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Virtual inclusion through telepresence robots: an inclusivity model and heuristic

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ABSTRACT

This article leverages existing literature around the use of telepresence robots to provide a conceptualisation of virtual inclusion. Telepresence involves the use of mediating technology to generate connection with others in a remote context. Recent developments have seen telepresence robots used to create a sense of 'being there' when the person's physical presence is not possible. Telepresence robots can provide children with the capability to maintain an embodied experience in schooling locations when they are absent due to chronic illness. Through building their knowledge of integrating this technology into their pedagogy, teachers can support students to engage in classroom activities through real-time virtual communication. The article extends what is known about how telepresence robots can be used for virtual inclusion and what the challenges and considerations are for the use of telepresence robots in schools. Technological, physical, social and pedagogical aspects of telepresence robots use for virtual inclusion are detailed with heuristic for introducing them into schools.

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Introduction

Telepresence robots are an emerging phenomenon in the education settings of affluent societies. They provide students, who are unable to physically attend school, to participate from a distant location through the physical presence of a robot incorporating two-way video and audio (Tsui, Desai, and Yanco 2012). Telepresence provides 'a perceptual illusion of non-mediation' [where there] where a medium (e.g. audiovisual equipment, a telepresence robot,) creates a sense of 'being there' in the phenomenal environment (Pelet, Ettis, and Cowart 2017, 115). The question: 'How can telepresence robots support virtual inclusion in schools'? is addressed in this article.

Over the last five years, telepresence robots have been refined in their design for use in schooling contexts (Page, Charteris, and Berman 2021). They are a recent technological innovation in schools in the USA (Soares, Kay, and Craven 2017), Japan and Australia (Tanaka et al. 2013) and France (Gallon et al. 2019). They are essentially assistive

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technology comprising video conferencing units that are embedded in remote-controlled robots, and which provide an embodied presence in social contexts. The video conferencing hardware is placed on a wheeled platform which is under the control of a remote user. Telepresence robots afford an embodied presence that connects geographically dispersed people. They provide relationality as a means for social, pedagogical, affective and intellectual engagement at distance. In this article we detail how telepresence robots can be used to create a robot/child interface that can facilitate virtual inclusion.

Telepresence robots permit children to watch, listen, move about, and relate with their peers and teachers synchronously when they are not physically present in school. Manipulating a robot from their home or hospital bed, students can observe and take part in lessons through their camera and speaker. Children and teachers in the classroom can see and converse with the homebound student on a live screen feed. The child at home is able to move the robot on its wheels during class time and at breaktimes to connect with and learn alongside their peers.

This review of literature maps how telepresence robots can be used to foster virtual inclusion. It details the emerging uses of telepresence robots broadly and in schools specifically. The article makes three key contributions. Firstly, it lays out the ways telepresence robots have been used in a range of fields to date. Secondly, it provides considerations for researchers and practitioners interested in promoting a responsive approach to virtual inclusion in schools. Thirdly, it provides a heuristic guide to support the implementation of virtual inclusion through telepresence robots in schools.

The article commences with detail on the literature review process. Telepresence is explained, with detail on how it been used to support connectedness across contexts. Virtual inclusion is defined, alongside an explanation of how robots are currently used in schools. The article concludes with a framework that can be used to prepare practitioners to work with telepresence robots in their classroom to support inclusion of students who use robots to access classrooms.

A review of literature

A literature review approach, as described by Hogg (2011), is used here in an attempt to examine salient and emerging issues around the use of telepresence robots in schools. Like Hogg (668), we used an 'organic review process' by starting with specific objectives and guiding questions, yet remained open to issues that become apparent through our reading.

The initial search was implemented on February, 2020, in the University of New England library databases. We found 164 peer-reviewed journal articles that used the terms 'telepresence robots'. We also located 14 peer-reviewed articles on 'telepresent robots'. We further refined the searches to add the term 'school'. There were 72 for 'telepresence robots' and 'school' and 9 for 'telepresent robots' and 'school'. The articles were initially skimmed for their references to telepresence robots in schools. Many of them alluded to telepresence in education with general references to school, yet did not explicitly focus on their use in schools. The articles that referred to the use of telepresence in schools were mapped for their contribution to our question following Machi and McEvoy's (2016) process. We asked: 'How are telepresence robots being used for inclusion in schools?'

We used a grid template to organise data from the texts on how telepresence is used and this enabled us to create Table 1 below. Noting the paucity of literature on the use of telepresence robots in K-12 classrooms settings, we then drew on our own knowledge of inclusive education and school pedagogy, and broadened the literature base to review a wider pool of articles around telepresence to consider how telepresence robots support inclusion in schools.

The emerging use of telepresence robots

Telepresence is a term that was first used by Minsky (1980). It pertains to a range of technologies that give a 'compelling sense of being in a mediated space and not where the physical body is located' (Newhart, Warschauer, and Sender 2016, 10). Telepresence is ubiquitous in advanced technological societies where it is used to afford connectedness for people across geographical distances. It can manifest through day to day smartphone

Table 1. Uses of telepresence robots to support connectedness.

Domain where telepresence robots support connectedness.	Description of use	Authors
Aged care	Telepresence robots can be used by people in aged care to alleviate the loneliness through connecting with family and friends. Although there is no research at this point, it has also been suggested that they can to enable people with a mobility issue to attend concerts, sporting events, and visit museums and theatres.	Beer and Takayama (2011); Cortellessa et al. (2018); Moyle et al. (2019)
Academic activities	Telepresence robots can permit attendance at academic conferences and other professional activities by giving those who cannot attend in person an opportunity to be present.	Herring (2013); Neustaedter et al. (2018)
People in healthcare facilities	Residents of healthcare facilities, can participate in remote activities with friends or family through operating telepresence robots.	Tsui et al. (2015)
Pre-service teacher education and co-teaching	Telepresence technology can facilitate synchronous classroom practicum experiences in pre-service teacher education. A supervising teacher in the classroom and pre-service teacher working remotely collaborate to co-teach.	Wertzberger (2019)
Foreign language learning	Learners use telepresence robots to gain virtual access to places where a target language is spoken. Students can interact with native speakers in distant locations in real-time.	Kwon et al. (2010); Liao and Lu (2018); Tanaka et al. (2014)
Chronically ill students' connections to school	Virtual inclusion for students who are not able to attend school due to medical conditions.	Gallon et al. (2019); Newhart, Warschauer, and Sender (2016)
Remote access to teaching professionals	Telepresence robots assist teachers who working remotely to teach classes in schools.	Tota and Vaida (2019)
Medical procedures	Telepresence robots are used to perform surgery.	Morris (2005)
Connecting family members	They have been used to support loved ones separated by distance to engage in a joint activity of shopping together.	Yang et al. (2018)
International programs for education	Children have used telepresence robots to support international communication between distant classrooms.	Tanaka et al. (2013)
Teleconsultation	School psychologists undertake consultations through telepresence robots to connect with students in remote and underserved school settings.	Fischer et al. (2019)

mediated interactions where applications like Snapchat, Facebook, Zoom and Skype are used to disseminate live video footage (Tsui et al. 2011).

Telepresence robots have been used in a range of domains and they have a growing range of functions. They can provide team members working is a range of spaces with an embodied presence (Stoll et al. 2018). They may be used solely as a conversation tool, as a means to check on family, or as a way to be present in a remote space to feel connected with others in an activity (Tsui, Desai, and Yanco 2012). They can provide care for the elderly, facilitate learning (Bell et al. 2016), school attendance (Newhart and Olson 2017), teaching (Tanaka et al. 2014) and consultancy (Fischer et al. 2019) from a distance. Table 1 details studies to date into the different use of telepresence robots.

Having mapped the emerging use of telepresence robots generally, we now signal the potential importance of this technology for educational inclusion and provide a conceptual framework for the notion of inclusion through virtual presence.

The use of telepresence by chronically ill students

There is a significant need for telepresence-mediated inclusion. Each year in the USA it has been estimated that 5 million to 7.5 million students miss nearly a month of school with health conditions cited as a leading cause (Cha et al. 2017; Soares, Kay, and Craven 2017). In Australia, approximately 1.6 per cent of students experience school absence due to significant illness or injury (Australian Research Alliance for Children and Youth 2015). With improved survival rates for children and young people who have life-threatening conditions, there are calls for these students to be identified and their academic progress monitored (White and Rosauer 2015). However, as Yates et al. (2010) indicate, 'for many young people with chronic illness, various kinds of disconnections in relation to family, social lives and education [are] repeatedly experienced.' Moreover, chronically ill young people can slip through the cracks between the healthcare system and the education system (Australian Research Alliance for Children and Youth (ARACY) 2015). If the continuity of education provision is to be ensured, the creative use of technology with measures like the adoption of telepresence robots, is required.

The Australian Research Alliance for Children and Youth (2015, 83) report found a 'paucity of research, and no strongly evidence based 'ideal model' or 'best practice' approaches to continuing the education participation and connection of students with significant illness or injury.' Recommendations from the report signal a gap in the field that this article speaks to. There needs to be:

- development of a culture of inclusion in schools which improves knowledge of the needs of students with significant illness or injury;
- practitioner support and 'up-skilling' teaching professionals;
- implementation and integration of ICT into the school and home environments to allow students to maintain connection with school; and
- the use of information and communication technology as an integral part of learning, allowing for remote education an 'virtual' presence in school. (ARACY 2015, 9–10)

In the USA (Newhart, Warschauer, and Sender 2016), Sweden and the UK (Gilmour 2018) telepresence robots are increasingly used to connect chronically ill children with

their schooling settings. In Australia over the last few years, students and schools have participated in telepresence robot trials (New South Wales Government 2018). Robots have been deployed to help reduce the sense of isolation for young cancer patients who are absent from school for protracted periods of time (New South Wales Government 2018). The student who is at home, in a hospital school, in a hospital ward or any other distant location, can manipulate the robot in real-time using their digital device. According to the New South Wales Government the robots have been well received.

> Students have reported that robots are great for keeping them connected to their peers. 2018 saw an increase in students who are managing periods of isolation or are discharged and not able to attend their census school having educational plans that address digital connectedness to both Sydney Children's Hospital School classrooms and census schools and/or continued attendance in Sydney Children's Hospital School classrooms. (New South Wales Government 2018, 5)

Telepresence has been increasing used in school classrooms. Robots have been used in classrooms to supplement teaching structures and provide support to children in their learning (Baxter et al. 2017). Studies into the classroom use of telepresence robots for foreign language learning have indicated that students experience improved learner engagement, self-assurance, and motivation (Liao and Lu 2018; Tanaka et al. 2014). Telepresence can support students' sense of connectedness and enable them to participate in classrooms from a distance when they cannot attend school. They exert an embodied presence in classrooms through operating a remote-controlled robot (Newhart, Warschauer, and Sender 2016). Children, therefore, who are absent from school can use technology to project a presence into their classroom which enables them to sustain their engagement with peers and to maintain an alignment with their educational pathway (Newhart, Warschauer, and Sender 2016).

This article on virtual inclusion is timely and relevant as the area is under theorised in education. However, the term can potentially be problematic, if inclusion is merely equated with social presence.

Virtual inclusion

Telepresence robots provide an important conduit between the student at home and the teacher and peers at school. Teaching in their university setting, Bell et al. (2016, 20) likened the use of telepresence to 'coming to class with the aid of assistive technology such as a wheelchair.' Social presence is 'the degree to which a person is perceived as 'real' in mediated communication' (Cobb 2009, 241). In the following definition virtual inclusion has been conceptualised broadly as 'attendance' and 'interaction'.

> [It is] 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. (Newhart, Warschauer, and Sender 2016, 10)

Social presence, through the use of telepresence robots, can afford connections with peers, teachers, and support staff in schools so as to enable virtual inclusion. Virtual inclusion can be defined as a philosophy and set of practices that enable students

working remotely to access intrapersonal, interpersonal, cultural, physical, and cognitive resources in the classroom that their present peers can access. The similar term 'E-inclusion' signals 'the use of digital technologies to break down barriers of gender, race, age, sexuality or class' (Abbott 2007, 5). For virtual inclusion to work well, it is important that students do not feel self-conscious in using telepresence. Bell et al. (2016, 20) acknowledge the importance of removing 'the sense of intrusion or limitation, so those with the assistive technology do not feel the need to apologise, and they are treated as full members of the learning environment'. When virtual educational practice is premised on inclusion, all students are provided scope to participate and contribute in the classroom. It is ensured that they have opportunities to achieve and are valued by their peers and their teacher (Anderson, Boyle, and Deppeler 2014).

A caveat on passivity and tokenism

To be truly inclusive, virtual classroom pedagogy needs to be responsive to the unique needs of diverse learners, 'contribute to the growth and development of every learner' (Berman and Graham 2018, 30), and foster collaboration so that peers serve as instructional resources for each other (Wiliam 2011). When learning is inclusive there are opportunities for students to engage in competency based learning, which is active, fosters substantive thinking, promotes students' capacity to relate with others (Berman and Graham 2018). It is pertinent to offer a salutary warning against using the technology to merely support interaction and passive attendance. With little substantive engagement in learning or serious scope for contribution in the social relationships of the classroom, the use of telepresence for social presence may be little more than tokenistic.

Concerns have been raised that telepresence technologies can serve to reinforce real world segregation with 'inclusion by telepresence being a 'second best' for groups denied rights or without power' (Sheehy and Green 2011, 142). Sheehy and Green (2011, 135) proposed that children could use telepresence robots to bridge education environments for children with high and very high needs, with robots creating a 'bridge between mainstream and special school classrooms, allowing children to 'visit' each other and explore each other's classrooms'. While reasons for the separation between the schools were given as concerns of personal risk and access, for instance it can be difficult to arrange transport to school (Sheehy and Green 2011), this is an example where telepresence is a solution for inclusion that paradoxically sustains dislocation and segregation. Having outlined the value of telepresence robots for supporting virtual inclusion, we now turn to the considerations for their use and furnish a model that is designed to assist educators with their inclusion in educational settings.

Considerations around the use of telepresence robots for virtual inclusion

There are a range of issues that need to be taken into consideration when supporting virtual inclusion through telepresence robots. The issues emerging from the literature are firstly explained and then an inclusivity model for the use of telepresence robots in schools is provided alongside a set of questions that are designed as a heuristic.

Portability

Because the dimensions can be quite large, telepresence robots are not necessarily easy for children to carry if a child wants to move the robot to an area that is inaccessible to wheels (Tota and Vaida 2019). For instance, the robot may not be easily portable in a playground with grass and rough terrain. Educators need to give similar consideration to the robot as they would to wheelchair access (Newhart and Olson 2017).

Expense

There is also an issue with their expense – in their initial purchase and costs of ongoing maintenance of the technology in the school setting (Tota and Vaida 2019).

Privacy

Privacy issues have been raised for adults in residential care using robots (Niemelä et al. 2019; Rueben et al. 2017). Privacy may also be an area of concern with the use of video technology connecting the classroom and a student's home environment. As Newhart and Olson (2017) point out, it is important to ensure privacy for the student at home so that personal possessions are not placed on display and family conversations are overheard, and repeated. Noises from siblings, pets and the household can be audible through speakers in school. Finding ways to reduce the background noise and visual information transmitted from home can free parents and students from the imposition of 'having visitors' in their house every day (Newhart and Olson 2017). Furthermore, if a chronically ill child undergoing treatment has significant changes in appearance, they may prefer not to be visible on a screen and if their energy levels are low they may prefer just a low key social presence in the classroom on some occasions (Wadley et al. 2014).

Access protocols

Clarity around the use of the robot is important. It is helpful to ensure that all parties (at school and at home) are clear and in agreement around protocols for use of the robot (e.g. whether there is capacity to record or not) and there is alignment with school privacy policies (Gilmour and Meyers 2018). In Australia, adults who work in schools are required to pass a police check. Adults without this clearance who are connected with the child remaining at home may be able to access the classroom through telepresence.

Access to physical materials

A child at home may not have access to physical learning resources that are provided to students in the classroom. It may not be possible to arrange for the student to use large or specialist equipment at home, however the spontaneous use of documents like handouts or quizzes could be supported with the provision of an email and printer (Newhart and Olson 2017).

Access to the classroom

To ensure that the robot is well located work is required before students use the robot in the classroom. Newhart and Olson (2017) advocate a special session is held between the teacher and the student working remotely so that they are best placed to see around the classroom and the whiteboard. They need to hear the teacher clearly and in turn be able to be heard satisfactorily. It is important the robot does not obscure the view of peers (Gilmour and Meyers 2018).

Student attendance

The child especially one who is chronically unwell may have times where they are unable to attend class. It is helpful for teachers to know the students' likelihood of attendance (Newhart and Olson 2017).

Student relationships

By developing a sense of normalcy around the classroom use of the robot, the home-bound child is able settle into its day to day use. Newhart, Warschauer, and Sender (2016) report that a child in their study returned her robot because she 'didn't like all the attention' and another student in the class referred to the robot as a 'a vacuum cleaner'. Although the interchange was not necessarily malicious, it had a negative impact on the student at home. This highlights the need to socialise the class to the robot in their midst, perhaps even before the child commences using it.

Teacher education

Preparation of teachers around the use of the robot is important as teachers' positive attitudes influence the acceptance or rejection of the initiative (Hartman, Townsend, and Jackson 2019). There is a need for teacher education around operating the robot controls. This includes manipulating the speaker levels and docking the machine to charge it, and ensuring that other teachers and casual relief teachers have access to this information (Newhart and Olson 2017).

Planning for engagement

Teachers need to foster the relationships between students in the classroom and the child who is embodied in the robot. Classroom strategies can be used like developing a buddy system to help the robot manoeuvre between objects in the classroom (Gilmour and Meyers 2018). Group work needs to be planned in order to provide student with pedagogical structures around peer dialogue and including the student meaningfully in shared activities.

Power relations

The use of a robot may challenge the power relationship between teacher and student as they do not work in the same physical space (Furnon and Poyet 2017). Teachers may be

used to circulating around the class, monitoring what is on students' screens and helping them as needed. However, teachers do not have access to the screen of the student operating the robot and they cannot directly supervise the activity to assist them. In short, they cannot ensure 'compliance with the rules of procedures of the class' (Furnon and Poyet 2017, 1065).

An inclusivity model for telepresence robots

Newhart and Olson (2017, 343) note that there is 'no research which highlights the key issues pertaining to how telepresence robots bridge school to outside places, homes and/or hospitals'. The diagram in Figure 1 draws together elements from existing studies to address this lacuna by providing an overview of considerations for inclusion through virtual presence. The diagram delineates physical and environmental, social and cultural, pedagogical and technological considerations. The issues emerging around the outside of the diagram are not exhaustive and they do overlap. For instance, the privacy element could be social (family conversations becoming public), physical (relating to the visibility of the room that the child is sitting in) or technological (the capacity to mute the audio device in the robot). With a focus on each of the key considerations in this model, the

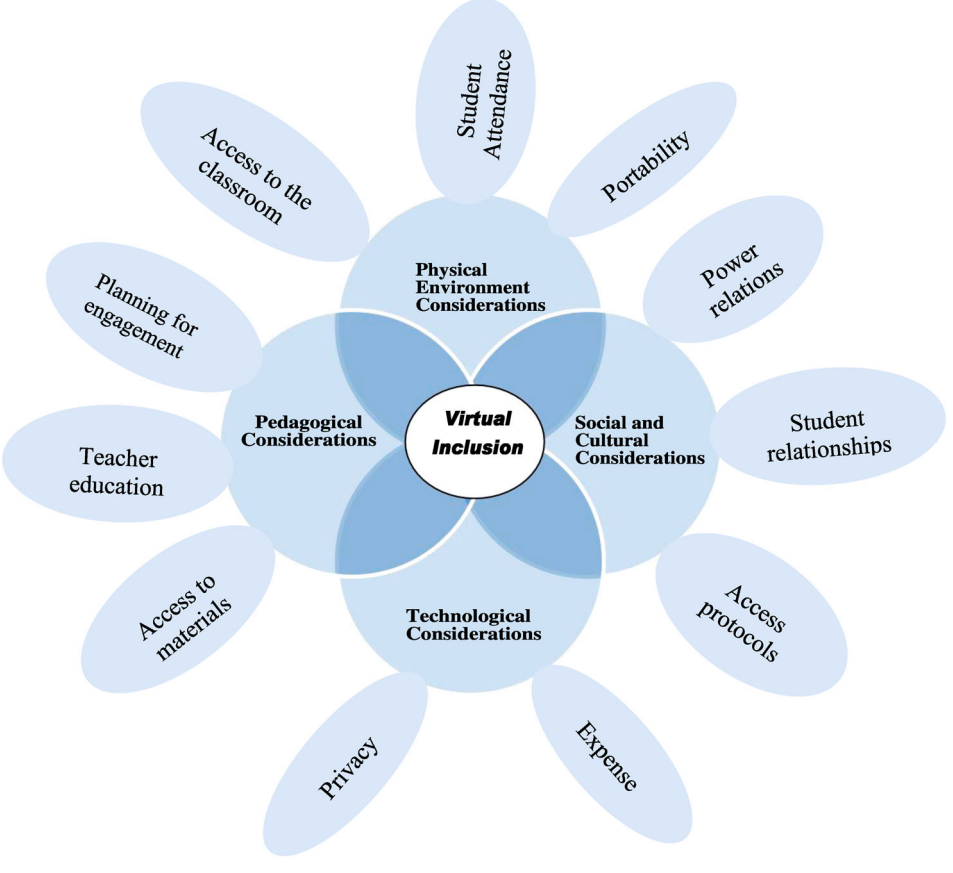

Figure 1. Model for education virtual inclusion.

following questions could be used by practitioners to prepare a school environment that supports virtual inclusion.

Physical and environmental considerations

Is there a screen or set of curtains to prevent peers and school staff from viewing personal objects?

How can the robot move as a freely as possible in the classroom and playground?

How do you ensure optimal placement in the classroom for the different activities?

Pedagogical considerations

How can peers be taught the group work skills to effectively include the robot child in activities?

How are lessons structured so that the robot child has a meaningful role?

How can teachers and children in include the robot child in classroom learning talk so they can have meaningful input in discussions?

How can lesson materials be provided to the robot child both ahead of time and on a spontaneous basis?

How can teachers assess the robot child's learning and support them to engage in self and peer assessment practices at distance?

What professional learning do teachers and teaching assistants need in the school to address the robot child's learning needs to that they have the same opportunities that their peers have to learn?

Technological considerations

How can you ensure all users understand how to use the robot and have opportunities to trial it ahead of lessons?

How can you ensure the robot is charged and maintained?

How do you check audio and video are working efficiently?

Social Considerations

How do you ensure the robot child can rest when they need to?

How are students are equipped to establish and/or sustain relationships with the robot child?

How can children be assisted to understand the affordances of the technology?

Can the robot child opt out of activities when they wish to?

Considerations for teachers

Teachers are busy practitioners and it will always require some adjustment to have a robot in the classroom. Confidence with the technology is important. It is important that teachers are supported in the technical and operational use of the robot technology and have someone to go to if it is not working. They need to be prepared so that the student at the other end has the materials required for the lesson that are pitched to their point of need. Teachers should also being remember to show their full-face size and provide eye contact when possible during interactions. Checking in with the child is important, as there is extra effort required to make sure the student understands what is happening in the lesson and they know what they are learning and the activity they are undertaking. There is work required in ensuring children know the protocols for interacting with the robot and understand that the child operating the robot may choose to turn their monitor off if they are feeling tired. Sometimes children with

chronic illnesses die and this is extremely tragic for the school community. The robot should be removed quickly from the room and processes put in place to support students and teachers as they work through their grief.

Conclusion

In Oceania, the provision of education to children who are absent from school due to a health condition 'has been characterised by a lack of policy direction, fragmented services and disconnection between education systems and health care systems' (Hopkins 2015, 4). The evolving use of telepresence robots addresses this fragmentation. However, it means that inclusion of students who have a virtual presence needs to be understood and addressed purposefully by practitioners and policy makers alike. To date, there is paucity of literature on the use of telepresence for addressing the needs of students who are not able to attend school because of physical and psychological health reasons. Few studies detail children's use of telepresence robots for the purposes of inclusion in classrooms (Newhart, Warschauer, and Sender 2016 ; Sheehy and Green 2011; Tanaka et al. 2013). In this article we have provided an inclusivity model and heuristic that brings together literature on both inclusion and the use of telepresence robots in schools. There is scope for further research in this area for the efficacy of the heuristic framework to be explored.

In this article the emerging use of telepresence robots to support virtual inclusion in education has been mapped and considerations provided for classroom practice. Participation for chronically ill students in the classroom needs to be as streamlined as possible, so that teachers, students and peers are not inhibited in their communications. Further, there is need for a range of supports to be put in place to enable the success of the robot. For instance, aside from the logistics of technical support, there is a need for professional learning for teachers and guidance for parents and caregivers so their use is optimised and there is a shared understanding around protocols and practices for the classroom and playground. There is potential for students using telepresence robots to achieve a sense of connectedness where they are treated as full participating members of the learning environment and they have the capacity to develop meaningful telepresence-mediated relationships.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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