attend school.

For all students who attended school before diagnosis and experienced homebound services, the experience of being socially isolated was described in negative terms. The return to the classroom and subsequent social interactions via robot was, at least initially, a positive experience. Even for Eileen, who decided to return her robot, she felt that using the robot to "hang out" with friends, "was the fun part." Social isolation can have negative consequences for students and studies have shown that children with chronic illness who are restricted in their social activities should receive extra attention because they are especially vulnerable for problems in their social development (Meijer et al. 2000). For the majority of the students in this study, the robots seemed to provide a valuable tool for returning to school and experiencing some normalcy as students. However, even this technology did not remove all feelings of isolation. All students who attended school before the robot, like Daniel, expressed a desire to be back in school and physically present with their friends.

New Experiences that Generated Talk of an Academic Future

New social experiences presented themselves to the homebound students and along with the new experiences came a new discourse about the future of the student. Teachers and administrators made frequent references to "when s/he comes back" as an important motivator for using the robot. All participants including homebound students, classmates, teachers, parents, and administrators made references to the need for the student to be academically prepared when s/he "comes back to school." Nathan's teacher commented, "When he comes back … he's gonna know exactly what we're talking about … I think it will be such a smooth transition for him…"

The virtual inclusion of students with chronic illness not only allowed for the homebound students to engage in new experiences and interactions with peers and teachers as part of their academic experience, but it also allowed their teachers and classmates to include the student in the discourse of the classroom and talk of the future. Talk of the homebound student attending class, participating in peer groups, and being prepared academically when s/he physically returned to school became part of the classroom discourse because the student was considered "present" in the classroom. The student's presence, even though it was via robot, allowed for the student to engage in new experiences that contributed to both discourse and active engagement in their academic future.

Discussion

The representations of the data that emerged from the analysis provided a set of themes for understanding the experiences of children with chronic illness using telepresence robots to attend school. It is important to emphasize that these results were grounded in the participants' experiences and opinions and may not be generalizable to other groups. They do, however, provide valuable insights into the educational experiences of children with chronic illness utilizing telepresence robots to attend school. Nathan and the other homebound students interviewed for this study are just a small representative sample of a growing population in our educational systems that experience physical segregation and social isolation from school as a routine part of their experience. Exclusion from school is not unique to this population.

Historically, there have been other vulnerable populations that were excluded from our school systems due to the dominant public attitude that traditional schools could not accommodate them or meet their needs. For example, until a few decades ago, for reasons of both law and public opinion, most children with Trisomy 21 were excluded from attending public school. Following the passage of the 1975 Individuals with Disabilities in Education Act (IDEA), this situation has changed and the vast majority of children with Trisomy 21 now attend school where they learn to read, make friends, and prepare for greater independence as adults (Buckley and Bird 2000).

More than twice as many children in the US are diagnosed with cancer per year (about 16,000) (Ward et al. 2014) as are born with Trisomy 21 (about 6,000) (Parker et al. 2006), and thousands more face other debilitating illnesses such as heart disease and immunodeficiency disorders (Ward et al. 2014). Though for reasons of health rather than cognitive disability, too many of these chronically ill children are today excluded from school, also with serious negative consequences for educational and social development. This small study suggests that with new technologies and the right approach, chronically ill students may also be better integrated into public education.

Implications for Practice and Future Research

The use of robots by children with chronic illness to attend school is a complex issue occupying the intersection of three different fields of research: education, healthcare, and technology. However, there is very little interaction between the professionals in these worlds and the child and family are often left to navigate this intersection on their own. The use of robotic technology allows students to remain connected to their school community while navigating the health care world but, as seen in this study, the use of this technology has also drawn a spotlight to the physical segregation and social isolation experienced by most children with chronic illness.

Innovations in technology (e.g., the robots) are not new to education but this study highlights a different approach than most technological advances in education. Technology in education is an ever-evolving field, but technological innovations in education have historically been implemented in a top-down, teacher-centered approach for more than 100 years (Cuban 1984; 1993). By contrast, the use of robots for children with chronic illness has come to the schools in the opposite fashion. The robots are being brought to schools in a bottom-up approach—individuals who are concerned about the quality of life of the individual child are introducing them into school systems. The use of robots for virtual inclusion was not introduced to improve school accountability or to assist teachers—the sole purpose was to help chronically ill children remain connected to their schools and friends. As information spread about this innovative use of a telepresence robot, individuals began advocating for the use of robots in schools and the technology was introduced into willing school districts (Hooker 2011).

For educators, one of the concerns expressed about this form of technology being brought to schools by individuals is that the robots have gone straight from production to consumer without any study on the impact of robot use on students or the most effective ways to implement this technology in a traditional school setting. In this study, the use of robots for virtual inclusion in the classroom looks promising for children with chronic illnesses but the success of this form of inclusion will vary by setting and participant characteristics. This study took place in rural communities with schools that strongly supported the use of robots in the classrooms. Urban schools or schools with resistant or hesitant school administrators and teachers may produce different outcomes and experiences.

Of equal concern is the issue of teacher preparedness. Since children with chronic illness have traditionally been excluded from their school communities, guidelines do not exist for teachers or schools on how to facilitate virtual inclusion or partner with health care teams to best meet the needs of these students. The partnership between education, technology, and health care teams is a key component to the success of virtual inclusion as the child will no longer be isolated at home but will be an active member of the school community and most educators have had little training on the needs of children with medical conditions in the classroom (Olson et al. 2004). The experiences of the children in this study suggest that professionals in education, technology, and health care need to increase collaborative efforts to provide more opportunities for improved health and social outcomes of a continually growing and vulnerable population of children.

Conclusion

While no general conclusion can be drawn beyond the experiences of these five children, the impact of remaining connected to their school communities is undeniable. The implications from this small sample are sobering—children with chronic illness and their classmates are strongly affected by physical segregation and social isolation and, until recently, there has not been a way to provide them with inclusive academic and social experiences.

One student comment may have captured the overall attitude of these students towards this experience. While Daniel and his mother were being interviewed at the hospital (per parent request), Daniel did not feel well and his mother suggested that he get some rest. He opted out of the interview and the interview continued with his mother in the hospital room. After a while, Daniel lifted his oxygen mask and called from across the room, "Hey. I wanna be more a part of the interview." This desire to participate even though he was not feeling well seemed to capture the spirit of the participants in this study—to be a part of the life that is going on around them. Future studies may provide insight into whether telepresence robots present a valuable means for them to do so.

Acknowledgements

We are immensely grateful to case study participants for their time. Funding for this work was provided by the Children's Hospital of Orange County, Hyundai Cancer Institute.

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ISSN: 2327-0144

ISBN 000-0-00000-000-0