



Telepresence Robot Use for Children with Chronic Illness in Australian Schools: A Scoping Review and Thematic Analysis

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Abstract

Around the world there has been growing interest in the use of technologies to connect students who are absent from school because of a health or medical condition to their teachers and peers in school. In this article findings are presented from a scoping review which sought to map the impacts of telepresence robots (TPR) for students who miss school because of illness. In Australia, TPRs are being piloted across the country in efforts to address the isolation of students with chronic illness. However, there is very little research internationally and no research in Australia that maps the potential and issues associated with students who are connected to their classrooms through TPRs. Therefore, research-based guidance regarding how best to direct the successful implementation of TPRs is required. Findings from the limited research available suggest that TPRs can enable positive experiences in education and can foster the social development of chronically-ill students; improvements to the design of TPRs are still required to maximise educational and social benefits; there is a need for appropriate professional learning for teachers in engaging with students through TPRs and for planning between all stakeholders; and, finally, issues of privacy and possible negative reactions from all parties involved need to be addressed.

Keywords Telepresence · Chronic illness · Students · Classroom · Connectedness · Robot

1 Introduction

Chronic illness or injury affects thousands of students in countries around the globe who are unable to attend school. These absences may include a block of many months or intermittent periods that accumulate to months or even years of missed schooling [2]. Depending on levels of illness, students might attend hospital schools, or have schoolwork sent home, or not be engaged in any schoolwork at all [2]. Telepresence robots (TPRs) are remote-controlled, wheeled devices that are connected wirelessly to the internet. They use a tablet to allow interaction using the medium of video and audio capabilities. The robot is used in classrooms where the student connects from a distance to the classroom environment and can move around the room and interact face-to-face with others [14]. Telepresence robots are being used around the world to enable students to connect remotely and participate in their classroom environment without being physically

present, offering a face-to-face experience of in-class instruction [14, 27]. The most appropriate TPRs for students to use for school-based learning and to connect socially are designed for full mobility. These TPRs are video conference systems mounted on a mobile robotic base allowing the user to move around the environment [19]. Because of the scarcity of research in this area however, it was considered worthwhile to explore TPRs that are immobile to assess the commonalities and differences between mobility and stationary affordances. These TPRs are video and audio devices, such as a tablet that is stationary and usually placed by the teacher at the back of the room or with a group of students at their desks [42].

The scoping review discussed in this article, was designed to determine the potential impacts that TPRs have on the educational experiences of those who use them and to define future research directions to inform the use of TPRs. We commence the scoping review by framing the problem of students missing school due to chronic illness or injury. Next, we address how non-negligible school absences and social isolation can be mitigated through the use of TPRs and detail their current use in Australia. An outline is then provided of our method and search strategy for a scoping review. Results

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are presented that highlight the value and challenges of using TPRs in educating students with chronic illness or injury, the value of teacher education to support their use, the importance of stakeholder planning and issues around privacy. By presenting these themes arising from the review, we offer important considerations for stakeholders implementing the use of TPRs in school.

1.1 School Absences

Children have a right to fully participate in education [37] and in Australia there is a legal requirement for children to attend school between the ages of five and the minimum leaving age of between 15 to 17 depending on the different Australian state or territory [4]. However, it is estimated that 12% of the school population, that is over 400,000 Australian children and young people, have serious health conditions that suggest the extent of a cohort that may be adversely affected by their capacity to participate in education [41]. Other data from Australian Research Alliance for Children and Youth (ARACY) reports an estimated 1.6%, or 60,000 Australian students experience school absences as a consequence of chronic illness or injury [2]. These estimates, while wildly varied, reveal a gap in the data taken to accurately record the absences from school for students with chronic illness. Notwithstanding the variation in estimates, the number is undeniably substantial. The issue then, is the identification of provisions and support that address the educational concerns which subsequently arise because students cannot attend school regularly.

Childhood chronic illnesses are typically defined by their medical health condition, that is, an ongoing condition such as asthma, cancer, cystic fibrosis, diabetes, chronic pain or autoimmune conditions [31]. However, the issue of absenteeism becomes noteworthy when additional school absences are taken into consideration. School absences may occur, for example, as a result of students not being able to attend school because of mental illness such as Anxiety Disorder, Depression, Attention Deficit Hyperactivity Disorder, and Conduct Disorder [20]. School refusal may underpin these figures, where children and young people refuse to attend school because of high emotional distress, which affects one to five % of Australian children [16].

The impact of student school absence is well documented [17, 18, 36]. Within this broader context many Australian students are, as a result, not engaging in education, and not participating within their school community or with a school-based social network. The implications of school absences are highlighted by Hancock et al. [18] for example, who reported on the relationship between attendance and student academic outcomes. Hancock et al. found that there was a correlation between student attendance and NAPLAN academic scores in numeracy, reading and writing. For every day

of absence from school there was an associated progressively lower achievement result.

The association between school connectedness and chronic illness is well documented [13, 24, 29]. School connectedness refers “to the study of a student’s relationship to school” [22, p. 274] and includes measures of attachment, bonding, connectedness, and engagement. Children who report dislocation from school and peers because of enforced absences from school also report that this can lead to isolation and to disruption in their learning [38]. The dislocation experienced by students with a chronic illness is therefore important to address in regard to the possible interventions that might be put into place. The current scoping review, therefore, explores the efficacy of TPRs in ameliorating the effects of dislocation and isolation for these students.

1.2 Addressing School Absence and Isolation with TPRs

Advancements in communication technologies have made it possible to provide connectivity between the home and classroom for students who are absent from school in Australia [14] and in a range of other countries [1, 9], TPRs within the educational field have been available in various forms for the last 20 years. ‘Providing Education by Bringing Learning Environments to Students’ (PEBBLES), was the most significant step towards the use of TPRs as we know them today. The early iteration of PEBBLES did not include independent mobility but had a monitor that the person operating the robot could be seen by others and could see others by turning the ‘head’ left or right [42]. The research from these early TPRs provided support for subsequent use of TPRs for chronically ill children where TPRs were shown to greatly enhance a sense of real class presence and classroom learning behaviours [11, 40]. A further prototype was developed for use in high schools, although not tested with students with chronic illness [43]. The significance of testing TPRs specifically on the population of chronically ill children is that the needs for sick children are specific to this very considerably large group. Examples include that there are constraints to their ability to see and hear as well as access school across long periods or consistent periods of time because of their illness [2].

In subsequent years, the technological development of mobile robots has allowed the capacity for the robot to move around the classroom which allows the user to be independent of needing others to connect socially and academically [19]. Further iterations of TPRs include robots which allow the user to control more complex movements of the robot such as head tilting and different microphone and audio placements [1]. While TPRs have the capacity to be used for all children who are missing school for any reason, the focus and primary use of TPRs are for children who are chronically ill largely

because of the political and economic support from health-care agencies [7], although other students are beginning to benefit from the understanding that was developed from using TPRs with children with chronic illness, for example students who avoid school [32].

1.3 Telepresence Robots in Australia

There is almost no research to report on the outcomes of the use of TPRs in schools in Australia, despite its accessibility since 2010. Virtual technology in Australia has been used for chronically ill children since the Royal Children's Hospital in Melbourne first created and tested an ambient orb in 2010. An orb is a robot that flashes a coloured light that the child can turn off or on and change colour depending on what is wanted to be communicated. It was designed to connect hospitalised children with their schoolmates and enabled a presence for these absent children in the classroom [15]. The Ambient Orb Project is the only evidence-based implementation to date in the area of technology to address connectedness using robots in Australia, although the orbs did not enable interactive, two-way conferencing.

Later, in 2017, a significant step forward involving TPRs was the implementation of a pilot programme by MissingSchool. MissingSchool, a non-for-profit organisation in Canberra, plans to extend the use of TPRs and place 75 See-Be OHMNI TPRs in schools by 2021 [14]. At this stage there are 60 TPRs in Australian schools and currently no published research to support its effectiveness in addressing school connectedness or academic outcomes [14]. Neither is there any research associated with the Robots Project, run by the organisation Canteen. Canteen provides TPRs to young people aged 12 to 18, if they are still enrolled in school, with cancer who are missing school in New South Wales and Victoria with a focus on developing social relationships [35]. While research is currently taking place in conjunction with the University of Sydney, at this stage there are no published findings available. The New South Wales Department of Education and Training have also provided TPRs for children with chronic illness in the state's schools so that they can connect with their peers [21]. Again, there is currently no research that supports the efficacy of these TPRs. Finally, there are also a few individual students with chronic illness who have accessed TPRs as a result from private funding across Australia [25], although there is no documented research about these cases.

2 Study Design

A scoping review is deployed for “reconnaissance,” and is used to map or explore the literature in a field of research [10, p. 3]. It is framed by an a priori protocol and includes sys-

tematic and comprehensive searching that is transparent and reproducible [5]. Unlike a systematic review, a wide range of issues can be considered. There are four common reasons why researchers may undertake a scoping study [3]. These are:

1. To examine the extent, range and nature of research activity;
2. To determine the value of undertaking a full systematic review;
3. To summarise and disseminate research findings; and
4. To identify research gaps in the existing literature [3, p. 21].

All of these reasons are relevant to this review, as the use of TPRs to support the education of chronically ill students is an emerging field. In this scoping review research is examined and compared to provide direction regarding how mobile and stationary TPRs can be best used. The review aims to highlight the issues for students who miss school and the effect and outcomes in relation to learning and social connections that are afforded by using TPRs.

The research question was: *What are the impacts of using TPRs for chronically ill students who miss school?*

The scoping review methodology was deployed with reference to Peters et al. [33] framework, where key concepts are uncovered relating to the research question. Additionally, the framework clarifies definitions and understandings of the conceptual boundaries of the research area [33].

The first step was to establish the objectives and research question. The second step was to develop key search terms through preliminary searches. Next, a review protocol was established where data were extracted from the studies that have been included. Data were taken from those studies which were related to the impact of TPRs on children with chronic illness missing school.

2.1 Search Strategy

A three-step search strategy was employed that involved a systematic search of four databases: ERIC, Scopus, IEEE Xplore, and PsycInfo. The search was limited to studies which were published from January 2000 to May 2020. Through an iterative process, the key search terms were developed. This process was facilitated by the familiarity that the researchers gained as they worked through the databases. Subject terms used in the search included combinations of ‘telepresence’, AND ‘robot*’, AND (‘sick’ OR ‘absen*’ OR ‘housebound’), AND (‘child*’ OR ‘school*’, OR ‘classroom’ OR ‘education’), AND (‘virtual’ OR ‘technolog*’, OR ‘mobile’), AND (‘inclusion’, OR ‘connected*’, OR ‘social’ OR ‘presence’).

This phase of the search strategy was assisted through the analysis of title, abstract and index terms of the relevant papers. Further, an additional search using these listed search terms was completed across all of the four databases. The reference lists of the relevant articles were used to also provide further identification of pertinent studies that may have been missed in the initial screening process.

The process of article selection followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis model) by Moher et al. [26] where Fig. 1 signifies the process of the selection of articles for each step that was taken.

Inclusion/exclusion criteria

The criteria for inclusion was identified as:

1. Publications reporting on TPRs for students missing school for chronic health reasons.
2. Publications reporting on chronically ill primary or secondary school students using the robot to connect to others and/or learning in the mainstream school setting.
3. Publications that presented a quantitative or qualitative evaluation.
4. Publications between January 2000 to May 2020.
5. Publications that were reported in English.
6. Publications that were peer-reviewed and grey literature.

The criteria for exclusion was identified as:

1. Publications that did not involve the use of TPRs.
2. Publications that involved TPRs for students who missed school for other than chronic health reasons.
3. Publications of research that were a conceptualisation.

3 Results

The summary provided in Appendix 1 outlines the overview of the peer-reviewed studies and grey literature reports that were included in the scoping review. The 11 included studies provide the results for six mobile and five stationary TPR data: authors, purpose, research design, method/s and sample, country of study, the main finding, and suggestions from the main finding. Of note, all of the articles involved the use of qualitative methodology. Additionally, only three were conducted outside the USA. Several different research findings were published by the same authors from the same study, narrowing the range of the exploration even further. Appendix 2 outlines the available operating specifications that were provided in each article and although not extensive, offers some information regarding the form and function of the systems used.

A thematic analysis was completed in accordance with Braun and Clarke [8] procedure for conducting thematic

analyses. Inductive thematic analysis was performed of the 11 articles with emergent themes being assigned after hand coding for classification. From the codes generated by this process, a system of overarching themes was produced through discussion between the authors.

The summary of the 11 articles falls into the following themes: TPRs enable positive experiences for the educational and social development of chronically ill students; Design of TPRs is still required to maximise educational and social outcomes; Professional learning for teachers on TPRs is essential; Considered planning between all stakeholders is essential; and finally, Issues of privacy are discussed.

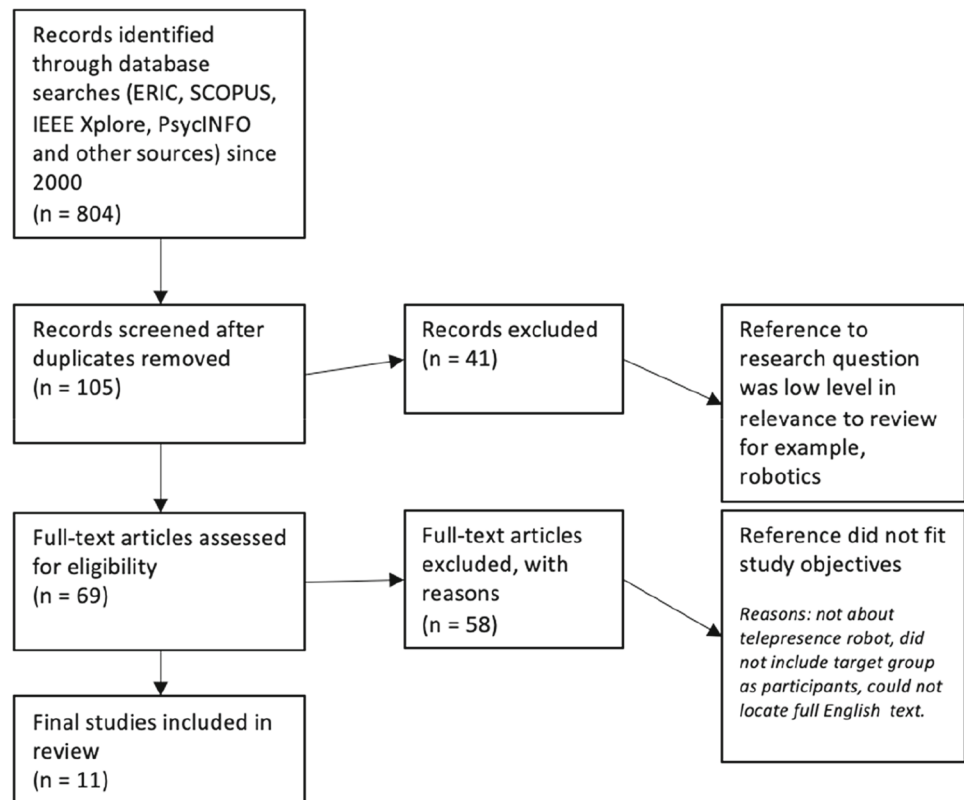
These themes are explained in detail below.

3.1 TPRs Enable Positive Experiences for the Educational and Social Development of Chronically Ill Students

Even though at times, students reported negative experiences using the TPR [30] students also reported positive experiences as well for both social and academic development in every one of the studies. Fels and Weiss [12] found, for example, that telepresence has a very clear and statistically significant effect on the students' social and academic interactions after using a TPR. Aligning with this finding, Beeman and Henderson [6] as well as Weibel et al. [39] reported that academically, and socially, TPRs enabled students to feel included and stay connected, allowing the return to school seamlessly.

In regard to reports showing positive levels of student wellbeing, Newhart et al. [29] indicated that 91% of children using the TPR demonstrated on a Likert scale that they felt 'happy' or 'good' when using the robot. Further, Lister [23] although reporting on only one student using the TPR, described that there were positive gains made in the student's perception of normalcy and autonomy. These improvements assisted the student's ability to engage with their peers and teacher. The student reported that their personal control of the TPRs movement was related to positive levels of perceived social presence and identity. The ability to interact and initiate participation gave opportunities to engage socially and academically. Rather than be a recipient of learning, the student reported that they felt empowered and could contribute to others' successes. This finding supported the work by Weiss et al. [40] who stated that TPRs can effectively enhance learning opportunities for students at home as they facilitate concentration and connectedness with academic tasks.

Contributing to the notion of identity, personalisation of the robot also helps students develop a sense of identity in class as well as assist them to integrate within the school community [34, 39]. Ahumada-Newhart and Olson [1] for example, reported that often this would be achieved by dressing the TPR or using the live video feed, where, for instance,

Fig. 1 PRISMA flow diagram for selection of articles

the student wore a school uniform. Additionally, peers identified with the anthropomorphic characteristics of the TPR which in turn contributed to normalcy and acceptance of the TPR and connectedness of the student with the classroom [1, 23]. Moreover, new social experiences allowed for a new discourse about returning to school to take shape the child who was homebound, creating an important motivator for using the robot [29].

Fels et al. [11] and Weiss et al. [40], have similarly reported on the benefits of using TPRs to impact positively on learning, where students were observed to engage in academic behaviours at the same levels to that of their peers. In these studies, the researchers found that teachers, parents and peers all reported that they perceived the robot to be having a vital role to play for the student in terms of their participation, relationships and emotional state.

3.2 Design of TPRs is Still Required to Maximise Educational and Social Outcomes

While it has been found that students did not find the operation of the TPR difficult [39], all 11 articles suggested technological improvements to the robot design could enhance their use. Some of these suggestions include attention to connectivity, a reliable power source, and reliable communication [1, 6, 11, 23, 34]. Additionally, the technical infrastructure of the school needs to be able to cater for a TPR

that includes more robust wifi connectivity, hotspots, battery life and back-up provisions at school, and the availability of a secondary communication if all else fails [1, 6, 23, 39].

Issues of occupation awareness were also raised by Ahumada-Newhart and Olson [1] which describes how others become aware of a person entering a room. As the robot is already in the room, it became difficult for others to know if the student was present or not. One possible solution offered was the design of soft announcements for entry and exits, or a light that is activated when the student is present [1]. Another important consideration to effectively gain attention in class was observed to be using a blinking light over other options such as raising the head, calling out, moving forward, or making the robot taller [1].

Audio difficulties have long been apparent in TPRs [12, 40]. A microphone using echo-cancelling speakers can be used to change the settings. As a design solution for audio difficulties, there is also the ability to change the height of the TPR from sitting to standing to enable student conversations [1].

One key consideration for mobility of the robot is the ability to not only turn the body of the robot but to turn its head left and right and move the head up and down to maximise quality of social and learning interactions [1]. Mobility ensures autonomy and engagement and the capacity to be able to cross thresholds, navigate different levels and to move with

the capacity that another would have when they ‘walked’ were all challenges reported by students [1, 23].

Suggestions that robots, mobile or stationary, were light, stable and had a wide viewing camera were recommended. These have different mechanisms to control different aspects of movement especially when movement becomes more complex [1, 40]. Overall, the impact of the limitations in the design of the TPR is that it appreciably affects student agency in their learning, where there was a disconnect between the lack of advanced actions in the TPR and the student having to ask for help in moving or manipulating the robot into a space for learning [23]. Therefore, by making the design of TPRs a priority, there will be timely benefits for student learning.

3.3 Negative Reactions Towards the Telepresence Robot

While positive experiences were reported from the use of the TPRs, there were a few examples of negative reactions by students using TPRs, their peers, other adults, and teachers towards the TPR [6, 29, 30]. Furthermore, not all students who used TPRs felt included socially or academically [39] while others described feeling uncomfortable with their appearance [6]. In one study, students reported experiences of being bullied, where other students would, for example put their hand in front of the TPR screen or experience negative verbal behaviour [30]. One of the explanations as to why bullying behaviour sometimes occurs towards the TPR was perhaps the mechanism of anthropomorphism, where the TPR takes on a persona that is then targeted [30].

An additional negative response was noted by Lister [23] who reported that levels of acceptance, while quick to become established within the immediate classroom, were not as rapid with adults and other school members who were not in the student’s class. Further, in a few cases teachers were not willing to have a TPR in their classroom [1], for privacy issues, which will be described in Sect. 3.5.

3.4 Professional Learning for Teachers on TPRs is Essential

Professional learning in the technical and operational methods of the TPR was regarded as essential. Specifically, teachers were concerned about the social complexities of the TPR in that the robot belonged to the student and the teacher could not just switch it off [39]. In one study teachers reported frustration with dealing with changes that resulted from learning resources, such as handouts [6, 27]. Teachers reported that academic materials would be better in real time (e.g., online forms) to promote inclusive teaching [1, 27]. Leveraging their findings, Ahumada-Newhart and Olson [1] suggest that there should be encouragement for teachers to take up practices that improve student engagement.

Examples of engagement included teachers being aware that they should show their full-face size and that eye contact is desirable for both teacher-student, and student–student interactions. Finally, teachers also indicated that they required professional learning in regard to their role and responsibility for the robot [6, 27].

Some of these concerns around responsibility pertained to a fear about the financial accountability associated with damaging the robot [27]. Professional learning, as well as the implementation of strategies to address many of the teachers’ issues, therefore, can address concerns of role and responsibility.

3.5 Considered Planning Between All Stakeholders is Essential

Three major stakeholders were identified in cases where TPRs were considered successful and they were parents, teachers and administrators [1, 6, 34]. Parental support and adequate training for parents in the use of TPRs, then administrative approval, and finally teacher support and training in TPRs were key considerations, in that order [27].

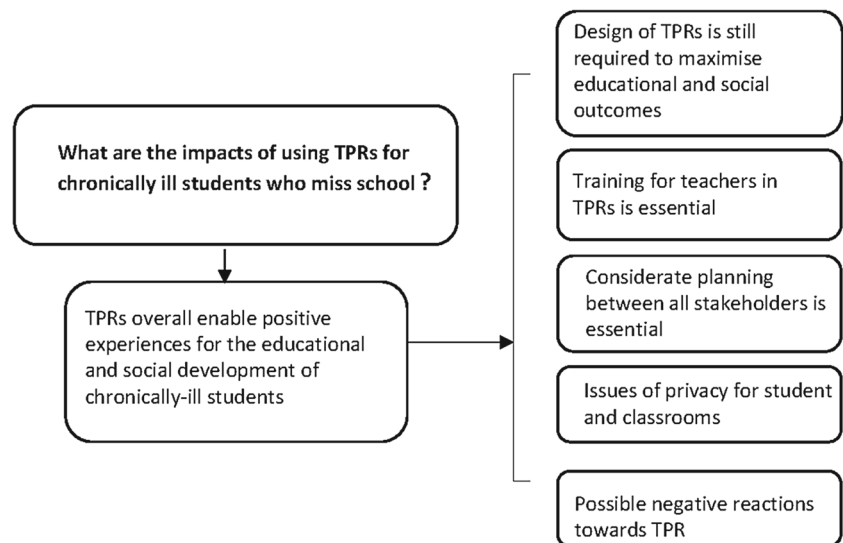
Once stakeholders come together, understanding the needs of a student with chronic illness is first and foremost in the development of a plan to meet those needs. While the opportunity to attend class is valuable, homebound students require flexibility because of their medical conditions [1]. Within the classroom itself, forward planning to facilitate responsive teaching practices is essential; to arrange lessons and teach in multiple modalities requires time [23, 40].

Additionally, considerations for stakeholders must include planning for the function of the robot, troubleshooting of connectivity, and a timeline to effectively organise both the student and the school in preparation for the TPR [6, 34].

3.6 Issues of Privacy

Several privacy issues were raised. One of the issues was that with a live telepresence is that students with chronic illness may suddenly become unwell and will need a plan to be able to quickly exit the classroom. Further, students who are unwell may not want their peers or teacher to use the live video camera but just engage the audio function [1, 6, 27]. Of note, when teachers decided not to use TPRs in the classroom, they cited privacy issues as the main reason, in particular, where other adults could see what happened in classrooms and could possibly post images or information on social media sites [27]. Newhart and Olson [27] offer a possible solution where parents fulfill the same requirements in terms of privacy that volunteers in a classroom would. Issues of privacy are indeed relevant in the increasingly technologically accessible world and careful considerations has to be

Fig. 2 Summary to guide future research in TPRs for students with chronic illness to connect to school



given to the development of practices and policies to ensure the future of TPRs in classrooms.

4 Discussion

The scoping review presented here sought to answer the research question, “What are the impacts of using TPRs for chronically ill students who miss school?” The findings indicated that TPRs provided an overall positive experience for the educational and social development of chronically ill students. Additional themes emerged across the literature; that the design of TPRs can still be improved to maximise educational and social outcomes; that professional development for teachers is paramount; that planning is essential between stakeholders to ensure the success of TPRs in classrooms; that there are issues of privacy to be taken into consideration; and finally, that there are possible negative reactions to TPRs that need to be acknowledged. A summary is provided in Fig. 2 below and highlights relationships between the findings that allow directions to be given for future research.

There are five areas of further research work that are recommended and they are the design of TPRs, teacher training, the importance of planning which in turn provide better outcomes for students using TPRs, addressing the area of privacy for students using a TPR, and finally, addressing the few negative issues that arise when TPRs are introduced into a school [28].

Telepresence robots have enabled students to connect remotely and to participate in their classroom environment without being physically present. They offer a face-to-face experience of in-class instruction. This scoping review focused on TPRs that could be independently controlled

by a student without having to rely on others to negotiate their social and academic experiences. Telepresence robots have been regarded as very significant for students who miss school for reasons of chronic illness. While there have been a number of TPRs made available and the benefits become anecdotally shared, there is little published research however in the field of telepresence and education. This scoping review has identified the few research publications in the use of TPRs in the classrooms of chronically ill students. The 11 articles reviewed from 2000 to 2020 indicate that TPRs in general enable positive experiences in relation to the educational and social development of chronically-ill students, better design of TPRs is still required to maximise educational and social outcomes, explicit training for teachers in TPRs is essential, considered planning between all stakeholders is essential, and issues of privacy and possible negative reactions to TPRs need to be addressed.

From these trends derived from the 11 reviewed articles, Fig. 2 indicates the direction that future research can take. One of the limitations of the research was that they did not consist largely of qualitative research. The very narrow range of not only the overall number, but methodological approaches, highlights the need for future study to take place in this field.

One of the limits rather than a limitation of the scoping review is that it consisted of articles that specifically related to research that involved students with chronic illness, rather than including research that could be applied to this topic. This procedure was undertaken as it was considered that generalisations should not be made from other populations e.g., from children using TPRs to learn languages or from students who were not chronically ill, influencing the design of TPRs for students who are sick. Additionally, research that investigated the use of TPRs that could not be indepen-

dently moved were included, however, mobile TPRs allowed more for the full experience of school connectedness [1, 6]. Indeed, the mobile TPR is the model being used in Australian schools as it is considered to address the fundamental issue of academic and social connectedness. Because of the specific affordances of mobility, comparison to other technology was not regarded as relevant but in itself, it would be valuable to research the potential affordances and challenges of static compared with mobile robots.

5 Conclusion

Technology, and specifically, the development of TPRs has provided schools with an opportunity to address the needs of students who are absent from school so they can continue with their school academic learning and social networks. The implementation and application of TPRs internationally has so far been supported by little research, and in Australia, there is a scarcity of research, despite TPRs being present in Australian classrooms since 2017. The finding that there is very little research signifies clearly the value in conducting a systematic review [3] for the topic of TPRs in relation to their use with students with chronic illness.

There were several limitations in the conclusions that could be made in the scoping review. First, only brief operating specifications were provided in each article and this information was not always provided consistently across the 11 articles. It is of note that these specifications while not extensively reported in the articles are valuable as the design and affordances of each robot impact on how the robot is experienced. Therefore, the findings in the articles in the scoping review are limited in their ability to be generalised across populations.

Secondly, this scoping review was not able to offer a comparison between mobile and stationary robots as again, there was not enough information reported across the articles to make any firm conclusions. It is therefore, recommended for future reporting that detailed information regarding the technological and operating aspects of TPRs are included.

The findings in regard to the use of TPRs for chronically ill students who miss school can inform the work of education and health systems, policy makers, technology distributors, teachers and researchers. As well, students who are ill, and their families, can be more fully informed about the potential of this technology, and can be forewarned about possible difficulties so that these can be pre-empted or dealt with as soon as they arise. The small amount of current research has provided insights for practice in classrooms as well as some ways forward for future research. Although in this review we discuss the issue within the particular Australian context, and in the context of student illness, the findings on the impacts of TPR use can be applicable to a range of international contexts as well as to other reasons for long-term school absence.

Funding Not applicable.

Availability of data and material Not applicable.

Compliance with ethical standards

Conflict of interest There are no conflict of interest identified.

Code availability Not applicable.

Appendix 1

See Table 1.

Table 1 Data extracted from the included studies

Author	Purpose of study	Research design	Methods and sample	Country	Results	Suggestions made by authors
<i>Mobile telepresence robots</i>						
Ahumada-Newhart* and Olson, 2019	To identify aspects of fit of robot to school for (learning and connectedness)	Qualitative	Data from 19 students with 11 student interviews (5–18 yrs), 16 parents, 20 teacher 16 administration, 2 class observation and 2 focus groups	USA	Some features were not compatible with school setting including connectivity, personalisation, interaction, height, academic issues	Design of robot for learning needs adapting to meet user needs in the classroom and in a school
Ahumada Newhart, and Olson, 2017.	To identify how schools manage TPRs (interaction and school attendance)	Qualitative	Interviews 14 teachers and 8 administrators	USA	Not all adopted TPRs: 12 teachers and 6 administrators adopted TPR	Adequate training in TPRs in schools and home school shared plan needed
Lister, 2020	To examine TPRs influence of virtual inclusion and normalcy, perception of autonomy and socio-emotional engagement (socio-emotional and inclusion)	Qualitative case study	1 student (11 yrs old) interviewed, interviews teacher and peer students in groups	USA	Gains in normalcy and autonomy, improvements in personal agency in learning, rapid acceptance of robot normalcy	Recommended TPRs for use for students with chronic illness and to facilitate inclusion. Considerations for planning recommended. Need for teachers to be responsive in their practices
Newhart*, Warschauer, Jones, and Eccles, 2018.	To explore motivation for use of TPRs and levels of happiness	Qualitative	Interviews 11 students (5–18 yrs), parents/guardians, interviews and observations 20 teachers and 16 administrators, focus group 44 classmates	USA	Connecting with peers primary reason for using TPRs (91%), and 95% felt 'happy' or 'good' using the robot	Understanding this motivation should lead to explore TPRs as effective intervention more
Newhart, Warschauer, and Sender, 2016	To explore students remaining connected to address loneliness, depression (educational and connection)	Qualitative case study	Interviews and survey of 5 children, 5 parents/guardians, 16 teachers, 6 administrators, 2 Classroom observations and classmate focus group	USA	Overcoming isolation, anthropomorphising TPR as bridge to future learning, technology challenges	TPRs need development to affect better inclusive practices
Soares, Kay, and Craven, 2017.	Explored strategies and challenges of using TPRs (academic and socio-developmental)	Qualitative case study	1 hospitalised and 8 at-home students participated in TPR delivery	USA	Case study illustrated process and feasibility of TPRs. Key lessons time to set up, connectivity, and getting schools on board	Educators at time resistant to new technology, privacy, operational, financial issues are all challenges

Table 1 continued

Author	Purpose of study	Research design	Methods and sample	Country	Results	Suggestions made by authors
<i>Stationary telepresence robots</i>						
Beeman and Henderson, 2015	Investigated live video technology to educate and socialise homebound students (academic and social)	Qualitative case study	Case study reported on 1 school's experience of 1 student (13 yrs old) with live video and audio technology using remote control to manipulate functions	USA	Interactive technology enabled student to stay connected and enhanced educational experience	Success of implementation requires co-operation of parents, teachers, administrators and technology staff
Fels, Waalan, Zhai, Weiss, 2001	Studied benefits of PEBBLES for students (academic and social)	Mixed methods case study	3 students observed, parents, classmates, teachers, medical staff interviewed and given questionnaires	USA	Communication high to start with in lessons, concentration levels appropriate for grade level. Others perceptions positive for learning and social outcomes	TPR greatly enhanced classroom presence and academic behaviours for student. Support given by peers, and adults for using TPRs
Fels and Weiss, 2001	Studied the frequency of interactions and usage behaviours (academic)	Mixed methods case study	Video-tape data over 6 weeks 1 student (12 yrs old) teacher, hospital teacher, nurse, questionnaires and projective drawing technique peers in class also interviewed	USA	Student able to spend most time on academic tasks despite technical difficulties and distractions	Audio difficulties persisted through study and needs to be improved
Weibel, Nielson, Topperzer, Hammer, Moller, Schmiegelow, Baekgaard Larsen, 2020	Explored how AV1 TPRs help connect students socially and academically with classmates (social and academic)	Qualitative pilot study	Interviews 3 12–14 yr old students, 3 parents, 2 teachers, 15 classmates (focus grp). Participant observation students at home and in classroom	Denmark	TPR facilitated social interactions and inclusion in learning, reduced loneliness and lacking behind education, but issues with exclusivity of TPR, technical issues and mutual expectations	Include nurses in planning of TPR use in regards to timing of medical issues. Technological aspects and education of TPR technology needs to be improved
Weiss, Whitely, Treviranus and Fels, 2001	Investigated impact of TPR on child and the people whom she interacted (social and educational)	Mixed methods case study	Video-tape data over 6 weeks 1 student (12 yrs old), parent, teacher, hospital teacher, nurse, questionnaires and projective drawing technique peers in class also interviewed	USA	TPR influenced behaviours and attitudes of all involved with TPR indicating positive effect on student and all participants but most dramatic effect on student	Technical aspects mostly related to sound need addressing. An additional camera would be of benefit

*Note that Ahumada-Newhart and Newhart are the same author

Appendix 2

See Table 2.

Table 2 Telepresence robot specifications extracted from the included studies

Author	System	Controlling mechanism	Connectivity	Audio function	Visual function	Additional highlights
<i>Mobile telepresence robots</i>						
Ahumada-Newhart* and Olson, 2019	VGo and Double	Mouse and joystick	Wifi	2-way	2-way but no camera tilt	Lightweight (7 to 8.6 kg) and height of primary school child. Double able to adjust in height
Newhart, and Olson, 2017	Beam Pro using web-based software	Keyboard controls	Not stated	Adjustable and ambient sound reduction	Dual cameras allowed adjustable and zoom-in function	Adjustable speed function
Newhart*, Warschauer, Jones, and Eccles, 2018	Not stated	Not stated	Not stated	Not stated	Not stated	Not identified
Newhart, Warschauer, and Sender, 2016	VGo	Not stated	Wifi	2-way	2-way	'Raised hand' using flashing lights
Soares, Kay, and Craven, 2017	Mobile robotic telepresence (MRT) system	Controller tablet	Wifi	Microphone and speakers	Web camera	Connectivity issues with some participants
<i>Stationary telepresence robots</i>						
Beeman and Henderson, 2015	Polycom video system: television and mobile cart at back of classroom	Remote control	Wifi	2-way set up at back of class	2-way with zoom-in function	Connectivity issues
Fels, Waalan, Zhai, Weiss, 2001	PEBBLES: yellow egg shaped device at users end using video-conferencing system	Game-pad controller	Not stated	2-way	Able to move up and down, left and right and zoom-in	Had a mechanical hand that 'waved'
Fels and Weiss, 2001	PEBBLES: yellow egg shaped device at users end using video-conferencing system	Video-game controller	Not stated	2-way	Able to move up and down, left and right and zoom-in	Had a mechanical hand that 'waved'
Weibel, Nielson, Topperzer, Hammer, Moller, Schmiegelow, Baekgaard Larsen, 2020.	AV1: activated via an app on a mobile device. Device at classroom end looks like a stereotypical 'robot'.	Not stated	Wifi	2-way	1-way	Connectivity at times an issue
Weiss, Whitely, Treviranus and Fels, 2001	PEBBLES: PC based video-conferencing	Game-pad controller	Wifi	2-way	Able to move up and down, left and right and zoom-in	Wireless microphone worn by teacher, 'hand' that waved

*Note that Ahumada-Newhart and Newhart are the same author

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